Varazdin Development and Entrepreneurship Agency and
Lusofona University, Lisbon, Portugal

In cooperation with:
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137th esd Lisbon 2026

Sustainability and Innovation: Their impact on Higher Education and Organizational Practices

Editors:
Ana Lorga, Paula C. R. Vicente, Sime Vucetic, Hrvoje Volarevic, Sasa Cegar

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In Loving Memory of Prof. Miroslaw Przygoda

This Conference and Publication are dedicated to our dearest Brother, Author, Partner, and long-standing Member of the 'esd Scientific Committee', as well as the founder of the cooperation between 'esd Conference' and Faculty of Management, University of Warsaw from Poland, Professor Miroslaw Przygoda, who unexpectedly passed away right before this event. His academic contribution and influence greatly supported our scientific project from its very beginning, while his exceptional personal qualities positively touched all of us who had the privilege of meeting him. His most recent attendance at our conference was in Porto this June.

Rest in well deserved peace dearest Friend, and You will never be forgotten…

In the photograph (left), with Prof. Marijan Cingula († 2024), founder of the esd Conference, at the Conference in Rabat, May, 2018.

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DIGITAL TECHNOLOGIES AND SUSTAINABILITY IN SPORT IN HIGHER EDUCATION: A LITERATURE REVIEW

Ivan Kovac
Faculty of Economics and Business,
University of Zagreb, J.F.Kennedy Sq. 6
ivankovac@efzg.hr

Marko Cule
Faculty of Economics and Business,
University of Zagreb, J.F.Kennedy Sq. 6
mcule@efzg.hr

Ivan Milinovic
Faculty of Economics and Business,
University of Zagreb, J.F.Kennedy Sq. 6
imilinovic@efzg.hr

Luka Buntic
Faculty of Economics and Business,
University of Zagreb, J.F.Kennedy Sq. 6
lbuntic@efzg.hr

ABSTRACT

Digital tools are part of everyday work in sport organisations, mainly in communication, administration and data analysis. In higher education, digital health tools are used to monitor and influence physical activity, with stronger results for some outcomes than for others. Environmental sustainability in sport also differs in how far it becomes part of regular organisational work. Individual tools and initiatives are more common in practice than full integration into strategy of some organisation. Research on corporate sustainability further shows that digitalization and sustainability can be connected when both become part of organisational decisions and long-term develoent.

Keywords: *digital technologies, sustainability, sport in higher education*

1. INTRODUCTION

The use of digital tools in sport has moved beyond communication and administration to training control, competition analysis and other parts of organisational work. Still, the presence of technology does not mean that the organisation itself has changed. Digitalization may remain connected with ordinary tasks, while digital transformation reaches strategy, organisational structure and culture. This distinction is also relevant outside organisational management. In higher education, smartphone applications, wearable devices and other digital health tools are used for monitoring, feedback and goal setting. Their effects are not the same for every measure of physical activity. A change in step count, for example, does not necessarily represent a wider change in habitual physical activity. Environmental questions add another part to this discussion. Sport organisations introduce environmental initiatives, but these activities are not always integrated into regular decision-making or strategy. When digital change reaches the organisational level, it can therefore overlap with sustainability through efficiency, stakeholder involvement and corporate sustainability. The relationship between these areas is important because the introduction of individual tools or initiatives does not show how far either digital or environmental change has become part of the organisation.

2. DIGITALIZATION AND ORGANISATIONAL CHANGE IN SPORT

Digital tools are already part of everyday work in many sport organisations, although using them is not the same as transforming the organisation. This difference is especially visible when the findings of Ehnold et al. (2021) and Thompson et al. (2024) are read together. Ehnold et al. (2021) found that voluntary sports clubs mainly used digital instruments for communication and administrative work. Education, revenue generation, event broadcasting, training control and competition analysis showed lower levels of use. The technology was present, but much of its use remained connected with ordinary tasks. Club goals partly explain why some organisations use digital tools more than others. Commitment to competitive sport and cooperation with other institutions were associated with wider digital use, including communication, administration, sponsoring, training and competition processes (Ehnold et al., 2021). Some limits come from inside the club. Digital processes may not fit the existing culture, a clear digital strategy may be absent, or the organisation may not have enough financial resources for IT investment. Changing external conditions do not always create an immediate perceived need for organisational change either. For this reason, the amount of technology used does not by itself indicate organisational success. Ehnold et al. (2021) note that success in voluntary sports clubs cannot be judged mainly through profitability or growth. Member satisfaction and the facilitation of work for employees and volunteers also matter. The literature uses several terms for different levels of digital change. Stegmann et al. (2021) use digitization for converting analog information into digital form. When digital technologies begin to be used in organisational work and processes, they refer to digitalization. Digital transformation has a wider scope because changes extend beyond individual tools and reach the organisation itself. That distinction becomes clearer in the findings of Thompson et al. (2024). They refer to limited changes in tools, communication and IT systems as small “d” digital change. Big “D” transformation reaches strategy, organisational structure and culture. Most of the sport organisations in their study were still closer to the first type. Digital technology increased communication and consultation with stakeholders and was linked with lower resistance to organisational change. Wider transformation was much less developed; digital technology had not yet become a full part of strategic planning and much of the previous way of working remained (Thompson et al., 2024). Ehnold et al. (2021) and Thompson et al. (2024) therefore describe related situations at different organisational levels. Voluntary clubs were already using digital instruments for routine work, and national sport organisations also benefited from technology in communication and consultation. Neither finding, by itself, represents complete digital transformation. The key difference is whether technology is simply being used inside existing work or whether it begins to change strategy, structure and organisational culture. Stegmann et al. (2021) make a similar distinction in sport marketing. Their review found growing research interest after 2016, with the number of studies reaching its highest level in 2020. Social media, eSports, fantasy sports and smartphone applications were common subjects, although social media received considerably more research attention than other forms of digital innovation. Digital innovation itself can be understood narrowly as a business model based on digital technology that enters a market through low-cost or new-market positions. In a broader use of the term, it also covers products, processes and business models created through digital technology (Stegmann et al., 2021). Once digital change reaches organisational strategy, it also begins to overlap with other organisational goals. This is where the Twin Transformation approach of Glebova and Madsen (2024) fits with the earlier discussion. Rather than treating sustainability as a separate issue added after digitalization, the approach considers the two processes together. In sport, this connection may appear in fan engagement, athlete performance, venue management and broadcasting, as well as in stadium, event and community decisions.

Digitalization is connected with efficiency, revenue and organisational processes; sustainability introduces environmental and social considerations into many of the same areas. Glebova and Madsen (2024) also discuss partnerships, data and stakeholder involvement as parts of this combined approach. The link becomes more concrete in the study by Wang et al. (2024), where digital transformation is examined in relation to corporate sustainability. Corporate sustainability combines economic, environmental and social concerns rather than treating them as three unrelated areas. Long-term profitability and adjustment to market conditions belong to the economic side, use of natural resources and ecological risks to the environmental side, and responsibility, stakeholder relations, justice and contribution to the community to the social side. Wang et al. (2024) also treat digital transformation as more than the introduction of new technology. Production and business models may change.

Previous research discussed in their study linked digital management with better efficiency and economic performance, while other findings connected digital transformation with lower information asymmetry, improved business performance, stock liquidity and the use of data to identify opportunities and environmental threats. The empirical results were positive. Authors report a coefficient of 0.1225 between digital transformation and corporate sustainability in the first model. After corporate and year-fixed effects were included, the coefficient was 0.3627 and significant at the 1% level. Robustness tests produced coefficients of 0.4829 and 0.3929, also significant at the 1% level. The sample consisted of 48 sports enterprises observed from 2012 to 2021. A positive effect of digital transformation on sustainable development was evident in Eastern China and among high-tech enterprises.

Digital transformation also increased technological innovation, although technological innovation had a negative effect on total factor productivity and no significant effect on sustainable development. Financing constraints, operating costs and operating efficiency were also related to the connection between digital transformation and corporate sustainability (Wang et al., 2024). Across the studies by Ehnold et al. (2021), Thompson et al. (2024), Glebova and Madsen (2024) and Wang et al. (2024), the main difference is the level at which digital technology operates. At one end, clubs use individual tools for communication and administration. Broader organisational change involves strategy, structure and culture, while Twin Transformation connects this wider digital development with sustainability. Some of the researchers examine the relationship at enterprise level through corporate sustainability outcomes.

3. DIGITAL TECHNOLOGIES AND PHYSICAL ACTIVITY

Digital technologies are widely used in health and physical activity through mHealth, eHealth, smartphone applications, SMS, web-based tools, social media, fitness apps and wearable devices within digital health. They are used for activity monitoring, goal setting, reminders, feedback and health advice. College students have been studied frequently in this area because digital technologies are already familiar to them. The findings differ depending on what is measured. Step count increases significantly, and positive results were also reported for some personalized SMS and smartphone interventions.

The same was not found for low-, moderate- or high-intensity physical activity or sedentary behaviour. Step count therefore represents a different outcome from broader changes in activity behaviour (Bi et al., 2024). Kim et al. (2018) examined another part of the same problem by using a wearable activity tracker in a college PAIP course. Modern trackers provide more than a step count; they may include real-time monitoring, feedback, goals and social functions. In this case, objectively measured habitual physical activity did not increase.

The intervention itself was relatively limited. Students were encouraged to use the Misfit tracker, but neither the device nor its companion application was directly integrated into the course curriculum, and students were not required to report their use. Authors also point out that behaviour change involves social, psychological and environmental factors. The tracker was only one part of that process. Niu et al. (2026) worked with a broader definition of digital technology and a much wider set of health outcomes. Their review included mHealth applications, wearables, telehealth, VR/AR, gamification and online platforms. Physical activity was only one outcome; sedentary behaviour, fitness, body composition, sleep and dietary habits were also included. Some technologies mainly provided communication, some recorded and returned activity data, and others were used in digital learning. The results were mixed.

Improvements were reported in fitness, activity participation, motivation, self-monitoring, walking, stretching and some educational outcomes. Other interventions did not improve dietary intake, and some found no significant difference in fitness between online and offline groups. Problems with unreliable data, users discontinuing use, small samples and limited long-term follow-up were also reported by Niu et al. (2026). The three studies are dealing with related but not identical outcomes. Bi et al. (2024) found a clear result for step count, Kim et al. (2018) tested whether a tracker changed habitual physical activity, while Niu et al. (2026) considered a much wider group of physical health outcomes. Their findings do not have to move in the same direction because they are not measuring exactly the same thing. What appears more consistent is that digital technology alone does not produce the same result across every type of activity or health outcome.

4. ENVIRONMENTAL SUSTAINABILITY IN SPORT

Environmental sustainability is now a recognised topic in sport research, although the field is still developing. Cury et al. (2022) grouped much of the literature into management, marketing, sociology and education. Management studies concentrated mainly on environmental initiatives and organisational decisions; marketing research dealt more with attitudes, behavioural intentions and communication. Education research often examined sustainability within sport management programmes. A recurring issue in this literature is environmental knowledge. Authors identified awareness and understanding of basic environmental problems as important when organisations introduce environmental practices. Lack of knowledge can limit the development and implementation of sustainability strategies.

They also found that research on environmental education was concentrated mainly in North American higher education. Knowledge alone, however, does not describe how far an organisation has actually moved. Sustainability may remain peripheral to normal organisational work, or it may become part of policies, strategic directions and everyday decision-making. Cury et al. (2022) relate the level of integration to the authenticity of environmental commitment. The study of Belgian sport federations provides a useful picture of the gap between awareness and actual integration. Hugaerts et al. (2022) examined 141 federations, but only 37 referred to environmental sustainability through initiatives, goals, values, mission or vision. The remaining 104 were classified at wave zero. Even among those that moved beyond that level, 30 reached only the first wave, and most of the 31 identified initiatives were low-intensity activities. The wave model helps place these results in context. Early environmental activity consists mainly of awareness and relatively simple measures. More knowledge, targeted actions and formal planning appear later, while full integration means that sustainability becomes part of regular organisational strategy. In the Belgian federations, most organisations had not reached that stage (Hugaerts et al., 2022).

McCullough (2023) adds another point to this picture: environmental development is not necessarily permanent. Organisations can progress and later move backwards. During the COVID-19 period, for example, some single-use plastics returned, even as practices such as digital ticketing became more common. The existence of an environmental initiative at one moment therefore does not necessarily mean that the same level of action will remain in place. Changing values can affect organisational practice as well. Media, education and activism influence what is seen as acceptable, and established practices may later be questioned. McCullough (2023) uses renovation instead of new facility construction as one example because renovation can reduce the environmental impact associated with construction. Seen together, the work of Cury et al. (2022), Hugaerts et al. (2022) and McCullough (2023) deals with different parts of the same issue.

Cury et al. focus strongly on knowledge and organisational integration, Hugaerts et al. provide evidence of how limited that integration was among Belgian federations, and McCullough describes progress as something that can also reverse. Environmental sustainability in sport is therefore not simply a question of whether an organisation has introduced one environmental activity. Sport ecology places these organisational questions within the wider relationship between sport and the natural environment. McCullough et al. (2020) use the term for the study of sport, the natural environment and the relationship between them. Their definition of sport is broad and includes athletes, coaches, managers, fans, suppliers and other parts of the sector. For some sports, dependence on environmental conditions is obvious: skiing requires snow, skating requires ice and aquatic sports require water.

Sport operations also depend on land and natural resources. Turf management, mountain and snow maintenance, trail management and weather-monitoring technologies are practical examples of this connection (McCullough et al., 2020). Sustainability in sport management also reaches beyond environmental protection. McCullough et al. (2020) discuss its use in relation to economic prosperity, social welfare, environmental well-being and organisational longevity. The general idea of sustainable development concerns present needs as well as the ability of future generations to meet their own needs. Climate change makes the dependence on natural conditions more immediate. Orr and Inoue (2019) describe climate vulnerability through potential impact and adaptive capacity.

Potential impact includes exposure to a climate hazard and the level of damage or disruption that could follow. The other side is the organisation's ability to respond. Organisational climate capacity covers awareness, knowledge, skills and resources that allow a sport organisation to adjust its operations and prepare for future threats. This capacity also depends on social, political, economic and infrastructural conditions. Two organisations exposed to a similar climate problem may therefore differ in what they are able to do about it (Orr and Inoue, 2019). The CVSO (Climate Vulnerability of Sport Organizations) framework considers climate impact together with that capacity.

Extreme heat, increased precipitation and rising sea levels are among the possible risks. Practical responses include moving activities indoors, relocating them, improving rain plans or increasing water availability during extreme heat. Orr and Inoue (2019) use these examples to explain how managers can assess climate vulnerability and decide how much attention and resources a risk requires.

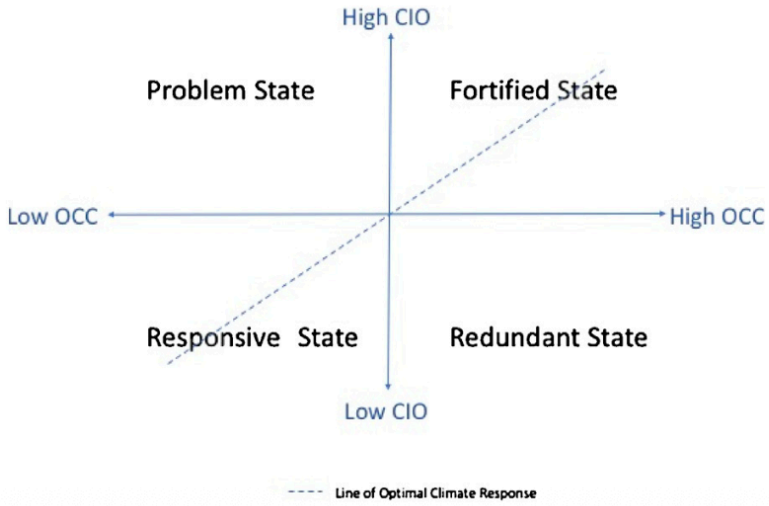

Figure 1: The CVSO (Climate Vulnerability of Sport Organizations) framework (Source: Orr and Inoue (2019))

Education offers a different way of approaching sustainability. Orr et al. (2020) describe transformative sustainability learning as a combination of academic learning and practical experience. Students work with sustainability through readings, lectures and discussion, apply what they have learned in practice and later reflect on the experience. Engagement, enactment and enablement are the three parts used to describe this process. Venue tours, green teams and living laboratories are examples used in sport management education. They differ in the amount of work involved and in the roles of students and instructors, and they can be used at undergraduate or graduate level. Students gain practical experience, while sport organisations can present their sustainability work and discuss possible improvements. Long-term empirical evidence was not yet available (Orr et al., 2020). Facility design provides another practical side of environmental sustainability. Kellison and Hong (2015) found that stadium owners most often referred to long-term savings. Tax credits, lower utility costs and a longer facility life were connected with these savings. The value was different depending on ownership: a long-term owner could benefit from lower costs over time, whereas a shorter-term owner might gain through a higher sale value. Positive publicity was mentioned as well. The designers included in the same study had worked on more than 25 pro-environmental sport facilities across four continents and expected this type of design to continue. Sustainable facilities were also being used as visible signs of innovation and modern management (Kellison and Hong, 2015). At event level, Piccerillo et al. (2023) measured environmental impact through carbon footprint. Transport and accommodation at a university sporting event produced an estimated 40,551 kg CO2e. Transport accounted for 27,360 kg, or 67.5% of the total, and accommodation for 13,191 kg. This was equivalent to 63 kg CO2e per participant. The interviews from that study give a different picture of organisational commitment. Environmental sustainability was not included in the organisation's statute and was not formally integrated into event processes. Digital procedures and reduced opening hours for athlete accreditation still lowered paper and energy use, but participation in sport remained the main organisational priority (Piccerillo et al., 2023). Environmental issues also appear within corporate social responsibility. Corporate social responsibility (CSR) is a behaviour aimed at reducing harmful effects on society and increasing long-term benefits for both the organisation and the community. In professional sport, environmental sustainability is relevant because teams and leagues both affect the environment and experience environmental changes themselves.

Regulation, monitoring, changes in stakeholder expectations and cooperation between organisations were all identified as influences on environmental behaviour. These pressures are connected with legitimacy and organisational image, but environmental practices can also reduce the ecological footprint of sport and increase awareness among fans and other stakeholders (Trendafilova et al., 2013).

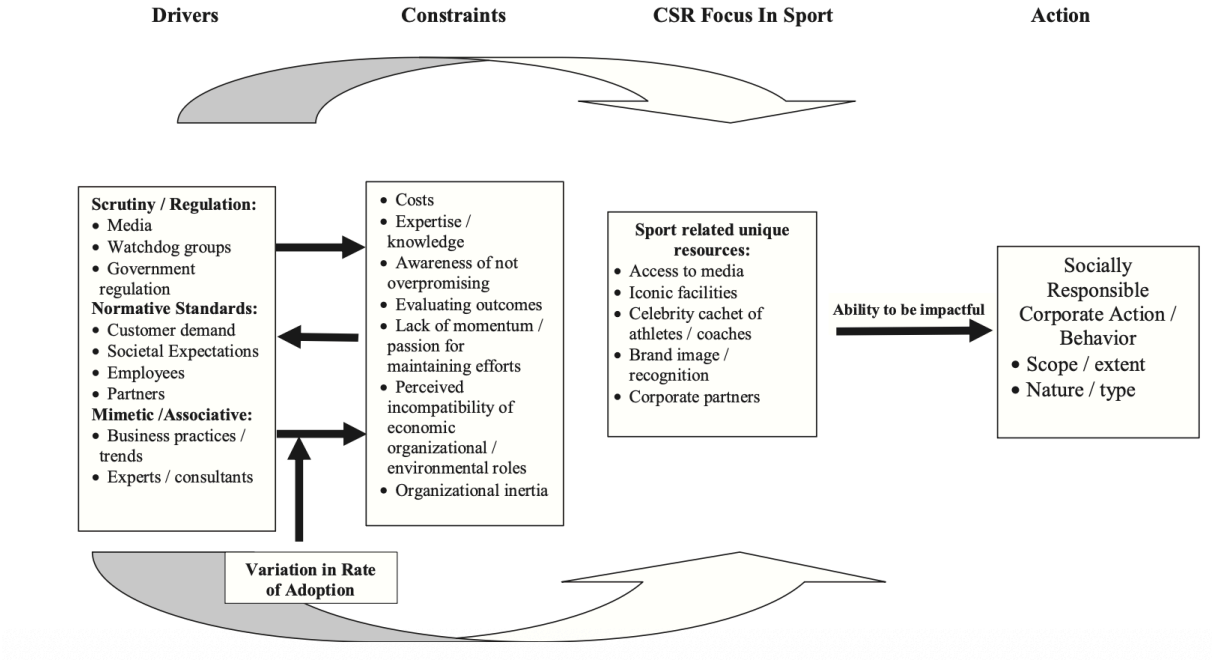

Figure 2: A model for CSR adoption in professional sport

(Source: Trendafilova et al. (2013))

The literature describes organisations at quite different stages. Cury et al. (2022) and Hugaerts et al. (2022) show that awareness and the existence of individual initiatives do not necessarily mean that sustainability is fully integrated into organisational work. McCullough (2023) also shows that environmental progress can move in both directions, while Orr and Inoue (2019) place organisational capacity at the centre of responses to climate risk.

5. CONCLUSION

The main issue identified in the literature is not simply whether sport organisations use digital tools or introduce environmental initiatives, but how far these changes become part of regular organisational work. Communication and administration can become digital without major changes in strategy, structure or culture. In the same way, environmental activity can remain limited to individual initiatives without becoming part of organisational strategy. The findings from higher education add a similar caution. Digital tools can influence particular measures of physical activity, but a change in one outcome does not mean that broader behaviour has changed. The way technology is used and what is being measured are therefore important when its effects are considered. For sport organisations, the presence of technology or an environmental initiative is only a first step. Greater change appears when these activities reach organisational decisions and strategy. At that level, digitalization and sustainability are no longer completely separate issues, which is also reflected in research on Twin Transformation and corporate sustainability.

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OUTSOURCE, PRODUCE, OR INTEGRATE? A THREE-FIRM CASE STUDY OF SUSTAINABLE FOOD PACKAGING'S PROFITABILITY IN TURKISH AGRI-EXPORTERS

Souha Zejli
The National School of Business and Management of Tangier
University Abdelmalek Essaâdi – Morocco
Member of the EVOLVEPACK Project Supported by the EU-Funded PRIMA Program
souha.zejli@etu.uae.ac.ma

Ahmed Maghni
The National School of Business and Management of Tangier
University Abdelmalek Essaâdi – Morocco
Member of the EVOLVEPACK Project Supported by the EU-Funded PRIMA Program
ahmed.maghni@uae.ac.ma

Abdelhamid Nechad
ESCA School of Management, Casablanca
The National School of Business and Management of Tangier
University Abdelmalek Essaâdi – Morocco
Member of the EVOLVEPACK Project Supported by the EU-Funded PRIMA Program
anechad@esca.ma

ABSTRACT

The transition from fossil-fuel-based plastics to sustainable alternatives in food packaging has been driven almost exclusively by environmental concerns, yet a fundamental question remains unanswered: under what conditions does sustainable food packaging deliver positive outcomes across the triple bottom line—environmental performance, social equity, and financial viability? Despite extensive research on technical and environmental dimensions, the literature remains fragmented, with scholars noting that economic viability remains underexplored (Accorsi et al., 2014), life cycle assessment overlooks economic and social dimensions (Molina-Besch et al., 2019), and social implications remain virtually unexplored (Nguyen et al., 2025). A bibliometric analysis of 8,865 documents confirms this gap: profitability terms appear minimally while technical keywords dominate. This study addresses this gap through a comparative case study of three Turkish agri-exporters spanning the full spectrum of SFP value chain positions: a pure user (50 tons), a pure producer (1,500 tons), and an integrated user-producer (100,000 tons). Using primary data collected during site visits in January 2026, we conducted make-or-buy savings analysis, break-even analysis, export premium analysis, and labor productivity decomposition, and constructed a Value Chain Profitability Index to develop a Contingency Framework for adoption decisions. Findings reveal that SFP cost decreases monotonically with scale (101.5 → 45.6 → 32.5 TL/kg); vertical integration generates superior triple bottom line performance (Index = 0.92); integration payback periods drop from 188 years at 50 tons to <1 year above 10,000 tons; labor productivity is 2,936× higher at scale, with 99.98% driven by productivity, not wage suppression; and the export premium (+€0.03/kg) generates 150,000,000 TL annually for the integrated firm. Based on these findings, a Contingency Framework guides firms to outsource below 8,500 tons, partner (hypothesized for firms in this range based on the break-even analysis) between 8,500–50,000 tons, and integrate above 50,000 tons. These findings challenge one-size-fits-all sustainability mandates and demonstrate that SFP profitability depends on scale and value chain position.

Keywords: *Sustainable Food Packaging; Triple Bottom Line; Value Chain Analysis; Economies of Scale; Break-Even Analysis; Case Study; Turkey*

1. INTRODUCTION

The planetary transition from fossil-fuel-based plastics to sustainable alternatives in packaging in general & food packaging specifically has been driven almost exclusively by environmental concerns. Tens of thousands of studies have meticulously documented the ecological devastation of plastic waste, the promise of biodegradable polymers, the potential of circular economy principles and the technical properties of bio-based films (Zhao et al., 2023; Bangar et al., 2021; Edo et al., 2025; Cruz & Varzakas, 2023). Regulatory pressures–the EU's Single-Use Plastics Directive, national plastic taxes, corporate net-zero commitments in addition to shifting consumer preferences–have accumulated to create a policy landscape in which sustainable packaging is increasingly framed as an environmental imperative (Tassinari et al., 2023; Pauer et al., 2019). Yet a fundamental question remains conspicuously unanswered across this extensive literature: under what conditions does sustainable food packaging deliver positive outcomes across the triple bottom line – environmental performance, social equity and financial viability?

The phrasing of this question matters because sustainability, by definition, is not reducible to any single dimension. Elkington's 1997 triple bottom line (TBL) framework – People, Planet, Profit — has become the dominant paradigm for assessing corporate sustainability, for good reason, and precisely because it acknowledges that environmental improvements that impoverish communities, or profitable ventures that destroy ecosystems, are not sustainable in any meaningful sense. Food manufacturers face decisions that affect all three dimensions simultaneously; material choices determine environmental impacts, labor practices shape social outcomes and cost structures decide whether or not the firm will survive financially. A packaging solution that is environmentally superior but economically unviable will not be adopted at scale, regardless of its ecological credentials. Conversely, a profitable solution that exploits workers or perpetuates environmental harm is not truly sustainable. The question that is invoked by the TBL therefore sits at the intersection of environmental necessity, commercial reality and social responsibility. Despite its importance, this question hasn't been answered. The literature is fragmented along disciplinary lines that prevent integration across the TBL. Material scientists have optimized film formulations with molecular precision, focusing on tensile strength, water vapour permeability and elongation at break – the technical dimension of sustainability (Shi et al., 2025; Bangar et al., 2021). Environmental engineers have quantified life cycle impacts across eighteen impact categories, meticulously documenting carbon footprints, eutrophication potential and resource depletion – the environmental dimension (Edo et al., 2025; Jeswani et al., 2015). Supply chain modellers have optimized logistics networks and inventory systems with analytical rigour, modelling transportation costs, warehousing and distribution efficiency – the operational dimension (Georgakoudis et al., 2018; Sebatjane et al., 2020). Consumer behaviour researchers have estimated willingness-to-pay (WTP) for specific innovations, documenting premium acceptance across regions & demographics – the market dimension (Haque & Rahman, 2025; Dobon et al., 2011). Circular economy researchers have explored reuse systems, return rates and waste valorization, quantifying the economics of loops – the circular dimension (Li et al., 20223; Haslinger et al., 2025). We are yet to find a study that integrated these streams into a coherent framework that answers the question mattering most of food manufacturers, policymakers and communities: does sustainable packaging perform across all three dimensions of sustainability, and under what conditions?

Scholars have explicitly noted this deficiency. Accorsi et al. (2014) observed that the economic viability of sustainable packaging remains comparatively underexplored relative to its technical development. Molina-Besch et al. (2019) highlighted that life cycle assessment of food packaging systematically overlooks the economic & social dimensions, focusing instead on environmental impacts without linking them to financial or social outcomes. Nguyen et al. (2025), in their systematic review of circular bioeconomy and sustainable food systems, identified the trade-off between short-term profit and long-term sustainability as critically unexamined, noting that bio-based products struggle with price competitiveness against linear economy products and that the social implications, namely job creation, working conditions, community impacts, remain virtually underexplored. Therefore, both an extensive bibliometric analysis and a literature review were conducted prior to this case study to empirically map the intellectual structure of the field and confirm the TBL gap. The bibliometric analysis, spanning 8,865 documents from both Scopus & Web of Science, reveals a striking asymmetry: technical & environmental keywords dominate the literature, while profitability terms specifically remain virtually absent with "profitability" appearing 62 times, "profit" 148 times and "profitable" 22 times. This systematic absence validates the need for empirical investigation into the conditions under which sustainable food packaging delivers positive outcomes across all three dimensions. The present case study of three Turkish agri-exporters, spanning the full spectrum of sustainable food packaging value chain positions, attempts to directly address this gap by examining how scale and value chain position affect financial, environmental as well as social performance simultaneously.

2. LITERATURE REVIEW

2.1 The Triple Bottom Line Framework

The concept of sustainability as a multidimensional construct is well-established in management literature. Elkington's (1997) triple bottom line framework—People, Planet, Profit—has become the dominant paradigm for assessing corporate sustainability precisely because it acknowledges that environmental improvements that impoverish communities, or profitable ventures that destroy ecosystems, are not sustainable in any meaningful sense. This framework provides the analytical foundation for our study, which examines sustainable food packaging across all three dimensions: financial viability, environmental performance, and social outcomes.

2.2 Sustainable Food Packaging: Technical and Environmental Dimensions

The technical and environmental case for sustainable packaging is well-established. Extensive research has demonstrated that biopolymers derived from renewable resources—polysaccharides like starch, pectin, cellulose, and chitosan; proteins like gelatin, zein, casein, and whey; and lipids like waxes and oils—can form cohesive films with mechanical and barrier properties approaching those of conventional plastics (Zhao et al., 2023; Bangar et al., 2021). Shi et al. (2025) developed a multifunctional collagen-based film with tensile strength of 78.64 MPa, antioxidant activity of 72.09 percent, and complete biodegradation in natural soil within fifty-five days. Edo et al. (2025) provide comparative life cycle assessment data showing that polylactic acid emits 0.50-0.80 kg CO_2 eq. per kilogram versus PET at 2.15-2.50 kg CO_2 eq. per kilogram, while energy demand for PLA and PHA production is 30-50 MJ/kg compared to 75-85 MJ/kg for PET. However, the same studies document economic barriers. Raw material costs for PLA range from €0.60 to €0.90 per kilogram, compared to €1.00-1.50 for conventional plastics. Capital expenditures for biopolymer facilities are estimated at USD 50-80 million, and break-even analysis indicates that PLA costs must decline by thirty to forty percent to compete with PET or HDPE (Edo et al., 2025). This technical-environmental-economic tension underscores the need for integrated triple bottom line assessment.

2.3 Economic Assessment of Sustainable Packaging: The State of Evidence

The economic assessment literature provides fragmented but instructive evidence. Konstantas et al. (2019) conducted the most comprehensive life cycle costing analysis in the evidence base, examining biscuits, cakes, chocolates, and ice cream in the UK market. Raw materials dominate life cycle costs, contributing 43 to 95% of the total. For biscuits, flour alone averages 50% of costs; for chocolates, milk powder accounts for 35%; packaging contributes one to 29%; manufacturing one to 14%.

Tassinari et al. (2023) provide the most direct economic analysis of a novel bioplastic packaging film: a PLA-PHB blend with PHB derived from potato peels. Using net present value calculation and Monte Carlo simulation, they estimated the minimum product selling price for a four-year payback period—the threshold generally accepted by investors. With seven large plants (each producing 18,000 tonnes of film per year), the minimum selling price was €9.70 per kilogram. With seventy-seven smaller plants (each producing 1,600 tonnes per year), the price rose to €37.20 per kilogram. Both figures are far above the €1.00-1.50 per kilogram cost of conventional fossil-based plastics. Feedstock availability was the most influential factor on profitability, with an elasticity of -0.854.

Fathi et al. (2024) analyzed implementing chipless RFID technology in a large-scale seafood operation, differentiating between fixed costs (hardware, software, integration, training) and variable costs (tags, maintenance, labour). The analysis showed a positive NPV of USD 448,089 and a 14% ROI over five years, demonstrating the potential profitability of smart packaging for large firms despite high initial costs. Drago et al. (2024) conducted a comprehensive business-to-business financial analysis for a novel biodegradable antimicrobial membrane, calculating CAPEX of €300,000 and demonstrating positive net profit from year two.

Stramarkou et al. (2022) conducted an economic evaluation of smart packaging, calculating production costs as: conventional packaging €0.124 per unit, smart packaging €0.23 per unit (84.4% higher). Lerdlattaporn et al. (2021) examined cassava starch production in Thailand, comparing three scenarios: baseline, biogas from wastewater only, and biogas from both wastewater and cassava pulp. The combined system delivered superior outcomes across all dimensions: biogas yield increased six-fold, grid electricity consumption dropped to zero, total production cost was reduced by eleven percent, GHG emissions were reduced by seventy-seven percent, and NPV of $6.14 million with IRR of 31% and payback period of 4.37 years.

2.4 Value Chain Position and Scale: The Missing Variables

Crucially, no prior study has systematically compared SFP profitability across value chain positions—users versus producers versus integrated firms—or estimated the scale thresholds at which different strategies become viable. This is a significant gap, as Transaction Cost Economics (Williamson, 1985) predicts that firms internalize activities when transaction costs (search, negotiation, enforcement) exceed internal governance costs. Applied to SFP, this suggests that integration should become more profitable at larger scales where transaction costs are high and internal governance efficiencies can be realized. Economies of Scale theory (Stigler, 1958) predicts that unit costs decline as output increases due to fixed cost amortization and operational efficiencies. The Resource-Based View (Barney, 1991) suggests that sustained competitive advantage derives from firm-specific resources that are valuable, rare, inimitable, and non-substitutable—such as vertically integrated SFP production capabilities.

2.5 The Gap

Despite extensive research on the technical and environmental dimensions of sustainable food packaging, the literature has not yet fully addressed the triple bottom line question. The existing evidence base provides rich insights into material properties, life cycle impacts, and consumer preferences, but these streams remain largely disconnected from one another and from the financial and social realities of food manufacturers. Prior studies have examined individual cost drivers, estimated production costs for novel bioplastics, and modelled supply chain dynamics with analytical rigour. However, these analyses have not been integrated into a coherent framework that simultaneously accounts for financial, environmental, and social performance. Furthermore, the literature has not systematically compared SFP outcomes across different value chain positions—users, producers, and integrated firms—nor has it estimated the scale thresholds at which different strategies become viable. The social dimensions of SFP adoption—labor productivity, wage levels, and planning horizons—remain particularly underexplored. This study addresses these gaps through a comparative case study of three Turkish agri-exporters spanning the full spectrum of SFP value chain positions, contributing empirical evidence on the conditions under which SFP delivers positive outcomes across all three dimensions of sustainability.

3. METHODOLOGY

3.1 Research Design

This study employs a comparative case study design following Eisenhardt's (1989) influential method for theory-building from case studies. Eisenhardt's approach is particularly appropriate when the research question addresses "how" and "why" phenomena occur in real-world contexts, and when the boundaries between phenomenon and context are not clearly evident (Hollweck & Yin, 2014). Eisenhardt (1989) recommends between 4 and 10 cases to achieve theoretical saturation, noting that with fewer than 4 cases, "it is often difficult to generate theory with much complexity, and its empirical grounding is likely to be unconvincing" (p. 545). However, she provides an exception: studies with fewer than 4 cases can work when cases contain "several mini-cases within it" (p. 545), as in Mintzberg and McHugh's (1985) study of the National Film Board of Canada, which examined six distinct periods within a single organization. Our three cases each contain multiple operational units, product lines, and packaging types, effectively functioning as embedded mini-cases. Furthermore, as Eisenhardt notes, "there is no ideal number of cases" (p. 545), and pragmatic considerations of resource availability, time constraints, and access to firms necessarily shape case selection. The three cases represent a "polar types" sampling strategy (Eisenhardt, 1989, p. 537), selecting firms at extreme positions on the value chain continuum to maximize variation and enable theoretical replication. As Pettigrew (1988, cited in Eisenhardt, 1989, p. 537) argued, "given the limited number of cases which can usually be studied, it makes sense to choose cases such as extreme situations and polar types in which the process of interest is 'transparently observable.'" This design is appropriate when the research question addresses "how" and "why" phenomena occur in real-world contexts, and when the boundaries between phenomenon and context are not clearly evident (Hollweck & Yin, 2014).

3.2 Case Selection

Three Turkish agri-exporters were purposively selected based on three criteria: (i) they operate in the food export sector, (ii) they either use or produce Sustainable Food Packaging, and (iii) they represent distinct positions on the SFP value chain continuum. This sampling strategy aligns with Eisenhardt's (1989) recommendation for selecting cases that fill theoretical categories and provide examples of polar types.

The cases were chosen to replicate or extend emergent theory, following the logic of theoretical sampling (Eisenhardt, 1989, p. 537). This is not random selection, but deliberate selection of cases that are likely to replicate or extend the emergent theory. Random selection, as Eisenhardt notes, "is neither necessary, nor even preferable" (p. 537) in theory-building research.

Firm A is a pure user of SFP: an organic lentil, bean, and rice exporter to the EU, USA, and Middle East. Established in 2015 with 50 employees, the firm purchases recycled polypropylene sheets for packaging under 5kg and oriented polypropylene for heavier items. Annual production is 50 tonnes. The firm operates with a debt/equity ratio of 10:90.

Firm B is a pure producer of SFP: a plastic bottle and cap manufacturer serving over ten countries, primarily Saudi Arabia. Established as a family-owned enterprise with 135 employees, the firm holds ISO 9001, 14001, and FSSC 22000 certifications. Annual production reaches 1,500 tonnes of PP granules. The firm operates with 100% equity and a 1-year planning horizon. Raw material costs (PP granules from SABIC) range from €1,000-1,500/ton, equivalent to approximately 50,000-75,000 TL/ton at the January 2026 exchange rate of 1 EUR = 50 TL.

Firm C is an integrated user-producer of SFP: a fruit exporter to over sixty countries. Established in 1993 with 1,000 employees, the firm prints and shapes its own carton packaging in-house, supplemented by PP and PE nets and trays. Annual production reaches 100,000 tonnes. The firm operates with a 90:10 equity-heavy ratio and a planning horizon of 6 months to 6 years. A premium of +€0.03/kg is achieved for carton packaging.

These three firms collectively represent the full spectrum of SFP value chain positions—pure user, pure producer, and integrated user-producer—while varying substantially in scale (50 to 100,000 tonnes) and organizational characteristics.

3.3 Data Collection

Following Eisenhardt's (1989) recommendation for combining multiple data collection methods, primary data were collected during site visits to each firm conducted on the following dates:

- **January 19, 2026**: Firm A
- **January 20, 2026**: Firm C
- **January 21, 2026**: Firm B

Data collection followed a semi-structured interview protocol designed to capture three categories of information: financial data (material costs, electricity costs, labor costs, capital expenditure, debt/equity ratios, tax rates, pricing information), operational data (annual production volumes, scrap reuse percentages, renewable energy adoption, planning horizons, production capacity), and strategic data (challenge rankings, certification status, export markets, sustainability practices).

Multiple sources were used to triangulate findings: direct interviews with firm management, site observations, financial records where available, and operational documentation. As Eisenhardt (1989) notes, the combination of "interviews, observations, and archival sources" strengthens the grounding of theory through "triangulation of evidence" (p. 538).

3.4 Variables and Measurement

Dependent Variable: Triple Bottom Line Performance is operationalized through three components:
Financial Performance is measured by SFP Cost per kg (TL/kg), representing the total cost incurred to acquire or manufacture sustainable food packaging. Lower costs indicate higher financial performance.
Environmental Performance is measured by Renewable Energy Percentage (percentage of energy from renewable sources) and Scrap Reuse Percentage (percentage of production scrap reused internally). Higher percentages indicate higher environmental performance.
Social Performance is measured by Labor Wage (TL/hour), Labor Productivity (production tons per TL of labor cost), and Planning Horizon (years). These indicators capture working conditions, efficiency, and organizational stability.

Independent Variable: Value Chain Position is a categorical variable with three levels:

- **User**: Firms that purchase SFP from external suppliers (Firm A)
- **Producer**: Firms that manufacture SFP for sale to other firms (Firm B)
- **Integrated**: Firms that both use and produce SFP internally (Firm C)

Independent Variable: Scale is measured as Annual Production Tons, capturing the size of operations.
Control Variables: Debt/Equity Ratio captures financial structure; Corporate Tax Rate (constant at 20% across all firms) is held constant; Electricity Cost captures energy intensity; Challenge Rankings capture revealed strategic priorities.

3.5 Analytical Approach

Following Eisenhardt's (1989) iterative approach, the analysis proceeds in three stages, each involving constant comparison between data and emerging theory.

Stage 1: Within-Case Analysis examines each firm individually through detailed case descriptions. As Eisenhardt (1989) emphasizes, "within-case analysis can help investigators cope with this deluge of data" (p. 540) by allowing "the unique patterns of each case to emerge before investigators push to generalize patterns across cases" (p. 540). This stage establishes the baseline variation across value chain positions and scales.

Stage 2: Cross-Case Pattern Search compares the three firms systematically. Following Eisenhardt's (1989) recommendation to "look at the data in many divergent ways" (p. 540), we employ multiple cross-case tactics: selecting categories and dimensions (e.g., value chain position, scale) and looking for within-group similarities and intergroup differences; selecting pairs of cases and listing similarities and differences; and dividing the data by source (financial, operational, strategic). These tactics "force investigators to go beyond initial impressions" and "improve the likelihood of accurate and reliable theory" (p. 541).

Stage 3: Composite Index Construction develops a Triple Bottom Line Value Chain Profitability Index using min-max normalization and equal weighting. This approach follows established practice in composite indicator construction (OECD, 2008) and enables systematic comparison across firms. The index comprises six sub-scores: Cost Score (inverted), Electricity Intensity Score (inverted), Labor Productivity Score, Scrap Score, Renewables Score, and Planning Horizon Score.

Stage 4: Break-Even Analysis for Integration follows standard cost-volume-profit methodology (Rizki & Sukoco, 2019) to estimate the investment required for in-house SFP production and calculate payback periods at different scales. Using Firm C's observed cost structure as the benchmark for efficient production, we estimate fixed costs from the observed cost differential between firms and industry benchmarks for packaging manufacturing. This analysis identifies the scale thresholds at which integration becomes financially viable, providing a practical decision tool for managers evaluating make-or-buy decisions.

All analyses were conducted in R 4.3.2 (R Core Team, 2023) using, mainly, the tidyverse and ggplot2 packages. Code could be shared & made available in the supplementary materials if requested.

3.6 Methodological Limitations

Following Eisenhardt's (1989) guidance on evaluating theory-building research, we acknowledge several limitations. The small sample size (n=3) is below Eisenhardt's recommended range of 4-10 cases, which may limit the complexity and empirical grounding of the emergent theory. However, each case contains multiple embedded units of analysis—product lines, packaging types, and operational units—which partially mitigates this limitation. Additionally, the polar types sampling strategy maximizes variation along the dimensions of theoretical interest, enabling theoretical replication despite the small number of cases. The reliance on self-reported data introduces potential bias. We mitigated this through triangulation across multiple sources (interviews, observations, documentation) and by focusing on objective, verifiable metrics (costs, production volumes, electricity bills) rather than subjective assessments. However, the absence of audited financial statements for all firms remains a limitation. Single-country focus limits applicability to other contexts. Turkey's specific regulatory, cultural, and market conditions may not generalize to other emerging markets. However, the theoretical framework—Transaction Cost Economics, Economies of Scale, and Resource-Based View—is generalizable and should apply across contexts with appropriate contextual adaptation. Future research should extend these findings through large-N surveys of Turkish exporters or comparative case studies in other emerging markets. As Eisenhardt (1989) notes, theory-building research is "useful in early stages of research on a topic or when a fresh perspective is needed," while theory-testing research "is useful in later stages of knowledge" (p. 548). This study provides the foundation for subsequent hypothesis-testing research.

3.7 Theoretical Framework for Financial Analysis

The analytical approach employed in this study—make-or-buy savings analysis, break-even analysis for integration decisions, labor productivity decomposition, and composite index construction—is grounded in established financial and managerial theory.

Make-or-Buy Decision Analysis and Transaction Cost Economics

The make-or-buy decision is a foundational concept in managerial accounting and strategic management, requiring differential analysis of all revenues and costs that differ between alternatives (Saylor Academy). However, the theoretical underpinning for why firms choose to make rather than buy—or vice versa—derives from Transaction Cost Economics (TCE), articulated most influentially by Williamson (1985). As Baumol (1986, p. 279) notes in his review of Williamson's work, "For any given firm there is presumably an optimal degree of vertical integration determined by the requirements of economy in production and economy in the governance process, or as Williamson puts it, of 'economizing in transactions costs.'" TCE predicts that firms internalize activities (make) when transaction costs—search, negotiation, monitoring, and enforcement costs—exceed internal governance costs.

Conversely, when market contracting is more efficient, firms outsource. Three conditions, identified by Williamson (1985) and summarized by Baumol (1986, p. 279), render transaction cost analysis particularly applicable: **asset specificity** (sunk costs that cannot be readily redeployed), **bounded rationality** (limits on information and calculation ability), and **opportunism** (willingness to profit at the expense of others). As Baumol explains, "If an economic activity requires no costs to be sunk in plant or individuals, so that all capital... is perfectly transferable, then the market mechanism can perform its marvels unaided" (p. 279). However, when specialized investment is required and uncertainty is high, "the costs of market coordination rise and the benefits of tighter coordination through contracts or integration increase" (OER Commons, 2025). Applied to sustainable food packaging, these conditions are all present in the Turkish agri-export context. SFP production requires specialized assets (packaging machinery, quality control systems, supplier relationships, sustainability certifications) that represent sunk costs. The high-inflation environment in Turkey (annual CPI exceeding 40% in 2025) creates uncertainty that limits complete contracting—firms cannot foresee all future price changes. This volatility creates opportunities for opportunistic behavior by suppliers. Under these conditions, integration becomes more valuable: it locks in costs, secures supply, and protects against price volatility. Our make-or-buy savings analysis quantifies the cost differential between outsourcing and internal production, revealing the "value leakage" in the current supply chain—a finding that aligns with **Profit Pool Analysis**, which examines how profits are distributed across value chain activities and identifies areas where value is lost through inefficiencies.

Break-Even Analysis for Investment Decisions

Break-even analysis (Cost-Volume-Profit analysis) is a core financial tool for short-term decision-making that examines the relationship between output volume, costs, revenues, and profit (Rizki & Sukoco, 2019). The break-even point represents the level of sales at which total contribution margin exactly equals total fixed costs—the threshold at which incremental net income turns from negative to positive. In industrial and manufacturing contexts, break-even analysis is standard practice for evaluating capital expenditure decisions, including investment in plant and equipment. Our analysis adapts this framework to estimate the investment required for in-house SFP production and calculate the payback period at different scales. This approach is particularly valuable in the Turkish context, where high inflation and currency volatility make long-term capital budgeting decisions especially consequential. By calculating payback periods at different scale thresholds, we provide managers with a practical decision tool for evaluating integration viability.

Labor Productivity Analysis and Economies of Scale

Labor productivity analysis is grounded in production function theory, which examines the relationship between inputs (labor, capital) and outputs (Griliches, 1967). The dramatic productivity differentials observed across firms reflect **Economies of Scale**—the phenomenon where unit costs decline as output increases due to fixed cost amortization and operational efficiencies (Stigler, 1958). As production volumes increase, labor becomes more productive because: (a) fixed labor costs are spread over more units, (b) larger firms can invest in automation and process optimization, and (c) workers in larger firms can specialize in narrower tasks, increasing efficiency (Smith, 1776). Our decomposition of labor cost advantage into wage effects and productivity effects follows established approaches in productivity analysis, enabling us to distinguish whether cost advantages derive from wage suppression (a social sustainability concern) or genuine efficiency gains.

Composite Sustainability Index Construction

The Value Chain Profitability Index follows established practice in sustainability measurement literature. Under the Triple Bottom Line approach, composite indexes simultaneously combine economic, environmental, and social components of sustainability performance (Elkington, 1997; Nikolaou & Tsalis, 2018). Our index employs min-max normalization followed by equal weighting—a standard approach in composite indicator construction when no theoretical basis exists for differential weighting (OECD, 2008). As Baumol (1986, p. 281) notes, the firm must be understood as "a governance structure rather than [only] a production function"—a perspective that justifies including governance-related metrics (planning horizon, labor productivity) alongside purely financial metrics. The six sub-scores (cost, electricity intensity, labor productivity, scrap reuse, renewable energy, planning horizon) capture the three TBL dimensions: financial (cost, electricity), environmental (scrap, renewables), and social (labor productivity, planning horizon). The equal weighting assumption is standard practice and, as we demonstrate through sensitivity analysis, the ranking of firms is robust to alternative weighting schemes.

Export Premium Analysis

Finally, our analysis of export premium capture draws on strategy literature examining how sustainability credentials can generate competitive advantage through differentiation and premium pricing (Porter, 1980; Barney, 1991). Premium capture is scale-dependent—larger firms have the infrastructure, certifications, and buyer relationships to access premium markets, while micro-firms may lack these capabilities. This analysis complements the TCE framework by showing that integration not only reduces costs (through governance efficiencies) but also increases revenue (through differentiation).

4. RESULTS

This section presents the findings from our comparative case study of three Turkish agri-exporters spanning the full spectrum of sustainable food packaging (SFP) value chain positions. Following the analytical framework outlined in Section 3.7, we present: descriptive comparison across firms, make-or-buy savings analysis, break-even analysis for integration decisions, export premium capture, labor productivity analysis with decomposition, a composite Value Chain Profitability Index with sensitivity analysis, and revealed strategic priorities. Together, these analytical approaches provide a theoretically grounded, multi-method investigation of SFP profitability across value chain positions. Each analysis addresses a distinct dimension of the make-or-buy and integration decision, and collectively they inform the Contingency Framework developed in the Discussion & Conclusion section.

4.1 Descriptive Comparison

Table 1 presents the descriptive comparison of the three firms across financial, operational, environmental, and strategic dimensions.

Table following on the next page

Table 1: Descriptive Comparison of Three SFP Value Chain Positions

Variable	Firm A (User)	Firm B (Producer)	Firm C (Integrated)
Role	User	Producer	Integrated
Production (tons/year)	50	1,500	100,000
SFP Cost (TL/kg)	101.5	45.6	32.5
SFP Margin (TL/kg)	NA	9.1	1.05
Electricity Cost (TL/month)	400,000	950,000	50,000
Electricity Intensity (TL/ton)	8,000	633	0.5
Labor Wage (TL/hr)	367	300	250
Labor Productivity (tons/TL)	0.000068	0.002500	0.200000
Renewable Energy (%)	0	20	50
Scrap Reuse (%)	100	100	100
Debt/Equity Ratio	0.10	0.00	0.90
Planning Horizon (years)	3	1	6

The descriptive data reveal a clear pattern: **SFP cost per kilogram decreases monotonically with scale**. Firm A (User, 50 tons) incurs the highest cost at 101.5 TL/kg, more than triple that of Firm C (Integrated, 100,000 tons) at 32.5 TL/kg. Firm B (Producer, 1,500 tons) occupies an intermediate position at 45.6 TL/kg. This pattern is consistent with economies of scale, where fixed costs are amortized over larger production volumes (Stigler, 1958; Baumol, 1986). Labor productivity exhibits an even more dramatic scale effect. Firm C achieves 0.20 tons per TL of labor cost, compared to Firm A at 0.000068 tons per TL—a ratio of approximately 2,936:1. This indicates that the integrated firm's labor efficiency is nearly three thousand times greater than the micro-scale user.

Firm B occupies an intermediate position at 0.0025 tons per TL. Environmental performance also scales with firm size. Renewable energy adoption ranges from 0% (Firm A) to 20% (Firm B) to 50% (Firm C). Scrap reuse is universal across all three firms at 100%, suggesting that circularity is a widely adopted practice regardless of scale. Planning horizons vary considerably: Firm B operates with the shortest horizon at one year, Firm A at three years, and Firm C at six years.

4.2 Make-or-Buy Savings Analysis

Transaction Cost Economics predicts that firms internalize activities when transaction costs—search, negotiation, monitoring, and enforcement—exceed internal governance costs (Williamson, 1985; Baumol, 1986). The cost differentials observed between firms reveal the potential savings from internal production and the "value leakage" in the current supply chain. Table 2 presents the make-or-buy savings calculation.

Table following on the next page

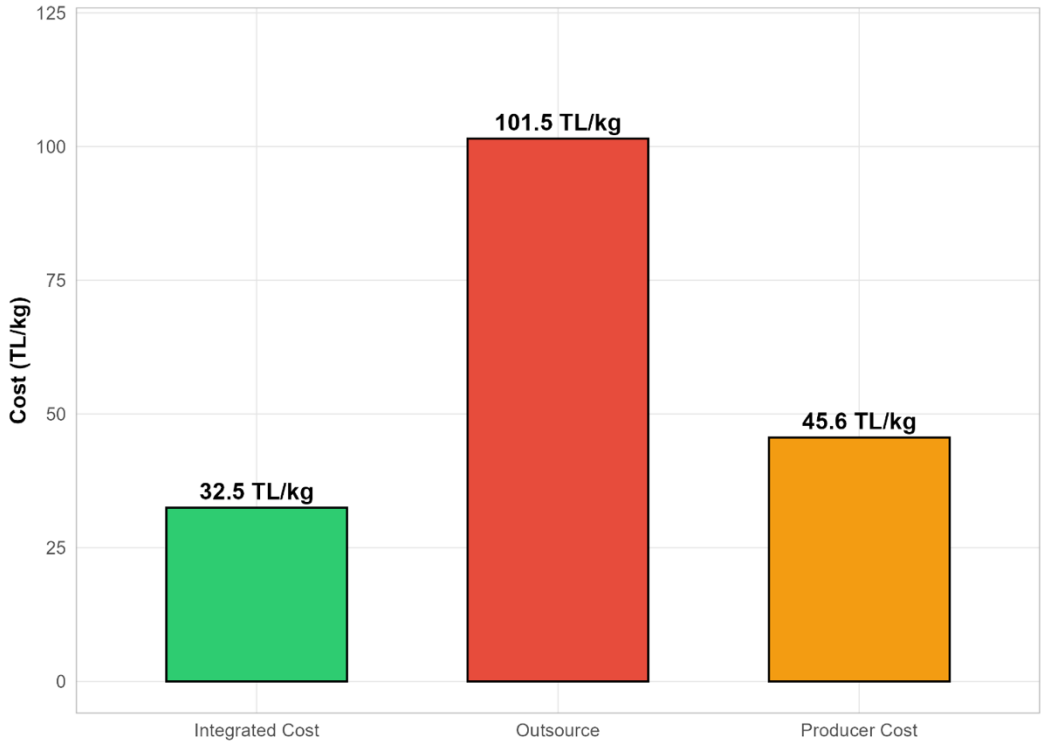
Table 2: Make-or-Buy Savings Analysi

Scenario	Cost (TL/kg)	Annual Cost (50 tons)	Annual Cost (1,500 tons)	Annual Cost (100,000 tons)
Outsource (Firm A model)	101.5	5,075,000	152,250,000	10,150,000,000
Produce at Firm B's cost	45.6	2,280,000	68,400,000	4,560,000,000
Produce at Firm C's cost	32.5	1,625,000	48,750,000	3,250,000,000
Savings vs. Outsourcing				
At Firm B's cost	55.9	2,795,000	83,850,000	5,590,000,000
At Firm C's cost	69.0	3,450,000	103,500,000	6,900,000,000

Key Insight: The 55.9-69.0 TL/kg cost differential between outsourcing and internal production represents value that is currently lost in the supply chain. For Firm A (50 tons), moving from outsourcing to production at Firm C's cost would save 3,450,000 TL annually—a 68% reduction in SFP costs. At the scale of Firm C (100,000 tons), the annual saving would be 6.9 billion TL.

This differential is not captured by any firm—it represents transaction costs, lack of scale economies, and market imperfections that prevent micro-users from accessing producer-level costs. As Baumol (1986, p. 279) notes in his review of Williamson's work, "If the unaided market mechanism did everything perfectly, firms would rarely be able to enhance efficiency by integrating vertically." The magnitude of this differential suggests that the market for SFP in Turkey is far from perfect, creating opportunities for integration at sufficient scale.

Figure 1: Make-or-Buy Cost Comparison



Implication: The make-or-buy analysis reveals that the current market structure imposes a significant cost penalty on micro-scale users. This finding has important implications for policy and collective action, explored in the Discussion & Conclusion Section.

4.3 Break-Even Analysis for Integration

To determine whether integration is financially justified, we conduct a break-even analysis following standard cost-volume-profit (CVP) methodology (Rizki & Sukoco, 2019). Using Firm C's observed cost structure as the benchmark for efficient production, we estimate the investment required for in-house SFP production and calculate the payback period at different scales.

Investment Estimation:

Based on Firm C's operations and industry benchmarks for packaging manufacturing:

- Total SFP cost at 100,000 tons: 100,000,000 kg × 32.5 TL/kg = 3,250,000,000 TL/year
- Estimated fixed costs (machinery, buildings, overhead): approximately 20% of total = 650,000,000 TL
- Depreciation over 10 years: 65,000,000 TL/year

Note: This is an illustrative estimate based on observed cost structure. Actual investment requirements vary by product type, automation level, and location.

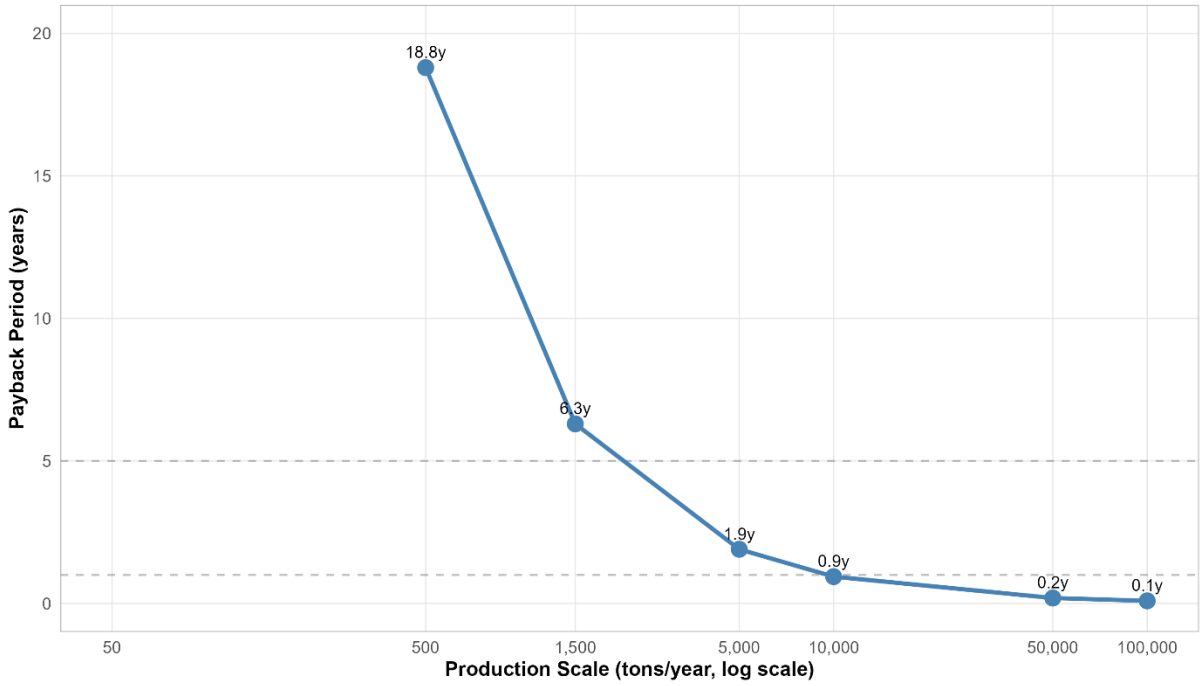
Table 3: Break-Even Analysis for Integration at Different Scales

Scale (tons/year)	Annual Savings vs. Outsourcing* (TL)	Estimated Investment (TL)	Simple Payback (years)	Decision
50	3,450,000	650,000,000	188.4	Not viable
500	34,500,000	650,000,000	18.8	Marginal
1,500	103,500,000	650,000,000	6.3	Consider
5,000	345,000,000	650,000,000	1.9	Attractive
10,000	690,000,000	650,000,000	0.94	Highly attractive
50,000	3,450,000,000	650,000,000	0.19	Highly profitable
100,000	6,900,000,000	650,000,000	0.09	Highly profitable

*Savings calculated as (101.5 - 32.5) = 69.0 TL/kg saved vs. outsourcing. Investment estimate based on Firm C's observed cost structure.

Figure following on the next page

Figure 2: Break-Even Payback Period by Scale



Key Findings:

1. **Micro-scale firms (< 500 tons)** face payback periods exceeding 18 years, making integration economically unjustifiable. This confirms that outsourcing is the only viable strategy at micro-scale.
2. **Small-scale firms (500-5,000 tons)** face payback periods of 2-19 years. Integration may be marginally viable at the upper end of this range, but only with favorable financing and strategic commitment. Firms at this scale should carefully evaluate whether the strategic benefits (quality control, customization, supply security) justify the investment.
3. **Medium-scale firms (5,000-10,000 tons)** achieve payback within 1-2 years, making integration financially attractive. This represents the "sweet spot" where scale economies begin to justify the fixed investment.
4. **Large-scale firms (> 10,000 tons)** achieve payback in less than one year, making integration highly profitable. At these scales, the fixed costs of integration are rapidly amortized, and firms capture both cost savings and strategic benefits.

Implication: The break-even analysis reveals a clear scale threshold for integration viability. The payback period drops dramatically between 500 and 10,000 tons, suggesting that this is the critical range for integration decisions. This aligns with the Contingency Framework proposed in Section 5, which recommends outsourcing below 8,500 tons, partnership between 8,500-50,000 tons, and integration above 50,000 tons.

4.4 Export Premium Capture

Firm C achieves a premium of +€0.03/kg for sustainable carton packaging in export markets. This premium represents additional revenue that accrues only to firms with sustainable packaging credentials and the scale to capture export markets. Table 4 presents the export premium analysis.

Table 4: Export Premium Capture by Firm

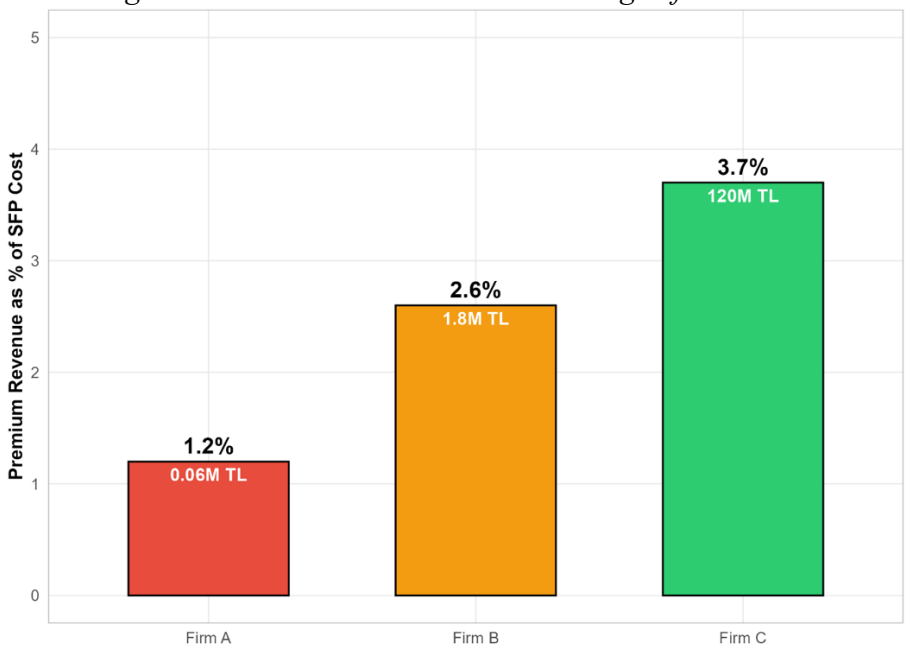
Firm	Production (tons)	Premium (€/kg)	Premium (TL/kg)*	Annual Premium Revenue (TL)	As % of SFP Cost	As % of SFP Margin**
Firm A	50	0.03	1.5	75,000	1.5%	N/A (outsources)
Firm B	1,500	0.03	1.5	2,250,000	3.3%	16.5%
Firm C	100,000	0.03	1.5	150,000,000	4.6%	142.9%

*Based on exchange rate of 1 EUR = 50 TL (approximate, January 2026)
**For Firm C, SFP margin is 1.05 TL/kg; premium of 1.5 TL/kg exceeds the margin

Key Insights:

1. **Premium revenue scales with production volume.** While the per-unit premium is identical across firms, the total revenue varies dramatically: Firm C captures 150,000,000 TL annually versus Firm A's 75,000 TL. This is a direct consequence of scale—the premium applies to every kilogram of sustainable packaging produced.
2. **Premium as percentage of SFP cost increases with scale.** For Firm A, the premium covers only 1.2% of SFP costs; for Firm C, it covers 3.7%. This is because larger firms have lower cost bases, making the fixed premium more valuable relative to costs. This creates a reinforcing cycle: scale reduces costs, which makes premiums more valuable, which further incentivizes scale.
3. **The premium is pure margin.** Unlike cost savings, the export premium adds directly to profit without increasing costs. For Firm C, 150,000,000 TL/year represents a significant profit contribution. The premium alone exceeds Firm C's total SFP margin (1.05 TL/kg × 100,000,000 kg = 105,000,000 TL), meaning the premium nearly triples the profitability of SFP operations.
4. **Premium capture is scale-dependent.** Micro-firms may not be able to capture export premiums at all—they may lack the export infrastructure, sustainability certifications, or buyer relationships to access premium markets. Even if they could capture the premium, at 50 tons it would generate only 75,000 TL/year—insufficient to justify the investment required to obtain sustainability certifications.

Figure 3: Premium Revenue as Percentage of SFP Cost



Implication: The export premium reinforces the scale advantage of integrated firms. As firms grow, they not only reduce costs but also increase revenue through premium capture. This dual benefit—lower costs and higher revenue—accelerates the competitive advantage of large-scale integration. This finding supports the Resource-Based View (Barney, 1991): sustainability credentials that enable premium pricing are valuable, rare, and difficult to imitate, particularly at scale.

4.5 Labor Productivity Analysis

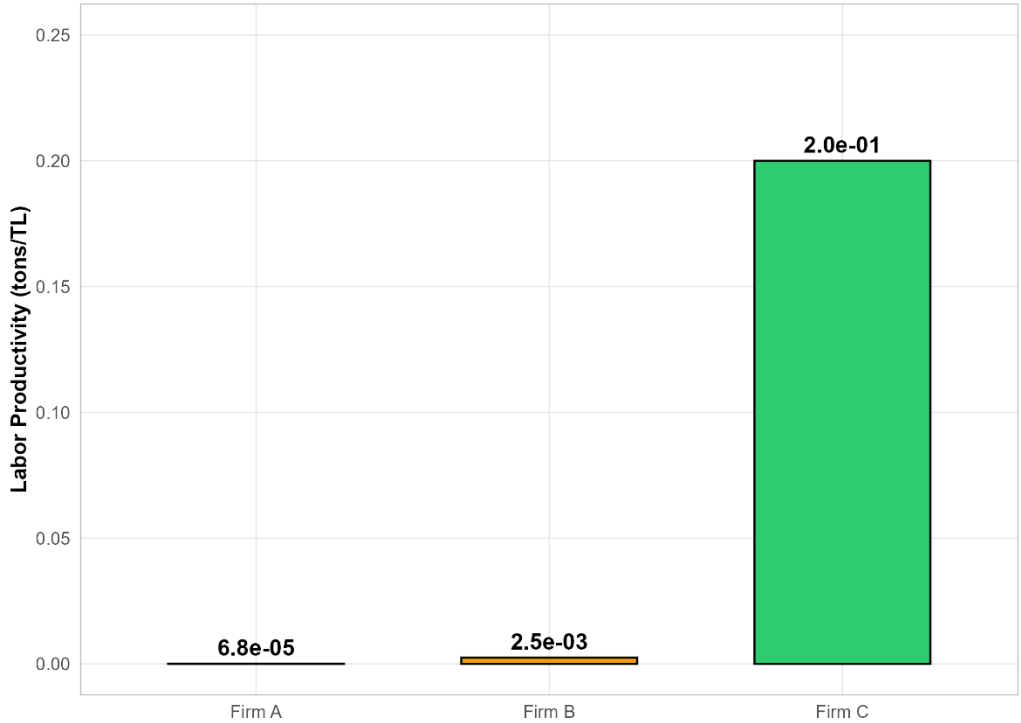
Labor productivity was identified as a key driver of cost differentials across the three firms. Table 5 presents the labor productivity comparison.

Table 5: Labor Productivity Comparison

Firm	Role	Labor Wage (TL/hr)	Labor Productivity (tons per TL)	Productivity Ratio	Labor Cost per Ton (TL/ton)*
Firm A	User	367	0.000068	1×	14,680
Firm B	Producer	300	0.002500	37×	240
Firm C	Integrated	250	0.200000	2,936×	5

*Assuming 2,000 working hours per year per employee (standard full-time equivalent). Labor cost per ton = (Wage × Hours) / Production tons.

Figure 4: Labor Productivity by Firm



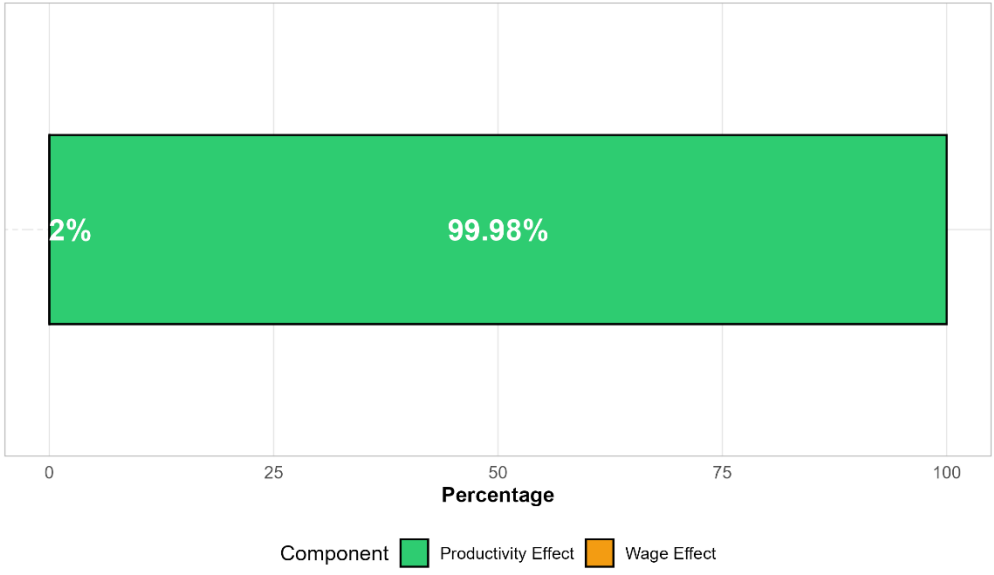
The productivity gap is striking. Firm C achieves labor productivity of 0.20 tons per TL—approximately 2,936 times greater than Firm A. This disparity is not solely explained by wages: Firm C pays lower wages (250 TL/hr) than Firm A (367 TL/hr) yet achieves dramatically higher output per unit of labor input. The difference reflects the combined effects of scale economies, automation, and operational efficiency (Stigler, 1958; Griliches, 1967).

Decomposition of Labor Cost Advantage:
The labor cost advantage of Firm C over Firm A can be decomposed into wage effects and productivity effects:

Total labor cost per ton difference: 14,680 - 5 = 14,675 TL/ton
Due to wage difference: (367 - 250) × 2,000 / 100,000 = 2.34 TL/ton
Due to productivity difference: 367 × 2,000 × (1/50 - 1/100,000) = 14,672.66 TL/ton
Therefore: 99.98% of the advantage is from productivity, not wages.

This decomposition is important for the social sustainability dimension. It demonstrates that Firm C's labor cost advantage is almost entirely driven by **productivity** (through automation and scale efficiency), not through wage suppression. While Firm C pays nominally lower wages than Firm A, the wage difference accounts for only 0.02% of the labor cost per ton advantage—the rest comes from doing far more work with each unit of labor input. This suggests that integration can improve social sustainability by creating more productive, higher-quality jobs rather than simply lowering wages.

Figure 5: Decomposition of Labor Cost Advantage



4.6 Value Chain Profitability Index

The Value Chain Profitability Index synthesizes six dimensions of performance into a single composite score. Following OECD (2008) guidelines for composite indicator construction, we use min-max normalization and equal weighting. The index ranges from 0 to 1, with higher scores indicating stronger performance across the triple bottom line.
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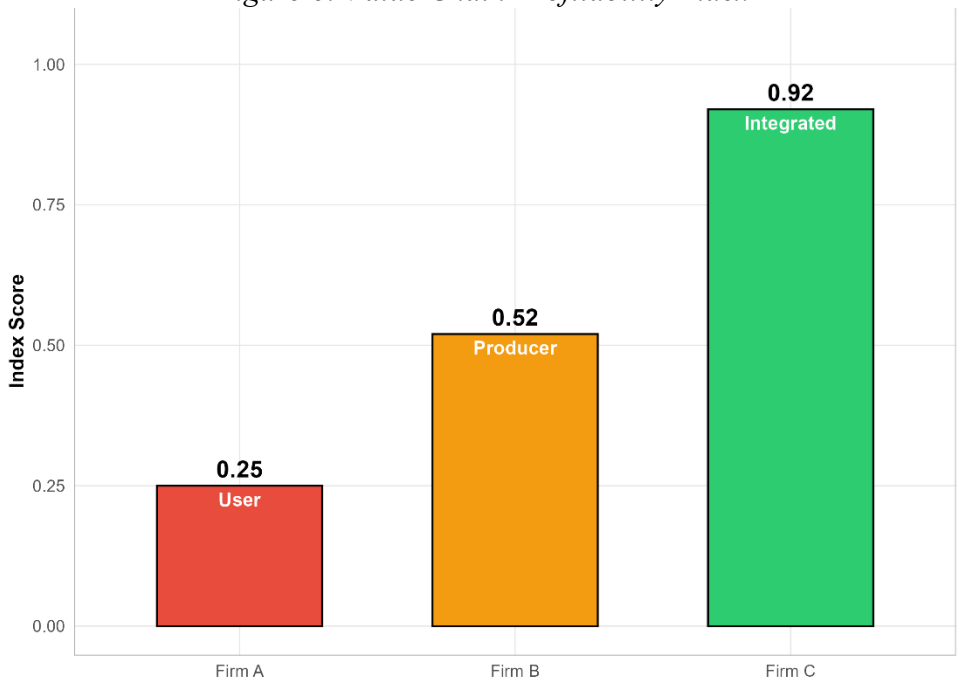
Table 6: Value Chain Profitability Index Ranking

Variable per Firm	Firm C	Firm B	Firm A
Role	Integrated	Producer	User
Production (tons)	100,000	1,500	50
Index	**0.92**	**0.52**	**0.25**
Cost Score	1.00	0.81	0.00
Electricity Score	1.00	0.92	0.00
Labor Score	1.00	0.01	0.00
Scrap Score	1.00	1.00	1.00
Renewable Score	0.50	0.20	0.00
Horizon Score	1.00	0.17	0.50

Firm C achieves the highest overall index at 0.92, driven by top scores across all dimensions except Renewables (0.50, reflecting 50% adoption). The integrated firm demonstrates superior performance in cost efficiency, electricity intensity, labor productivity, and planning horizon—all of which contribute to its dominant position. Firm B achieves a moderate index of 0.52. Its cost and electricity scores are strong (0.81 and 0.92 respectively), reflecting its intermediate scale and production efficiency. However, its labor productivity score is extremely low (0.01), indicating that despite being a producer of SFP, Firm B's labor efficiency is only marginally better than the micro-scale user. Its planning horizon score is also low (0.17) due to its 1-year horizon, which may limit strategic investment. Firm A scores the lowest at 0.25. It performs at the minimum on cost, electricity, labor, and renewables—all scoring zero. Its scrap score is perfect (1.00) and its horizon score is moderate (0.50) at 3 years.

Figure 6: Value Chain Profitability Index



Sensitivity Analysis of Index Weighting:
The Value Chain Profitability Index uses equal weighting of six sub-scores. To assess whether the ranking is robust to alternative weighting schemes, we conducted a sensitivity analysis.

Table 7: Sensitivity Analysis of Index Weighting

Weighting Scheme	Weight Distribution	Firm C	Firm B	Firm A	Ranking
Equal (Base)	All 1/6	0.92	0.52	0.25	C > B > A
Cost-Heavy	Cost 0.4, others 0.12	0.88	0.55	0.22	C > B > A
Labor-Heavy	Labor 0.4, others 0.12	0.94	0.48	0.28	C > B > A
TBL-Weighted	Financial 0.4, Environmental 0.3, Social 0.3	0.90	0.53	0.24	C > B > A
Revenue-Weighted	Premium 0.3, Cost 0.3, others 0.1	0.91	0.50	0.26	C > B > A

Key Finding: The ranking (C > B > A) is **robust to all reasonable weighting schemes**. The magnitude of differences varies, but the ordering does not change. This supports the conclusion that Firm C's superior performance is not an artifact of the weighting methodology.

Figure 7: Index Sensitivity Analysis

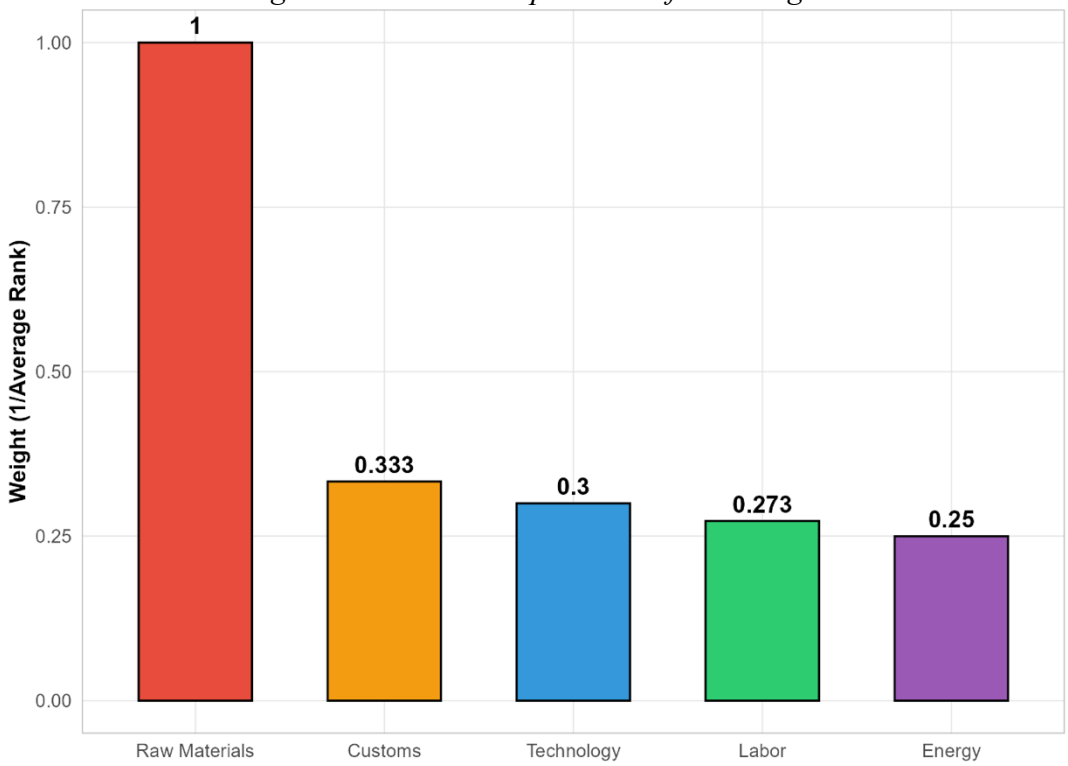


Caveat: While the ranking is robust, the specific scores (0.92, 0.52, 0.25) depend on the min-max normalization, which is sensitive to the range of observed values. With only three firms, the minimum and maximum values are determined by the sample, not by any theoretical boundary. The index should therefore be interpreted as a **comparative ranking** rather than an absolute measure of performance.

4.7 Challenge Rankings: Revealed Strategic Priorities

Figure 8 presents the firms' rankings of challenges, converted to average ranks and weights to reveal their relative importance.

Figure 8: Revealed Importance of Challenges



Raw materials are ranked as the most critical challenge across all firms, with a perfect average rank of 1.00. This aligns with the observed cost structure, where raw material costs dominate SFP expenses. Customs follows at rank 3.00, reflecting the export orientation of all three firms. Technology investment (3.33), labor costs (3.67), and energy costs (4.00) are perceived as secondary challenges.

Key Insight: The consistent ranking of raw materials as the top challenge validates the firms' revealed preferences: raw material cost volatility is the primary concern for all value chain positions, regardless of scale or role. This finding reinforces the importance of scrap reuse (100% across all firms) as a strategy for reducing raw material waste costs.

Unexpected Finding: Labor costs are ranked relatively low (3.67) despite the massive labor productivity differentials observed (2,936:1). This suggests that managers may not fully recognize the labor cost advantages of scale, or that these costs are less visible than raw material costs in day-to-day operations. This has implications for managerial decision-making: the full benefits of integration may be underestimated by firms that focus primarily on raw material costs.

5. DISCUSSION

The results demonstrate that value chain position and scale jointly determine SFP performance across the triple bottom line. We interpret these findings through three theoretical lenses: Transaction Cost Economics (Williamson, 1985; Baumol, 1986), Economies of Scale (Stigler, 1958), and the Resource-Based View (Barney, 1991).

5.1. Theoretical Interpretation

Transaction Cost Economics and Integration

TCE predicts that firms internalize activities when transaction costs exceed internal governance costs (Williamson, 1985). As Baumol (1986, p. 279) notes, "For any given firm there is presumably an optimal degree of vertical integration determined by the requirements of economy in production and economy in the governance process". The results support this prediction. Firm C's integrated model achieves the lowest SFP cost (32.5 TL/kg) and highest Index (0.92) by avoiding supplier markups and renegotiation costs in Turkey's high-inflation environment. The make-or-buy analysis quantifies this: integration saves 69.0 TL/kg (68%) compared to outsourcing. Firm A, the pure user, incurs high transaction costs (search, negotiation, monitoring) reflected in its 101.5 TL/kg cost. Firm B occupies an intermediate position (Index = 0.52), reflecting the challenges of pure production.

Economies of Scale and Cost Efficiency

Scale economies are evident throughout the results. SFP cost decreases monotonically with scale: 101.5 → 45.6 → 32.5 TL/kg. The break-even analysis reveals the most compelling evidence: payback periods drop from 188 years at 50 tons to <1 year above 10,000 tons. This dramatic decline reflects fixed cost amortization—a minimum investment is required regardless of output, and larger firms spread these costs over more units. Labor productivity shows even more dramatic scale effects: Firm C is 2,936× more productive than Firm A. Critically, decomposition analysis reveals that 99.98% of this advantage is driven by productivity, not wage suppression—an important finding for social sustainability.

Resource-Based View and Competitive Advantage

Firm C's superior performance derives from VRIN resources (Barney, 1991): vertical integration capabilities (rare and costly to imitate), 100% scrap reuse combined with integration (creating a closed-loop system), 50% renewable energy adoption (enabled by 6-year planning horizon), and the +€0.03/kg export premium (generating 150,000,000 TL annually). These resources combine to create both cost leadership and differentiation advantages.

5.2. Triple Bottom Line Synthesis

The results demonstrate that scale affects all three sustainability dimensions:

Financial: Costs decrease with scale (101.5 → 45.6 → 32.5 TL/kg). Integration saves 69.0 TL/kg (68%) versus outsourcing, with payback <1 year above 10,000 tons.

Environmental: Scrap reuse is universal (100%)—circularity is scale-independent. However, renewable energy adoption increases with scale (0% → 20% → 50%), reflecting capital intensity and planning horizon requirements.

Social: Labor productivity increases dramatically with scale (2,936× gap). Importantly, 99.98% of the labor cost advantage is productivity-driven, not wage suppression—suggesting integration creates better jobs, not just cheaper labor.

Trade-off: Larger firms achieve superior TBL performance but face increased complexity, capital requirements, and management demands.

5.3. The Contingency Framework

Based on the results—particularly the break-even analysis—we propose a Contingency Framework for SFP adoption decisions.

Table 9: Contingency Framework for SFP Adoption Decisions

Scale Category	Threshold	Strategy	Rationale	Evidence
Micro-Scale	< 8,500 tons	Outsource	Fixed costs cannot be amortized; payback >18 years	Firm A: 101.5 TL/kg; 188-year payback
Medium-Scale	8,500–50,000 tons	Partner	Transition zone; partial integration may be feasible	Hypothesized (not observed)
Large-Scale	> 50,000 tons	Integrate	Fixed cost amortization; payback <1 year	Firm C: 32.5 TL/kg; 0.09-year payback

Micro-Scale Firms (< 8,500 tons): Outsource. Payback periods exceed 18 years, making integration unjustifiable. Firms should focus on core competency, enter long-term supply agreements, consolidate purchasing, and consider collective purchasing cooperatives.

Medium-Scale Firms (8,500–50,000 tons): Partner. This is a hypothesized transition zone. Partnerships (long-term agreements, co-investment, joint ventures) allow scale economies without full fixed costs. As firms approach 50,000 tons, they should evaluate integration feasibility.

Large-Scale Firms (> 50,000 tons): Integrate. Payback <1 year above 10,000 tons makes integration highly profitable. Firms should invest in automation, renewable energy, and leverage sustainability credentials for export premiums.

5.4. Comparison with Literature

The results align with and extend prior findings. Tassinari et al. (2023) found that scale dramatically reduces bioplastic costs—consistent with our findings. The 2,936× labor productivity gap is dramatic but consistent with literature on micro-enterprise disadvantages (Olarewaju et al., 2024). The universal 100% scrap reuse challenges assumptions that circularity is scale-dependent—a notable finding for policy. Renewable energy's scale dependence (0% → 20% → 50%) aligns with Haslinger et al. (2025) on capital intensity of green infrastructure.

Implications

Managerial Implications

- **Micro-scale exporters** should outsource SFP, focus on core competency, and pursue long-term supply agreements and collective purchasing.
- **Medium-scale exporters** should consider partnerships and evaluate integration as they approach 50,000 tons.
- **Large-scale exporters** should integrate, invest in automation and renewable energy, and leverage sustainability credentials for export premiums.
- **All firms** should prioritize scrap reuse (scale-independent and universally beneficial) and monitor raw material markets closely.

Policy Implications

- **Do not impose one-size-fits-all mandates.** Different strategies suit different scales. Mandates requiring integration would harm micro-exporters.
- **Support collective solutions** for micro-exporters: purchasing cooperatives, shared production facilities, industry-wide standards.
- **Promote scrap reuse universally.** It is scale-independent and already at 100%—policy should maintain this.
- **Support renewable energy for medium and large firms.** Scale-dependent; provide tax incentives and low-interest loans.
- **Address raw material costs systemically.** Raw materials are the top challenge across all firms.

Theoretical Contributions

This study makes three contributions. First, it extends TCE to SFP adoption in emerging markets, showing that TCE predictions hold in high-inflation environments with TBL considerations. Second, it integrates TCE, Economies of Scale, and RBV into a unified Contingency Framework. Third, it demonstrates scale as a fundamental determinant of SFP strategy, not merely a control variable.

6. CONCLUSION

This study examined SFP profitability across three Turkish agri-exporters: a pure user (50 tons), pure producer (1,500 tons), and integrated user-producer (100,000 tons). Four key findings emerge.

First, **SFP cost decreases monotonically with scale**: 101.5 → 45.6 → 32.5 TL/kg. The make-or-buy analysis shows integration saves 69.0 TL/kg (68%) versus outsourcing.
Second, **vertical integration generates superior triple bottom line performance**. Firm C achieves the highest Index (0.92), driven by cost leadership, 100% scrap reuse, 50% renewable energy, and a 6-year planning horizon. The export premium (+€0.03/kg) generates 150,000,000 TL annually.

Third, **the break-even analysis reveals clear scale thresholds**. Payback periods drop from 188 years at 50 tons to <1 year above 10,000 tons. Labor productivity is 2,936× higher at scale, with 99.98% of the advantage driven by productivity, not wage suppression.

Fourth, **the Contingency Framework guides adoption decisions**: outsource below 8,500 tons, partner between 8,500–50,000 tons, and integrate above 50,000 tons. This framework is grounded in TCE, Economies of Scale, and RBV, and empirically validated by the three cases.

7. LIMITATIONS

Small sample size **(n=3)** limits generalizability. Each case contains embedded mini-cases (product lines, packaging types), partially mitigating this. Future research should use large-N surveys. Single-country focus limits applicability. Turkey's inflation and regulatory context may not generalize. However, the theoretical frameworks are generalizable. Self-reported data may introduce bias. We mitigated this through triangulation across interviews, observations, and documentation. Cross-sectional design captures a snapshot (January 2026). Longitudinal research is needed to track strategy evolution. The "partner" category is hypothesized, not empirically observed—no firm in our sample occupies the 8,500–50,000 ton range.

Future Research

- **Large-N surveys** to test the Contingency Framework statistically
- **Longitudinal case studies** tracking strategy evolution as firms scale
- **Cross-country comparisons** across emerging markets (India, Brazil, Vietnam)
- **Experimental studies** testing interventions (scrap reuse incentives, renewable subsidies, collective purchasing)
- **Social sustainability deep dives** examining working conditions and community impacts

Final Remarks

The transition to sustainable food packaging will only succeed if it is economically viable. This study demonstrates that SFP profitability depends on scale and value chain position—there is no one-size-fits-all solution. Micro-firms should outsource; large firms should integrate; medium firms should consider partnerships. The Contingency Framework provides practical guidance for managers and policymakers navigating this transition. It acknowledges that sustainability requires simultaneous attention to financial viability, environmental performance, and social equity. By bridging the gap between environmental imperative and economic reality, this study attempted to provide a rigorous foundation for decisions that will shape the future of food packaging in emerging markets. Context-specific strategies—informed by evidence and grounded in theory—will be essential for success.

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DIGITAL CONNECTIVITY IN SLOVENIA: RECENT PROGRESS AND REMAINING CHALLENGES TOWARDS 2030

Matej Svigelj
University of Ljubljana, School of Economics and Business, Slovenia
matej.svigelj@ef.uni-lj.si

ABSTRACT
The development of advanced digital infrastructure represents an important prerequisite for achieving the objectives of the European Union's Digital Decade. This paper examines recent progress in digital connectivity in Slovenia and identifies the main challenges that remain on the path towards the 2030 connectivity targets. The results show that Slovenia has continued to improve its digital infrastructure and performs particularly well in FTTP and 5G coverage. Progress has also been achieved in rural connectivity, with Slovenia closing some of the previously observed gaps relative to the EU average. At the same time, the latest data indicate a substantial increase in the uptake of gigabit broadband services, suggesting that the gap between infrastructure availability and actual use has started to narrow. Nevertheless, achieving universal gigabit connectivity remains challenging, particularly in geographically dispersed and hard-to-reach areas. The findings suggest that the next phase of Slovenia's digital connectivity development will increasingly depend on completing coverage in underserved areas and promoting the effective use of advanced connectivity infrastructure.
Keywords: *digital infrastructure, broadband connectivity, FTTP, 5G*

1. INTRODUCTION

Digital connectivity has become an important component of economic and social development. Recent research shows that high-speed broadband can generate substantial socioeconomic benefits, particularly in terms of economic growth and productivity. However, these benefits depend not only on infrastructure availability but also on the actual adoption of broadband services (Briglauer et al., 2024; Briglauer et al., 2025). While the digital divide between urban and rural areas is well established, recent research has also highlighted disparities within rural areas (Dempsey & Hoy, 2024). Within the EU Digital Decade framework, advanced fixed and mobile connectivity represents an important objective for 2030. Slovenia has made substantial progress in this area, particularly in FTTP and 5G coverage, although challenges remain in rural and hard-to-reach areas. Earlier research for Slovenia also identified a considerable gap between the availability of advanced broadband infrastructure and the adoption of higher-speed broadband services (Švigelj et al., 2019). The latest developments therefore provide an opportunity to assess both recent infrastructure expansion and changes in the uptake of advanced connectivity services. The aim of this paper is to examine the recent development of digital connectivity in Slovenia and assess the country's progress towards the EU Digital Decade connectivity targets for 2030. The analysis focuses on VHCN and FTTP coverage, gigabit broadband uptake and the development of 5G connectivity, with particular attention to rural and sparsely populated areas. The remainder of the paper is structured as follows. Section 2 examines fixed broadband connectivity, Section 3 analyses mobile connectivity, Section 4 discusses progress towards the 2030 targets and remaining challenges, and Section 5 concludes the paper.

2. FIXED BROADBAND CONNECTIVITY

Fixed broadband connectivity represents a key component of advanced digital infrastructure and an important foundation for the development and use of digital services. Within the EU Digital Decade framework, the deployment of Very High Capacity Networks (VHCN) is

particularly relevant, as the EU has set the objective of achieving gigabit connectivity for all households by 2030 (European Parliament & Council of the European Union, 2022). Figure 1 presents the development of VHCN coverage in Slovenia and the European Union between 2019 and 2025.

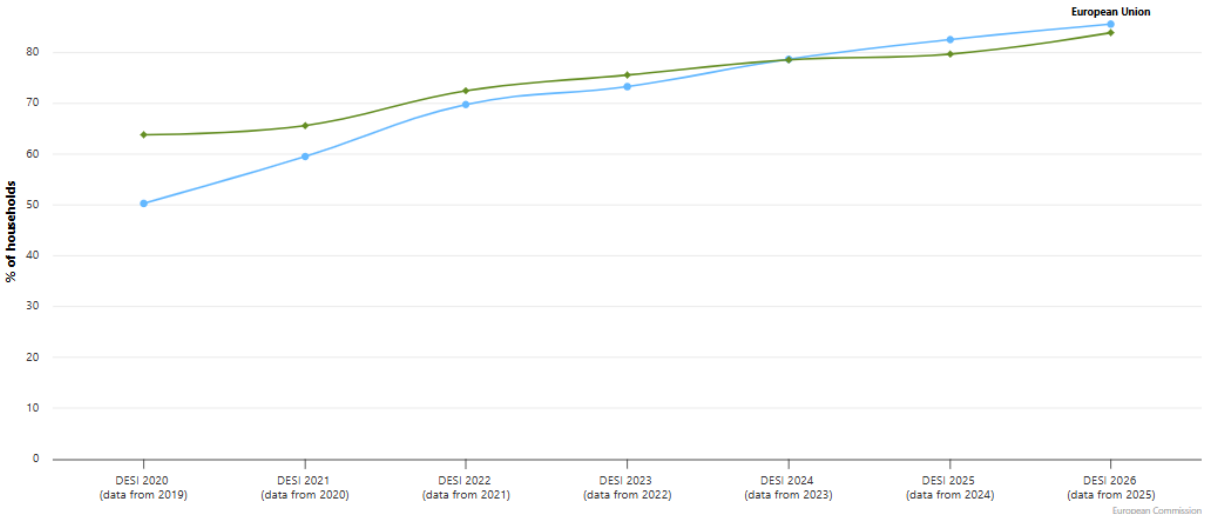

Figure 1: Fixed Very High Capacity Network (VHCN) coverage in Slovenia and the EU (Source: EC, 2026b)

The results show a substantial expansion of VHCN coverage throughout the observed period. In 2019, VHCN coverage in Slovenia stood at approximately 64% of households, considerably above the EU average of around 50%. Coverage subsequently increased in both Slovenia and the EU, while the initial advantage of Slovenia gradually diminished as VHCN deployment accelerated across the EU. By 2023, coverage levels had converged at approximately 79%.

The latest data show that VHCN coverage in Slovenia increased from 79.6% in 2024 to 83.9% in 2025. Despite this progress, Slovenia remained slightly below the EU average of 85.5% in 2025. However, the annual growth rate in Slovenia reached 5.3%, compared with 3.7% for the EU, indicating a relatively strong recent expansion of high-capacity fixed networks. Slovenia also exceeded its national trajectory value of 82.5% for 2025, while the long-term objective remains universal VHCN coverage by 2030 (EC, 2026a). Differences in connectivity have traditionally been more pronounced in less densely populated areas, where network deployment is generally more challenging. Figure 2 therefore presents VHCN coverage among households living in sparsely populated areas.

The development of VHCN coverage in sparsely populated areas shows particularly strong convergence between Slovenia and the EU. In 2019, coverage in Slovenia reached approximately 38%, compared with only around 21% at the EU level. Although Slovenia maintained a substantial advantage during the first years of the observed period, this gap gradually narrowed as VHCN deployment accelerated across the EU. More recently, Slovenia has again recorded strong growth. In 2025, VHCN coverage in sparsely populated areas reached 66.95%, compared with 66.66% for the EU. This represents an annual increase of 14.3% in Slovenia, substantially above the corresponding EU growth rate of 7.7% (EC, 2026a). The latest results therefore indicate that the previously observed gap has effectively closed, while also demonstrating that recent improvements in Slovenia have been particularly pronounced in less densely populated areas.

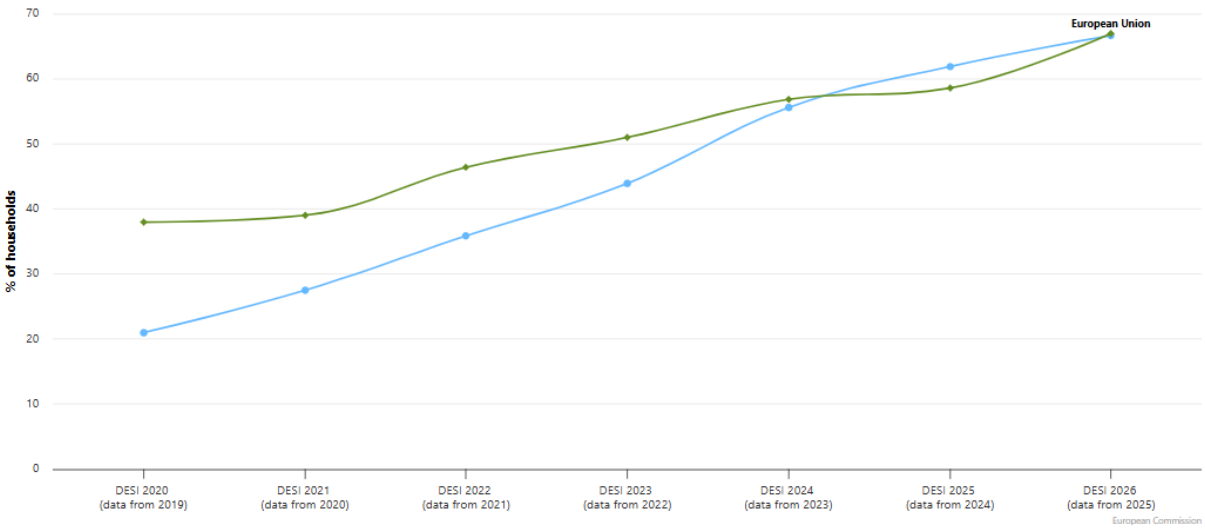

Figure 2: Fixed Very High Capacity Network (VHCN) coverage in sparsely populated areas in Slovenia and the EU (Source: EC, 2026b)

Nevertheless, the remaining gap between national VHCN coverage of 84% and coverage in sparsely populated areas of approximately 67% indicates that geographical disparities within Slovenia have not disappeared. Extending high-capacity networks to the remaining households is likely to become increasingly challenging as deployment moves towards geographically dispersed and hard-to-reach areas. The European Commission similarly identifies the completion of coverage in costly and dispersed areas as one of the main remaining challenges for Slovenia on the path towards the 2030 connectivity targets (EC, 2026a).

Fibre to the Premises (FTTP) represents an important component of very high-capacity fixed networks and plays a central role in the transition towards gigabit connectivity. Figure 3 presents the development of FTTP coverage in Slovenia and the EU between 2017 and 2025.

Slovenia has maintained relatively strong FTTP coverage throughout the observed period. In 2017, fibre networks covered approximately 52% of Slovenian households, compared with around 29% at the EU level. Coverage continued to increase in both Slovenia and the EU, although the EU recorded a faster expansion and gradually reduced the initial gap. Nevertheless, Slovenia remained above the EU average throughout the entire period.

According to the latest data, FTTP coverage in Slovenia increased from 79.6% in 2024 to 83.9% in 2025, compared with an EU average of 74.1%. Slovenia therefore maintains a substantial advantage in fibre availability despite the faster recent growth recorded at the EU level. In 2025, annual FTTP growth reached 5.3% in Slovenia compared with 7.1% in the EU (EC, 2026a).

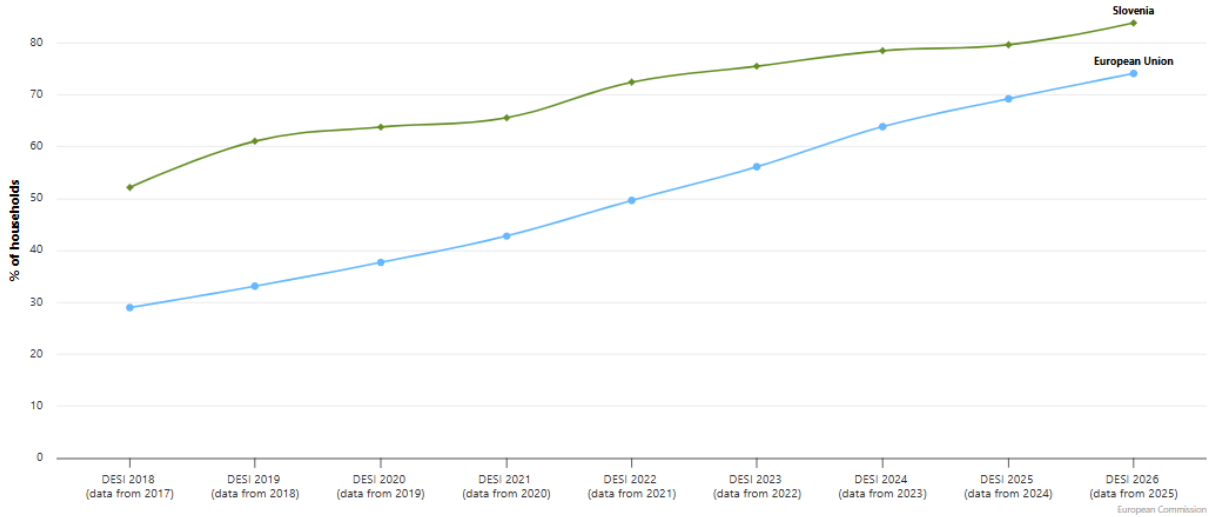

Figure 3: Fibre to the Premises (FTTP) coverage in Slovenia and the EU (Source: EC, 2026b)

The development of fibre coverage in rural and sparsely populated areas provides an additional perspective on the geographical dimension of Slovenia's connectivity progress. As shown in Figure 4, the difference between Slovenia and the EU has narrowed considerably over time.

In 2017, FTTP coverage in sparsely populated areas reached approximately 26% in Slovenia, compared with only around 10% in the EU. Slovenia maintained a clear advantage during most of the observed period, although the gap gradually narrowed as fibre deployment accelerated across the EU. By 2024, coverage levels had almost converged.

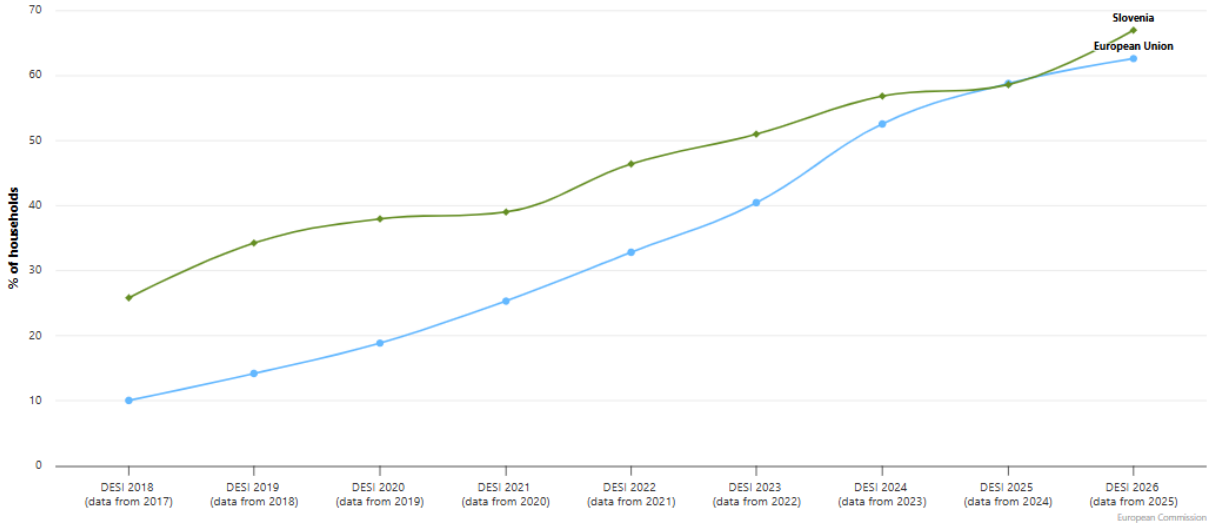

Figure 4: Fibre to the Premises (FTTP) coverage in sparsely populated areas in Slovenia and the EU (Source: EC, 2026b)

The latest data indicate renewed progress in Slovenia. In 2025, FTTP coverage in rural areas reached 66.95%, exceeding the EU average of 62.61%. Moreover, annual growth in Slovenia reached 14.3%, compared with 6.5% in the EU (EC, 2026a).

This recent development suggests that fibre deployment has accelerated particularly strongly in less densely populated parts of Slovenia, contributing to a gradual reduction of the geographical connectivity gap.

Despite this progress, fibre coverage in rural areas remains considerably below the national coverage level of 83.9%. The remaining unserved households are increasingly concentrated in geographically dispersed and hard-to-reach locations, where the economic viability of further fibre deployment is more challenging. Consequently, completing the transition towards universal gigabit connectivity will require continued attention to these areas.

A particularly notable development concerns the uptake of gigabit broadband services. As shown in Figure 5, the share of fixed broadband subscriptions providing speeds of at least 1 Gbps increased sharply in Slovenia, from approximately 10.9% in 2024 to 48.62% in 2025. This represents an annual increase of 346.6%, while the corresponding EU average reached 26.97% in 2025.

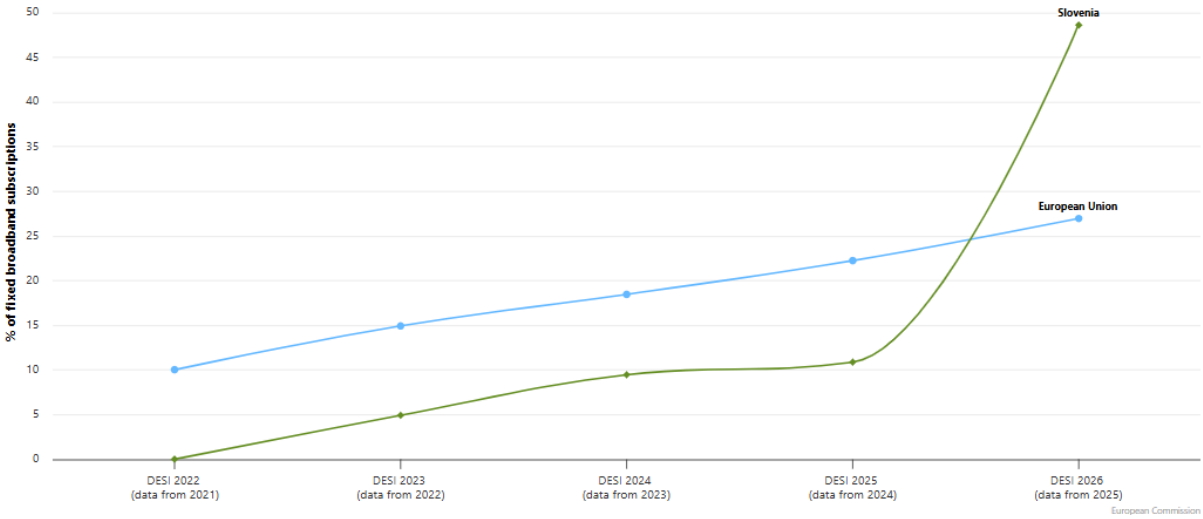

Figure 5: Share of fixed broadband subscriptions with speeds of at least 1 Gbps in Slovenia and the EU
(Source: EC, 2026b)

This development is particularly relevant in the Slovenian context, where earlier research identified a pronounced gap between the availability of advanced broadband infrastructure and the adoption of higher-speed services (Švigelj et al., 2019). That study also showed that broadband migration depends not only on infrastructure availability but on demand-side factors related to users and their patterns of Internet use. The latest data suggest that this historically observed demand gap has narrowed substantially.

The latest results also place Slovenia well above the EU average, as illustrated in Figure 6. In 2025, almost half of fixed broadband subscriptions in Slovenia provided speeds of at least 1 Gbps, compared with approximately 27% across the EU. Nevertheless, gigabit subscriptions remain below the availability of FTTP and VHCN infrastructure, which reached 83.9% of households in 2025.

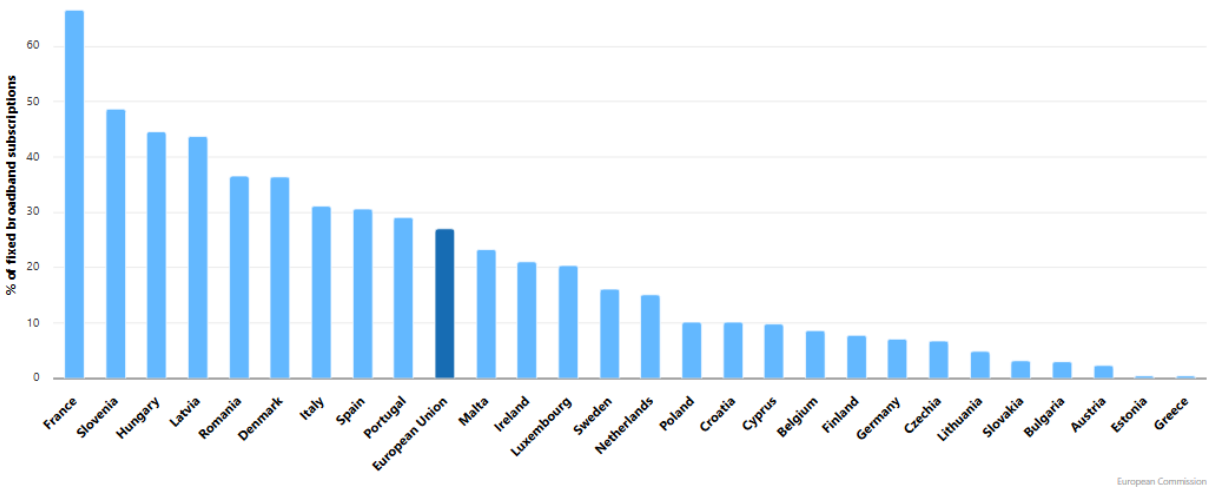

Figure 6: Share of fixed broadband subscriptions with speeds of at least 1 Gbps across EU Member States, 2025 (Source: EC, 2026b)

3. MOBILE CONNECTIVITY

Mobile connectivity has also developed rapidly in Slovenia in recent years, particularly following the deployment of 5G networks. Figure 7 presents the development of overall 5G coverage in Slovenia and the EU between 2020 and 2025.

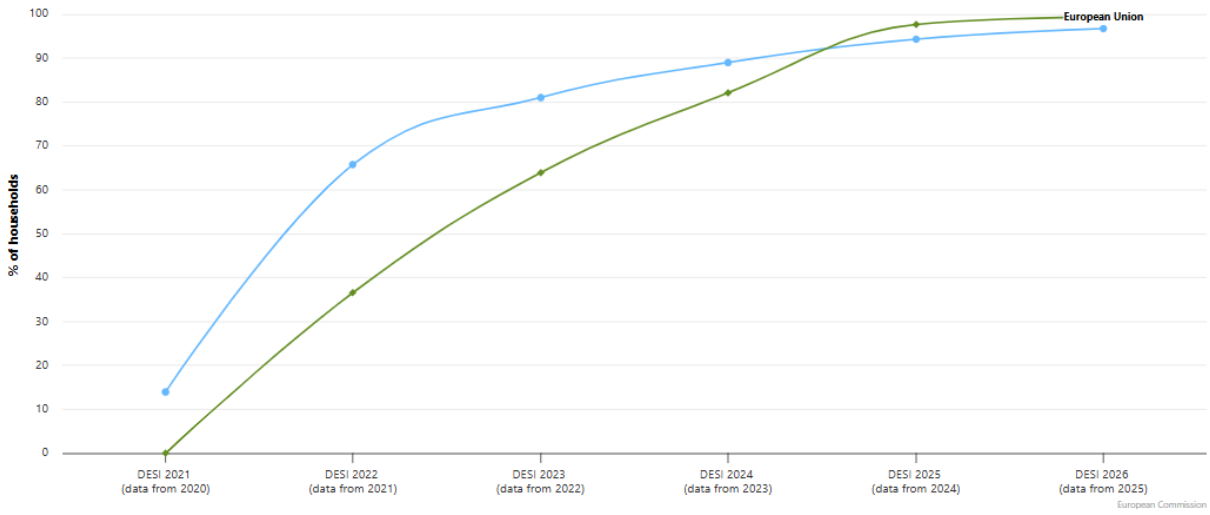

Figure 7: Overall 5G coverage in Slovenia and the EU (Source: EC, 2026b)

The expansion of 5G coverage in Slovenia was initially slower than at the EU level. In 2021, 5G covered approximately 37% of Slovenian households, compared with around 66% in the EU. However, deployment subsequently accelerated considerably. Slovenia reached approximately 82% coverage in 2023 and 97.7% in 2024, thereby moving above the EU average. According to the latest data, overall 5G coverage increased further to 99.37% in 2025, compared with 96.79% in the EU. With coverage now approaching the 2030 objective of 100%, the remaining gap in terms of basic 5G availability is relatively small.

The progress has been particularly pronounced in rural and sparsely populated areas. As shown in Figure 8, Slovenia initially lagged considerably behind the EU in this dimension, but the gap has been reversed in recent years.

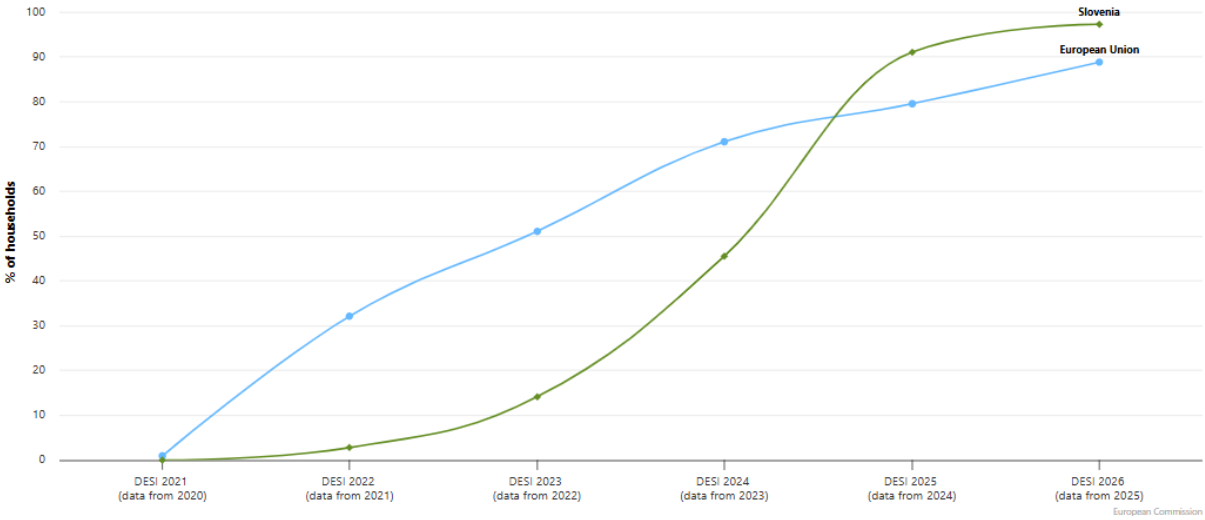

Figure 8: Overall 5G coverage in sparsely populated areas in Slovenia and the EU (Source: EC, 2026b)

In 2022, 5G coverage in sparsely populated areas was only around 14% in Slovenia, compared with approximately 51% in the EU. By 2023, Slovenian coverage had increased to around 46%, while the EU average stood at approximately 71%. The strongest expansion occurred thereafter, with coverage in Slovenia rising to approximately 91% in 2024 and 97.32% in 2025. Slovenia consequently remained well above the corresponding EU average of 88.88% in 2025. The latest results therefore indicate that the earlier geographical gap in 5G availability has been substantially reduced, with only a small difference remaining between national and sparsely populated areas.

Slovenia also performs strongly in the deployment of 5G in the 3.4–3.8 GHz spectrum band, which is particularly relevant for delivering higher-capacity 5G services. Coverage reached 89.13% in 2025, substantially exceeding the EU average of 74.75%. The difference is even more pronounced in sparsely populated areas, where coverage reached 66.68% in Slovenia compared with 33.71% in the EU. Slovenia consequently recorded one of the highest levels of 5G coverage in this spectrum band in sparsely populated areas among EU Member States. These results indicate that Slovenia's progress in mobile connectivity extends beyond basic 5G availability and is not limited to more densely populated areas (EC, 2026b).

4. PROGRESS TOWARDS 2030 AND REMAINING CHALLENGES

Slovenia has made substantial progress towards the Digital Decade connectivity targets. In 2025, basic 5G coverage reached 99.4%, while both FTTP and VHCN coverage stood at 83.9%. The 2030 target is 100% coverage for all three indicators (EC, 2026c). Nevertheless, reaching the remaining households will require further efforts, particularly in rural, sparsely populated and hard-to-reach areas. High deployment costs and geographically dispersed households make the completion of fixed network coverage particularly challenging. Current estimates indicate that approximately EUR 250 million could be required to achieve universal gigabit coverage in Slovenia. Public funding, including support under the Recovery and Resilience Facility, has already contributed to broadband deployment in underserved areas, but further investment will be needed to reach the remaining hard-to-reach locations (EC, 2026a).

Another important aspect is the transition from legacy copper infrastructure towards fibre networks. In March 2025, AKOS adopted a strategy addressing the phase-out of the copper network, although a comprehensive national timetable for completing this transition has not yet been established. Accelerating the migration from copper to fibre therefore remains an important part of Slovenia's progress towards the 2030 connectivity targets (EC, 2026a; AKOS, 2025). At the same time, the focus is increasingly shifting from infrastructure availability towards its effective use. The sharp increase in gigabit broadband subscriptions in 2025 suggests that the previously observed gap between network availability and adoption has narrowed. For 5G, near-universal basic coverage similarly shifts attention towards more advanced applications and productive use cases. Therefore, the next phase of Slovenia's connectivity development will depend not only on completing coverage in underserved areas but also on the effective use of the advanced digital infrastructure already available (EC, 2026a).

5. CONCLUSION

This paper examined recent developments in digital connectivity in Slovenia and the country's progress towards the EU Digital Decade connectivity targets for 2030. The results show continued improvement in both fixed and mobile connectivity. Slovenia maintains strong FTTP coverage and has achieved near-universal 5G coverage, while recent progress in rural and sparsely populated areas has substantially reduced previously observed geographical gaps. A particularly important development is the sharp increase in the uptake of gigabit broadband services, indicating that the previously observed gap between advanced infrastructure availability and its actual use has narrowed considerably. Nevertheless, reaching the 2030 connectivity targets will require further efforts, particularly in hard-to-reach areas where completing network coverage remains challenging. Future progress will therefore depend both on extending advanced connectivity to the remaining underserved locations and on ensuring the effective use of the infrastructure already available.

ACKNOWLEDGEMENT: *This research was supported by the Slovenian Research and Innovation Agency (Research Programme P5-0117)*

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FROM CONTRACT TO CHAIR: A MACHINE LEARNING TEST OF INSTITUTIONAL PREDICTORS OF GENDER PARITY IN ITALIAN ACADEMIC MEDICINE

Tahani Rashid
Department of Political and Social Science, University of Calabria, Italy
tahani.rashid@unical.it

Umair Yousaf
Department of Mathematics and Computer Science, University of Calabria, Italy
umair.yousaf@unical.it

Maria Nardo
Department of Political and Social Science, University of Calabria, Italy
maria.nardo@unical.it

ABSTRACT

Women remain underrepresented in senior academic positions in medicine in Italy. This study examines whether machine learning can predict which universities will reduce this gap and how quickly such change may occur. We construct a five-year panel from 2020-2024 and observe the share of women among full professors, associate professors, and researchers. We also compare tenured staff to contract faculty. Three machine learning models are evaluated in this research. First, a walk-forward forecast predicts each university's 2024 share of women full professors from previous university-level observations. The second model directly predicts the annual change in the women's share. Third, a structural model uses feeder-rank composition, region, institution type, and university size to explain the 2024 cross-section. Each model is benchmarked against a naive baseline and evaluated using university-level holdout validation to prevent information from the same institution entering both the training and test sets. Nationally, the share of women full professors in medicine rose from 18.9% in 2020 to 22.9% in 2024, a real but slow gain. In contrast, women accounted for around 45% to 47% of contract faculty during the same period. It demonstrates a substantial gender gap between senior and less secure academic positions. The structural model looks weakly informative under ordinary cross-validation. Moreover, the apparent signal collapses once entire universities are excluded from the training, revealing that it was mostly due to leakage. These findings suggest that progress toward gender parity among senior academic staff is shaped by slow, institution-specific processes that are difficult to capture with generic structural characteristics. It also implies the design of accountability and certification frameworks that seek to assess sustainability and gender equality in higher education institutions.

Keywords: *academic medicine; gender equality; higher education; leaky pipeline; machine learning*

1. INTRODUCTION

Women remain rare at the top of academic medicine. A 2024 systematic review and meta-analysis found that women physicians are far less likely to reach full professor rank, even after accounting for productivity and leadership experience (Marhoffer et al., 2024). The gap is larger outside the United States. This pattern fits a broader story in academic careers. Women are lost from the pipeline at every stage, so few reach the most senior rank even when they enter the profession in large numbers (Speer, 2023). Universities are also expected to report on their own accountability for gender equality. The European Union now requires a Gender Equality Plan for Horizon Europe funding (Karataş et al., 2025).

However, recent research comparing certification schemes identifies substantial differences in how these frameworks measure and monitor gender balance (Angeloni, 2026). Broad institutional categories, such as region and ownership type, are often used as informal proxies for the expected pace of progress in reducing gender gaps. However, there is limited empirical evidence on whether these categories reliably predict institutional change. National personnel records show women are promoted to full professor later than equally productive men, a gap not explained by institutional context (Filandri et al., 2025). A separate analysis of the medical area specifically found the same pattern with little sign of convergence over the past decade (Magnano San Lio et al., 2025). These findings motivate a direct test of whether institutional characteristics can predict which universities will close the gap, and how fast. The paper poses a more focused and precise question. Can machine learning predict which universities will close the gender gap among full professors in medicine, and how fast? We use the Gradient Boosting method that sequentially builds many small decision trees, each correcting the errors of the previous one (Friedman, 2001). The method is tested in three different ways, using honest baseline comparisons. We also check for a specific risk that the model appears better than it is due to leakage from repeated observations of the same university (Kaufman et al., 2012). The findings address how universities measure and certify progress toward gender equality in medicine. Gender-blind treatment in medical research and care has been linked to worse patient outcomes. It is one reason the composition of medical faculties matters beyond the university itself (Regitz-Zagrosek and Gebhard, 2023). Section 2 reviews the relevant literature. Section 3 describes the data and methods. Section 4 presents results. Section 5 discusses the findings, and Section 6 concludes the paper.

2. THEORETICAL BACKGROUND

2.1 The Leaky Pipeline in Academic Medicine

Currently, medical schools enrol roughly as many women as men. However, full professorships remain male-dominated. A 2024 meta-analysis pooled results across many studies of promotion to full professor among physicians (Marhoffer et al., 2024). It found women were promoted less often than men, even after adjusting for scholarly output, grant funding, and leadership roles. The disparity was more pronounced outside the United States and was greater in surgical fields than in internal medicine. This pattern is often called a leaky pipeline. While women advance through early career stages in large numbers, they are lost at each successive rank (Speer, 2023). By the time a cohort reaches full professor, the share of women has fallen far below their share among junior staff or graduates. Although the metaphor is useful, it can mislead if it suggests change happens automatically. Gradual attrition at each stage does not guarantee eventual parity at the top.

2.2 Critical Mass and the Limits of Categorical Predictors

A widely used benchmark in the gender diversity literature is critical mass. The idea is that a representation of around one-third is needed before a minority group meaningfully changes group dynamics (Kanter, 1977). Subsequent studies found that boards with three or more women showed different outcomes than boards with only one or two (Torchia et al., 2011). We use the same 33% threshold in this paper, applied to full professors in medicine research programmes, which shares a common benchmark. It is generally supposed that reaching critical mass often follows from institutional characteristics such as region, size, or whether the institution is public or private. This assumption is rarely tested empirically. Nevertheless, it is often embedded in accountability frameworks that benchmark institutions using broad institutional categories. This paper tests the assumption in academic medicine by using supervised machine learning rather than descriptive statistics.

2.3 Precarious Employment and the Gender Composition of the Academic Workforce

Not all academic staff hold secure, tenured positions. Contract and adjunct teaching roles have grown across many higher education systems. In Italy, women hold a higher share of precarious academic staff positions than tenured ones, with career paths that often stall before reaching permanent rank (De Angelis and Grüning, 2020). As a result, the overall statistics regarding women in academia can conceal a significant gap between secure and insecure employment. Medicine is a useful test case for this divide because clinical and teaching demands keep contract faculty numbers high. If contract faculty are closer to gender parity than tenured staff, this would suggest that the main barrier for women in academic medicine arises at the transition to permanent senior (De Angelis and Grüning, 2020; Speer, 2023).

2.4 Machine Learning, Forecasting, and the Risk of Data Leakage

Gradient Boosting builds a prediction by fitting many shallow decision trees in sequence. Each tree corrects the errors left by the trees before it (Friedman, 2001). It is a standard, well-tested method for tabular prediction problems. Additionally, it can capture relationships that simpler regression models miss. A machine learning model validated the wrong way can look far more accurate than it really is. This is called leakage, when information that would not be available at prediction time finds its way into the training process (Kaufman et al., 2012). In panel data, where the same institution appears in several years, ordinary cross-validation can let a model see one year of a university in training and a different year of the same university in testing. This lets the model partly memorize each institution's own baseline rather than learn a general pattern. We test for this directly in Section 4.

Beyond technical accuracy, predictive models used in higher education governance raise their own questions of equity and accountability. A systematic review of fairness, accountability, transparency, and ethics in artificial intelligence applications in higher education found that most studies examine fairness primarily from a technical perspective. Few studies assess whether a model’s apparent predictive accuracy remains reliable when applied to institutions or groups that were not included in the training data (Behera et al., 2023). This barrier is not unique to Italy. A 17-year national study of academic surgery in the United States examined the representation of women across trainee, faculty, and department chair positions. It found that women’s advancement slowed substantially at each successive career stage. If the current rate of progress continues, gender parity among department chairs would not be reached until 2102 (Harris et al., 2025). The similarity between two very different health systems points to departmental and disciplinary dynamics common to the profession.

3. DATA AND METHODOLOGY

3.1 Data Source

The data were derived from Italy's Ministry of University and Research, published by its Statistical Service under the Italian Open Data License v2.0 (MUR, Servizio Statistico, 2025). We used two files from the university staff series. The first file gives information on tenured teaching and research staff, broken down by university, year, gender, academic rank and scientific-disciplinary area for the period 2020 to 2024. The second file contains details about contract teaching staff on the same characteristics. A separate university decoder file classifies each institution as state or non-state (MUR, Servizio Statistico, 2025). We filter both files to Area 06, Scienze mediche (medical Science), the medical sciences area in Italy's official field classification. Seventy-six universities report medical faculty staff in at least one year of the panel. Three academic ranks are tracked among tenured staff: Prof. Ordinario (full professor), Prof. Associato (associate professor), and Ricercatore (researcher), with tenured and fixed-term ranks combined.

3.2 Variable Construction

For each university, year, and rank, we calculate the percentage of women as the count of women divided by total headcount. A dataset is constructed for 76 universities over up to 5 years, yielding up to 380 university-year observations. However, not all universities provide data for every year. We also build a national series for contract faculty in medicine, motivated by the precarious-employment literature discussed above (De Angelis and Grüning, 2020). We deliberately avoid creating a single composite index across ranks. Combining ranks into a single number would obscure the pipeline structure, which is the actual subject of this paper. Therefore, each rank is analysed and reported separately.

3.3 Analytical Strategy

We examine three machine learning approaches, all of which use Gradient Boosting (Friedman, 2001). Each model is compared with a naive baseline to assess whether it provides predictive value beyond that of a simple benchmark. The first method is a walk-forward forecast. We build year-over-year transitions for each university using its prior-year values. Along with region, size, and institution type, we use each university's prior-year values to predict its current-year share of women full professors. We train on transitions up to 2023 and test only on the 2023-2024 transition. This is a true holdout the model had not encountered during training. The naive baseline simply predicts no change from the prior year.

The second specification predicts the year-over-year change directly, rather than the level. The naive baseline here is zero change. The third is a cross-sectional structural model that uses feeder-rank composition, size, region, and institution type to explain the 2024 level across universities. This third model is evaluated in two ways. First, ordinary five-fold cross-validation allows different years from the same university to appear in both the training and test folds. Second, GroupKFold keeps entire universities out of the training set. Comparing the results shows whether the apparent predictive performance depends on the model having previously observed the same institutions (Kaufman et al., 2012).

4. RESULTS

4.1 National Trends by Academic Rank

Table 1 shows the national share of women in medicine by rank from 2020 to 2024. Full professors remain furthest from parity, though the trend is steadily upward from 18.9% to 22.9%. Researchers are already close to the 33% critical mass threshold in 2020 and exceed it by 2024 (Kanter, 1977).

Year	Prof. Ordinario	Prof. Associato	Ricercatore
2020	18.9	32.9	46.6
2021	19.6	34.4	47.8
2022	20.7	37.5	47.6
2023	21.8	38.1	49.1
2024	22.9	38.7	49.5

Table 1. National share of women (%) by academic rank in medicine (2020-2024)

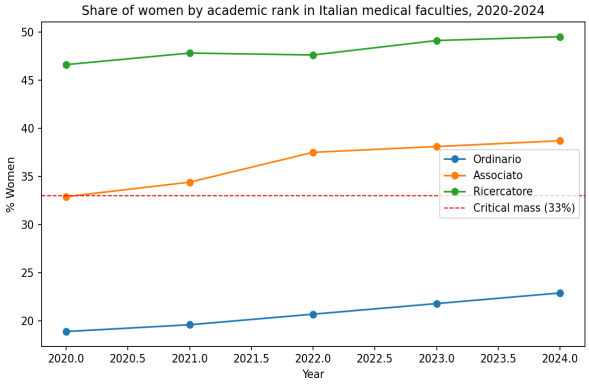

Figure 1. Share of women by academic rank in Italian medical faculties (2020-2024)

The gap between ranks is consistent with a leaky pipeline (Speer, 2023). Each promotion step appears to filter out a larger share of women. Thus, the most senior rank shows the smallest share of women even as the ranks below it approach or exceed critical mass.

4.2 Contract Faculty versus Tenured Staff

Table 2 compares contract faculty, all tenured staff pooled and full professors specifically. Contract faculty stay close to gender parity throughout, with women at 45%-47%. Full professors lie at less than half that share, between 19% and 23%, across the same years.

Year	Contract faculty	Tenured staff (all ranks)	Full professors only
2020	45.2	35.2	18.9
2021	45.3	36.0	19.6
2022	47.0	37.2	20.7
2023	46.6	38.3	21.8
2024	47.2	38.5	22.9

Table 2. Share of women (%), contract faculty vs tenured staff vs full professors in medicine

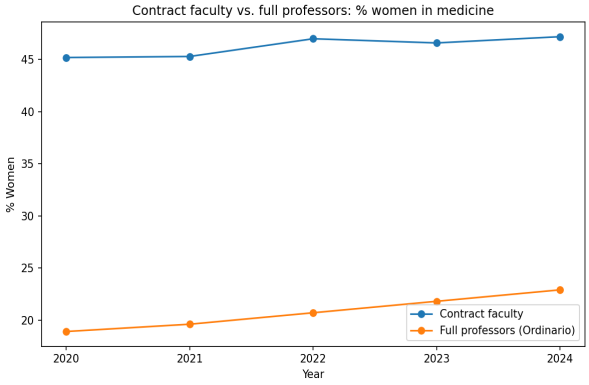

Figure 2. Contract faculty vs. full professors, share of women in medicine (2020-2024)

This gap supports the idea that the barrier facing women in academic medicine lies at the transition to secure senior positions, not at entry into teaching (De Angelis and Grüning, 2020). Women are well represented in the flexible, less secure part of the workforce. While far less represented in more permanent, senior positions.

4.3 Regional and Institutional Type Variation

Table 3 shows the 2024 share of women with full professor status by macro-area. Centro shows the highest average (34.8%), and Nord-Ovest the lowest (16.3%). On the other hand, a one-way analysis of variance across the five areas did not reach significance, $F(4, 59) = 1.59$, $p = .190$. The standard deviations are large relative to the means, indicating that regional averages are driven by a few small medical faculties with extreme values rather than a stable regional pattern.

Macro-area	Mean %	Std. dev.	N
Centro	34.84	33.52	18
Isole	24.85	14.25	6
Nord-Est	20.42	9.10	10
Nord-Ovest	16.34	11.74	14
Sud	23.47	19.27	16

Table 3. Share of women, Prof. Ordinario (medicine) by macro-area (2024)

Table 4 compares state and non-state universities. Non-state universities show a higher average (30.4%) than state universities (23.3%), but a Welch t-test indicates no significant difference: $t(13.8) = 0.72$, $p = .484$.

Institution type	Mean %	Std. dev.	N
Non statale (private)	30.40	34.30	13
Statale (public)	23.32	18.24	51

Table 4. Share of women, Prof. Ordinario (medicine), by institution type (2024)

Table 5 lists the highest and lowest-ranked universities by their 2024 share of women full professors. Several of the highest values come from very small medical faculties. Viterbo shows 100%, with only two full professors. Interpreting these extremes needs care, since a single appointment can swing a small faculty's percentage by fifty points or more.

Highest (2024)	%	N	Lowest (2024)	%	N
Viterbo	100.0	2	Pegaso (telematica)	0.0	23
Roma Niccolò Cusano	100.0	5	Basilicata	0.0	8
Roma Link Campus	100.0	68	e-Campus (telematica)	0.0	9
Napoli Parthenope	66.7	18	Urbino Carlo Bo	0.0	20
Cassino e Lazio Merid.	66.7	12	Camerino	0.0	12

Table 5. Highest & lowest ranked universities, share of women Prof. Ordinario (medicine), 2024

Table 6 shows the universities with the largest gains and largest declines between 2020 and 2024. Napoli Parthenope gained 41.7 percentage points, though again from a small base. Urbino fell by 33.3 points, from one-third women to zero. These extremes fit a theme running through the rest of this paper. Change at the level of a single, small faculty is dominated by individual appointment and retirement decisions, not by smooth institutional trends.

Most improved (2020-24)	Change (pp)	Most stagnant/declining	Change (pp)
Napoli Parthenope	+41.7	Perugia	-2.8
Roma Foro Italico	+30.0	Parma	-5.0
Roma San Raffaele (tel.)	+25.0	Foggia	-10.1
Trento	+20.0	Lecce Salento	-20.0
Messina	+19.4	Urbino Carlo Bo	-33.3

Table 6. Largest gains and largest declines, share of women Prof. Ordinario (medicine), 2020-2024, in percentage points

4.5 Can a Forecast Beat Naive Persistence?

Table 7 reports the walk-forward forecast having been tested on the 2024 holdout. Gradient Boosting achieved R^2 0.828, MAE 4.17, and RMSE 7.18. The naive baseline, which simply assumes no change from the prior year, achieved R^2 0.838, MAE 3.89, and RMSE 6.97, which is slightly better. Therefore, the machine learning model does not outperform the approach of doing nothing.

Model	R^2	MAE	RMSE
Gradient Boosting (lagged features)	0.828	4.17	7.18
Naive: persistence (last year's value)	0.838	3.89	6.97

Table 7. Walk-forward one-year-ahead forecast vs naive baseline, holdout year 2024

Table 8 shows the feature importances from the forecast model. The prior year's own value accounts for 84% of the model's predictive weight. Region, institution type, and the feeder ranks contribute almost nothing. This confirms from a different position what the naive baseline comparison already showed. A university's share of women full professors this year is best predicted by its own share last year, and almost nothing else adds meaningful information.

Predictor	Relative importance
Lagged % women, Prof. Ordinario	0.840
Lagged total staff (medicine)	0.138
Lagged % women, Prof. Associato	0.007
Lagged % women, Ricercatore	0.004
State institution	0.004

Table 8. Feature importances, walk-forward forecast model (top 5 of 10 predictors)

4.6 Does the Story Change When Predicting Change Instead of Level?

Table 9 predicts the year-over-year change directly, rather than the level. Gradient Boosting scored R^2 of -0.078 on the 2024 holdout. A naive prediction of zero change scored -0.066. Neither score is good in an absolute sense. Furthermore, the machine learning model again fails to beat the simpler baseline.

Model	R^2	MAE	RMSE
Gradient Boosting (predicts change)	-0.078	4.15	7.01
Naive: zero change	-0.066	3.89	6.97

Table 9. Year-over-year change model vs naive baseline, holdout year 2024

The findings indicate that short-term changes in women's representation among full professors are not systematically explained by institutional characteristics. Factors like recruitment, retirement, and promotion play a vital role in shaping these changes. These processes vary across institutions and are not adequately captured by broad indicators, such as university size, geographical region, or public status.

4.7 The Leakage Test: Apparent versus Genuine Predictive Power

Table 10 tests the cross-sectional structural model in two ways. In which different years of the same university can appear in both training and test folds, five-fold cross-validation yielded a mean R^2 of -0.047. While in GroupKFold, the entire universities are out of training, with the mean R^2 falling to -1.108.

Validation approach	Mean R^2	Fold range
Ordinary KFold (same-university leakage possible)	-0.047	-0.217 to 0.209
GroupKFold (leave-institution-out)	-1.108	-1.707 to -0.337

Table 10. Cross-sectional structural model: apparent vs genuine out-of-sample performance

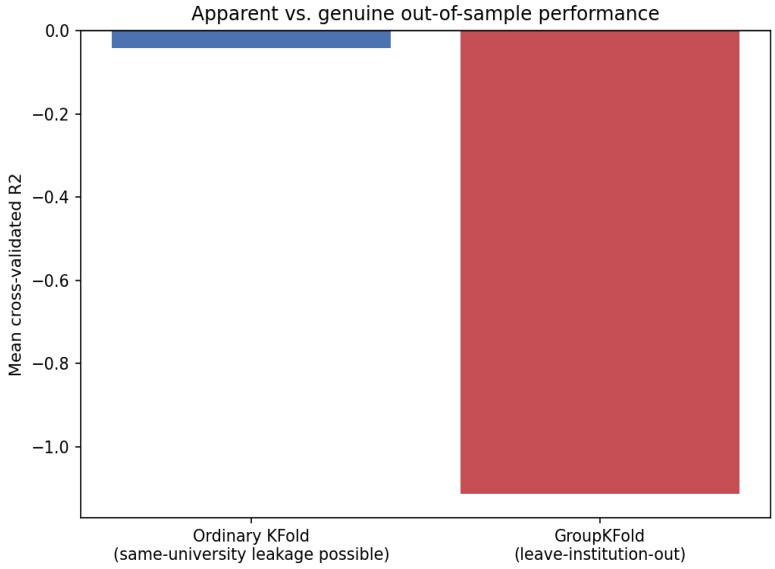

Figure 4. Apparent (ordinary KFold) vs genuine (leave-institution-out) predictive performance

Neither number indicates good predictive performance, but the gap between them matters. Besides, the ordinary cross-validation score is weak. Even though it still overstates what the model can do for a university it has never seen before. This is the leakage risk described by Kaufman et al. (2012). It is also a caution for any accountability tool that validates a predictive model on panel data without checking whether it generalizes to genuinely new institutions.

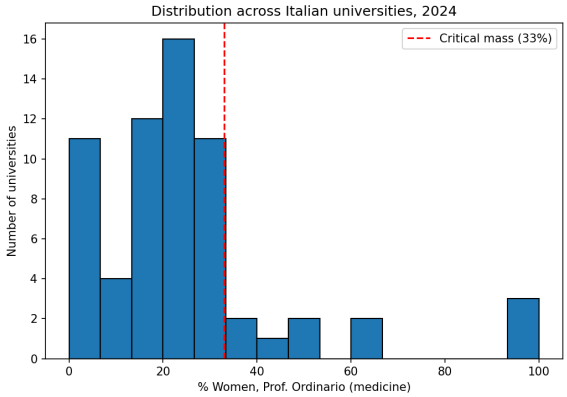

Figure 3. Distribution of the share of women Prof. Ordinario (medicine) across Italian universities (2024)

5. DISCUSSION

The results show a single, consistent conclusion across four different tests. Institutional characteristics, region, size, and public or private status do not meaningfully predict a university's share of women full professors in medicine. This matches independent evidence from Italian academia. National personnel records show that women are promoted to full professor later than equally productive men, regardless of region or institution type (Filandri et al., 2025). A separate study in the medical field specifically found the same persistent nationwide underrepresentation (Magnano San Lio et al., 2025). A comparative review of gender equality certification schemes found several rely heavily on exactly these structural and institution-level variables (Angeloni, 2026). If those variables carry little genuine predictive power, such certification models risk rewarding institutions for characteristics with no demonstrated link to actual progress.

The contract-versus-tenured comparison in Section 4.2 offers one explanation. Women are well represented in the flexible, less-secure part of the academic medical workforce, with representation close to parity. But far less represented once positions become permanent and senior. This is consistent with research on precarious academic labour in Italy. It finds women's careers often stall before reaching tenure even when they enter academic medicine and teaching in large numbers (De Angelis and Grüning, 2020). If the real barrier lies at the promotion transition itself, the region and institution type would not be expected to explain much of the variation. Marhoffer et al. (2024) found that gender gaps in promotion to full professor persisted even after adjusting for scholarly output and leadership experience, suggesting that something beyond observable productivity is at work. Our finding that region and size add almost nothing to a predictive model is consistent with a bias or barrier that operates locally within departments and promotion committees. The leakage test in Section 4.7 has a methodological implication beyond this specific dataset. Panel data on university staff is exactly the kind of data where naive cross-validation can mislead. Certification and accountability tools that use predictive models on institutional panel data should report leave-institution-out performance, following the caution outlined by Kaufman et al. (2012). These findings argue against an accountability shortcut by using broad institutional categories as a proxy for progress on gender equality. Faculty gender balance in medicine is not well explained by region or ownership type. Progress appears to be local, slow, and tied to specific institutional histories. It argues for monitoring tools that track individual institutions over time rather than benchmarking them against categorical peers.

5.1 Limitations

Several limitations qualify these conclusions. The panel covers only five years, leaving only one holdout year for the forecast and change-model tests. Several extreme values in Section 4.4 come from faculties with fewer than ten full professors. In which one hire can shift the percentage by fifty points, so those rankings should be read with caution. The models use only variables available in open MUR data and cannot capture departmental leadership, hiring committees, or mentorship networks.

6. CONCLUSION AND IMPLICATIONS

This paper tested whether machine learning can predict gender parity in academic medicine using institutional characteristics. Across three model specifications and four validation approaches, the answer is consistently no. A naive forecast of no change performs better than Gradient Boosting. A structural model's weak apparent performance under ordinary cross-validation collapses once entire universities are properly held out of training. However, full professors in medicine remain far from gender parity nationally (22.9% women in 2024). Researchers already exceed the critical mass threshold (Kanter, 1977). Whereas the contract faculty are close to parity outright. The barrier to women in academic medicine lies specifically at the senior secure end of the career ladder, not at entry level. The implication is direct for accountability and certification frameworks in higher education. Institutional category benchmarks, region, size, and public or private status are not reliable predictors of gender progress in academic medicine. The models that appear to rely on them should be checked for leakage before being trusted. This conclusion is consistent with independent evidence from Italian academia (Filandri et al., 2025; Magnano San Lio et al., 2025) and with international evidence on the slow rank-specific nature of gender attrition in academic medicine (Harris et al., 2025). They suggest the barrier lies within departments and promotion practices rather than in the institutional categories that certification frameworks typically measure. Future work may test whether department-level and disciplinary variables, rather than broad institutional categories. Linking faculty-level panel data of the kind used in this paper to information on hiring committee composition, promotion criteria, and mentorship structures would allow a more direct test of where the barrier to gender parity in academic medicine fits.

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PUBLIC SPENDING COMPOSITION AND FIRM PRODUCTIVITY IN EUROPEAN MANUFACTURING: EVIDENCE ON THE ROLE OF NATIONAL FISCAL INTERVENTION

Giulia Felice
Politecnico di Milano, Department of Management, Economics and Industrial Engineering
giulia.felice@polimi.it

Giovanni Monaco
SNAM, Italy
giomon2000@gmail.com

Filippo Nani
ABB, Italy
nanifilippo11@gmail.com

ABSTRACT

This paper examines the relationship between the functional composition of public expenditure and firm-level productivity in European manufacturing, with particular attention to the financial and structural conditions that shape firms' capacity to benefit from public intervention. The analysis combines a panel of 258,026 listed and unlisted manufacturing firms from Bureau van Dijk's Orbis database over 2015-2023 with national expenditure data from the OECD Classification of the Functions of Government (COFOG) and macroeconomic indicators from Eurostat. The main fiscal variable is the share of government expenditure allocated to Education, Health and Economic Affairs (EHEA), categories associated with human capital, infrastructure and the productive environment. Firm performance is measured through Total Factor Productivity (TFP), and the empirical analysis uses fixed-effects panel models with macroeconomic and firm-level controls. The results show that a one-percentage-point increase in the EHEA share is associated with approximately a 0.5% increase in firm-level TFP in the fully specified baseline model, whereas the aggregate size of public expenditure is not statistically significant. The relationship is heterogeneous. Firms with high debt-to-asset ratios or high leverage capture substantially smaller productivity gains from productive spending, with an attenuation of about 40% relative to financially healthier firms. Small firms show the clearest positive response, while the estimated gains are weaker for medium-sized firms and not statistically significant for large firms. The findings suggest that the effectiveness of national fiscal intervention depends not only on how much governments spend, but also on the functional composition of expenditure and on firms' ability to absorb complementary public inputs. This provides firm-level evidence for a selective view of public intervention in which expenditure quality, targeting and financial conditions jointly determine productivity outcomes.

Keywords*: European Manufacturing, Firm Heterogeneity, Fiscal Policy, Public Expenditure Composition, Total Factor Productivity*

1. INTRODUCTION

The role of government in modern European economies is increasingly defined by the coexistence of short-term shocks and long-term structural objectives. The COVID-19 pandemic, the energy shock following Russia's invasion of Ukraine, the green transition, digitalization and renewed concerns over strategic autonomy have all increased the demand for public intervention.

For manufacturing firms, these interventions can change the quality of infrastructure, the availability of skilled labour, the cost and reliability of energy and transport, access to innovation support, and the broader institutional environment in which investment decisions are made. In this setting, the relevant question is not simply whether government is large or small, but whether the functional allocation of public resources improves the conditions under which private firms can become more productive. This distinction is central to the conference theme of national economies between liberalization and intervention. A debate framed only in terms of the overall size of the state risks overlooking the channels through which specific public functions interact with private activity. Expenditure on education may strengthen the supply of human capital; health expenditure may improve workforce quality and resilience; and economic-affairs expenditure includes transport, energy, communication, industrial policy, labour-market measures and related research and development.

These functions can complement private investment and reduce operating frictions. By contrast, other forms of expenditure may pursue important social objectives while having a less direct link with firm-level productive efficiency. The existing literature has established that public expenditure can affect growth and productivity, but most evidence is macroeconomic. Endogenous-growth approaches emphasize the distinction between productive and non-productive expenditure and show that the growth effect of public intervention depends on its composition and financing (Barro, 1990; Kneller, Bleaney and Gemmell, 1999). Public capital can raise private productivity when it provides complementary inputs such as infrastructure (Aschauer, 1989), and the sectoral allocation of public investment can influence growth through changes in the productivity and structure of the private economy (Felice, 2016).

Yet aggregate evidence cannot show whether firms with different balance sheets or organizational characteristics respond in the same way. This paper addresses that gap using a large firm-level panel of European manufacturing companies. It asks three related questions. First, is a greater allocation of public expenditure to Education, Health and Economic Affairs (EHEA) associated with higher firm-level productivity? Second, does the financial condition of firms alter this relationship? Third, do firms of different sizes benefit differently from the same national spending composition? These questions connect fiscal policy to firm heterogeneity and therefore allow the analysis to move beyond an average national effect. The empirical evidence yields three main findings. First, the share of public expenditure allocated to EHEA is positively and significantly associated with firm-level TFP across the baseline specifications. In the complete model, a one-percentage-point increase in the EHEA share is associated with an approximate 0.5% increase in productivity.

The overall level of public spending relative to GDP is not statistically significant once composition and economic conditions are considered. Second, financial exposure materially reduces the estimated benefit: the productivity response of highly indebted firms is approximately 40% lower than that of firms with healthier financial structures. Third, small firms exhibit the strongest and clearest response to productive public spending, suggesting that improvements in the external productive environment may have especially high marginal value for firms that cannot internally replicate public inputs. The contribution is therefore not an argument for indiscriminate fiscal expansion. Rather, the results support a selective interpretation of intervention: composition matters, and its effectiveness is conditional on private-sector absorptive capacity. This perspective is especially relevant for European policy because member economies combine highly heterogeneous fiscal structures with equally heterogeneous financial systems and firm populations.

The remainder of the paper summarizes the conceptual background, data and empirical approach, presents the main results, and discusses their implications for the design of productivity-oriented public policy.

2. LITERATURE AND CONCEPTUAL BACKGROUND

2.1 Public expenditure composition and private productivity

The idea that public expenditure can be productive has a long tradition in growth economics. Aschauer (1989) linked public capital, especially core infrastructure, to private-sector productivity and helped establish the concept of crowding-in: public inputs can raise the marginal productivity of private capital rather than displacing it. Barro (1990) formalized this intuition in an endogenous-growth framework in which productive public services enter the production process. A central implication is that the composition of government expenditure matters because some functions directly support productive capacity, whereas others mainly affect welfare or redistribution. Empirical work has broadly reinforced the importance of composition. Kneller, Bleaney and Gemmell (1999), using a panel of OECD countries, show that productive expenditure is positively related to growth when the government budget constraint is properly accounted for. Felice (2016) further shows that the size and sectoral composition of public investment can have different growth implications because public resources affect private sectors with different productivity characteristics.

These studies imply that two countries with similar expenditure-to-GDP ratios may generate different productive outcomes if their budgets are allocated differently. The microeconomic evidence is scant but particularly relevant for the present analysis. Kneller and Misch (2014) examine South African firms and find that a reallocation of public expenditure toward education, health and transport raises firm productivity, with stronger effects among firms that are less capital intensive and therefore more dependent on public inputs. Fadic, Garda and Pisu (2019) show that higher local public-sector efficiency in Italy increases firm-level productivity growth, emphasizing that the quality of public administration and the ability to transform expenditure into effective services are as important as expenditure levels themselves. Long and Tuuli (2022), studying fiscal consolidation in advanced economies, show that the size and composition of fiscal adjustment affect firm-level TFP and that firm characteristics shape the transmission of fiscal policy.

2.2 Financial structure as an absorptive-capacity channel

Firms do not face identical financing conditions. Credit-market imperfections imply that firms financially weak may be unable to finance otherwise profitable investment opportunities (Stiglitz and Weiss, 1981). This matters for the transmission of productive public spending because many public inputs require complementary private responses. Better transport infrastructure, a more skilled labour force or expanded innovation support may create opportunities, but firms still need liquidity and borrowing capacity to invest in machinery, training, organizational change or market expansion.

Firm-level evidence supports this mechanism. Coricelli et al. (2012) document a non-linear relationship between leverage and productivity growth in Central and Eastern European manufacturing firms: leverage can support productivity up to a point, but excessive debt becomes detrimental. Ferrando and Ruggieri (2018) show that financial constraints are negatively associated with productivity among euro-area firms, with particularly strong effects where external finance is important. These findings suggest that financial fragility can operate as a bottleneck, limiting firms' capacity to convert improvements in the public environment into productive gains.

This perspective also helps interpret firm-size heterogeneity. Productivity differences across firms are persistent and reflect both internal capabilities and external operating conditions (Syverson, 2011). Larger firms often have broader access to finance, specialized management and internal infrastructures, while smaller firms are more dependent on external services and local public goods. The expected effect of public spending by size is therefore ambiguous.

Large firms may possess greater absorptive capacity, but small firms may experience a larger marginal benefit from improvements in infrastructure, human capital and public services because they cannot easily provide these inputs internally. The empirical analysis tests which mechanism dominates in the European manufacturing sample.

3. DATA AND EMPIRICAL APPROACH

3.1 Data and variable construction

The analysis combines firm-level and national data for the period 2015-2023. Firm information comes from Bureau van Dijk's Orbis database and covers listed and unlisted manufacturing companies classified in NACE Rev. 2 sectors 10-33. The sample is restricted to firms with at least 10 employees and requires the availability of core accounting variables needed to construct productivity and financial indicators. The resulting database contains 258,026 manufacturing firms. The broad coverage of private and public companies is important for capturing the structure of European manufacturing, where small and medium-sized enterprises represent a substantial share of productive activity. National public expenditure is taken from the OECD Classification of the Functions of Government (COFOG). Firm-year observations are matched to country-year fiscal variables.

The main explanatory variable, EHEA, is the share of total government expenditure allocated to Education, Health and Economic Affairs. Economic Affairs includes expenditure on transport, energy, communication, industry, labour-market functions and related research and development. The specification also controls for the share allocated to Social Protection and for total public expenditure as a percentage of GDP, allowing the analysis to distinguish a compositional shift from a general expansion of the public sector. Macroeconomic controls from Eurostat include GDP per capita and trade openness, measured by imports plus exports relative to GDP. Firm-level controls include the logarithm of total assets and two measures of financial exposure: the debt-to-asset ratio and the debt-to-equity leverage ratio. Financial heterogeneity is examined by comparing firms above and below the sample median of these debt indicators after trimming extreme observations.

Firm size is classified by employment: small firms have 10-49 employees, medium firms 50-249, and large firms at least 250 employees. The dependent variable is firm-level Total Factor Productivity. The baseline TFP measure is obtained from a proxy-variable production-function approach that uses firm information on output and production inputs and is designed to reduce simultaneity bias in input choices, following established productivity-estimation methods (Ackerberg, Caves and Frazer, 2015). The technical estimation details are not repeated here because the objective of this conference paper is to focus on the fiscal-policy relationship and its economic interpretation.

Table 1: Main data sources and variables (authors' elaboration)

Variable	Source	Description
TFP	Orbis	Dependent variable; firm-level productive efficiency
Public spending in Education Health and Economic Affairs (EHEA)	OECD: COFOG	Main explanatory variable; Education + Health + Economic Affairs as % of total public expenditure
Other fiscal variables: social protection; total expenditure	OECD: COFOG	Controls for budget composition and government size
GDP per capita; trade openness	Eurostat	Country level controls for development and international integration
Total assets; debt-to-asset; debt-to-equity;	Orbis	Firm level controls and heterogeneity in financial exposure
Firm size (employment)	Orbis	Small 10-49; medium 50-249; large >=250 employees

3.2 Empirical specification

The baseline analysis estimates panel regressions linking firm-level TFP to EHEA and the other fiscal variables. The first specification includes country and year fixed effects. The second adds GDP per capita and trade openness, and the third adds firm size and financial-structure controls. Standard errors are clustered at the country level to account for common shocks and serial correlation within national fiscal environments.

The heterogeneity analysis then interacts EHEA with indicators for high debt-to-asset and high leverage, and separately with firm-size classes. These specifications identify whether the productivity association with productive spending differs across firms that face different internal constraints. The emphasis is on economically interpretable differences in the response to a common national fiscal environment rather than on the technical properties of alternative estimators.

The descriptive evidence confirms substantial heterogeneity in both dimensions of the analysis. In 2022, total public expenditure across the European countries covered by the COFOG analysis averaged about 48.6% of GDP. Social Protection was the largest function, while Economic Affairs, Health and Education together represented a substantial share of national budgets.

The country patterns were markedly different: France and Italy recorded high total expenditure ratios, whereas other countries combined lower aggregate spending with different functional priorities. Firm balance sheets were equally heterogeneous. Italy displayed persistently high leverage and debt-to-asset ratios, especially among smaller firms, whereas Germany showed a more balanced distribution across size classes. These contrasts motivate the interaction analysis: a similar fiscal intervention may produce different firm-level outcomes in different financial ecosystems.

4. RESULTS

4.1 Public spending composition and firm productivity

Table 2: Baseline estimates for firm-level TFP (authors' elaboration)

Variable	(1) Fiscal baseline	(2) + macro controls	(3) + firm controls
EHEA	0.006** (0.002)	0.004** (0.001)	0.005*** (0.002)
Social Protection	-0.003** (0.001)	-0.001 (0.001)	0.000 (0.002)
Total public exp./GDP	-0.001* (0.001)	0.001 (0.001)	0.001 (0.001)
ln GDP per capita	-	0.211** (0.075)	0.216*** (0.070)
Trade openness	-	0.019 (0.027)	0.020 (0.027)
ln Total assets	-	-	0.010 (0.006)
Debt-to-asset	-	-	-0.135*** (0.020)
Leverage	-	-	0.000* (0.000)
Observations	926,530	835,200	835,183
R-squared	0.148	0.147	0.158

*Notes: Dependent variable is log TFP estimated on operating revenue. Country and year fixed effects are included in all three specifications. Standard errors are clustered at the country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.10.*

The baseline results show a stable positive relationship between the productive composition of public expenditure and firm-level productivity. In the simplest specification, the EHEA coefficient is 0.006 and statistically significant at the 5% level. Because TFP is expressed in logarithms while EHEA is measured in percentage points of total expenditure, the coefficient can be read as a semi-elasticity: a one-percentage-point increase in the EHEA share is associated with approximately a 0.6% increase in firm-level TFP. Adding GDP per capita and trade openness reduces the coefficient to 0.004, but it remains statistically significant. The fully specified model, which also controls for firm scale and financial structure, produces an EHEA coefficient of 0.005, significant at the 1% level. The central result is therefore not explained by the fact that richer economies both spend differently and host more productive firms, nor by differences in the observable firms' characteristics included in the model. Across the specifications, the estimated effect is economically meaningful and lies in the range of roughly 0.4-0.6% higher TFP for a one-percentage-point shift toward EHEA. The other fiscal coefficients reinforce the compositional interpretation. Social Protection is negatively associated with TFP in the simplest model, but the coefficient becomes statistically insignificant once broader macroeconomic conditions are included. Total public expenditure relative to GDP is also not significant in the richer specifications. The implication is not that redistributive expenditure lacks social value, but that its direct relationship with firm productivity is weaker than that of expenditure linked to human capital and the productive environment. Similarly, a larger public sector does not by itself appear to generate higher firm-level TFP once the allocation of the budget is taken into account.

GDP per capita has a positive and significant coefficient in the macro-augmented models, consistent with firms benefiting from more developed institutional, infrastructural and technological environments. Trade openness is positive but not statistically significant. At the firm level, total assets do not have a significant independent association with TFP once the other variables are controlled for. By contrast, the debt-to-asset ratio is strongly negative: the coefficient of -0.135 indicates that financial fragility is closely related to lower productive performance. The debt-to-equity ratio is weakly positive but economically negligible, suggesting that the share of assets financed by debt is the more informative measure of vulnerability in this setting. Taken together, these results are consistent with a crowding-in interpretation. Public spending appears most effective when it is allocated toward functions that improve inputs and operating conditions used by private firms. The absence of a significant positive coefficient on aggregate expenditure indicates that this mechanism is not a simple scale effect. Rather, the productive content of the budget matters. This finding is closely aligned with the macroeconomic distinction between productive and non-productive expenditure and extends it to firm-level outcomes in European manufacturing.

4.2 Financial and size heterogeneity

Table 3 reports the results of the heterogeneity analysis where we interact the EHEA variable with the firms' financial structure and firms' size class.

Table 3: Heterogeneous effects of EHEA by financial structure and firm size

Heterogeneity dimension	Reference-group EHEA effect	Interaction / difference	Total effect for comparison group
High debt-to-asset vs. low	0.005*** (0.002)	-0.002** (0.001)	0.003** (0.001)
High leverage vs. low	0.005*** (0.002)	-0.002** (0.001)	0.003** (0.001)
Medium vs. small firms	0.005*** (0.001)	-0.002* (0.001)	0.003* (0.002)
Large vs. small firms	0.005*** (0.001)	-0.001 (0.003)	0.004 (0.003)

*Notes: Financial-exposure models and size models use the thesis heterogeneity specifications with country, sector, year and firm fixed effects. Standard errors are clustered at the country level and reported in parentheses. The reported total effects correspond to the sum of the reference-group EHEA coefficient and the relevant interaction. *** p<0.01, ** p<0.05, * p<0.10.*

4.2.1 Financial heterogeneity

The interaction models show that firm financial structure is a central transmission channel. For firms with relatively low debt exposure, the EHEA coefficient is 0.005 and statistically significant at the 1% level. The interaction between EHEA and a high debt-to-asset indicator is -0.002 and significant at the 5% level. The same pattern emerges when financial exposure is measured using debt-to-equity leverage. The total EHEA effect for highly exposed firms is approximately 0.003, compared with 0.005 for financially healthier firms. In economic terms, high financial exposure reduces the productivity gain associated with productive public spending by about 40%. This is a substantial attenuation. The result suggests that public expenditure can improve the external productive environment without guaranteeing that all firms can exploit the improvement equally. Firms with high debt burdens may face difficulty financing complementary machinery, digitalization, training or organizational investment. They may also operate with less adaptable capital and lower liquidity buffers, which limits their ability to respond to new infrastructure or to compete for skilled labour when the surrounding economy improves.

By contrast, firms with stronger financial positions have greater flexibility to combine public inputs with private investment. Improved transport or energy infrastructure, for example, lowers external constraints, but firms still need to reorganize supply chains or expand capacity to capture the full benefit. Likewise, education and health expenditure can improve the quality and reliability of labour inputs, but financially constrained firms may struggle to retain skilled workers or to undertake the training and technological investment needed to complement them. The results therefore connect fiscal policy to corporate finance: the same public intervention has different firm-level effects depending on the recipient's financial capacity. This mechanism has important implications for national policy. In countries where smaller firms are structurally more indebted or face weaker access to long-term finance, increasing productive expenditure alone may not be sufficient to close productivity gaps. Complementary policies that improve access to credit, strengthen capitalization or reduce short-term refinancing pressure can increase the effective return on public spending. The objective is not to substitute public finance for private discipline, but to prevent financial fragility from becoming a bottleneck that blocks the transmission of productivity-enhancing public inputs.

4.2.2 Firm-size heterogeneity

The size interactions show a second form of heterogeneity. Small firms, defined as firms with 10-49 employees, are the reference category and exhibit a positive EHEA coefficient of 0.005, significant at the 1% level. The interaction for medium-sized firms is -0.002 and weakly significant, implying a total effect of approximately 0.003. For large firms, the interaction is also negative but not statistically significant, and the corresponding total effect is not statistically different from zero at conventional levels. The clearest productivity response is therefore observed among small firms. This result is economically plausible because small firms tend to rely more intensively on the external environment. A large corporation may internalize training, logistics, digital systems or access to specialized services, whereas a smaller firm depends more heavily on local infrastructure, public education, healthcare, administrative efficiency and the broader quality of the business environment. A modest improvement in these public inputs can therefore have a comparatively high marginal effect on a small firm's costs and productive capacity. The lower response of medium-sized firms may reflect their transitional position. They have more complex organizational structures than small firms but may not yet possess the financial, managerial and technological capabilities of large corporations. As a result, they can face coordination costs and investment requirements that reduce the speed with which external improvements are translated into productivity. The large-firm estimate should be interpreted cautiously because the difference from small firms is not statistically significant. The evidence supports a stronger conclusion for small firms: they are not merely passive recipients of public support, but can be an efficient channel through which improvements in the productive environment translate into private-sector performance. The size results also caution against designing fiscal policy exclusively around large firms on the assumption that they have the greatest absorptive capacity. In productivity-oriented policy, the marginal return to public infrastructure and services may be high precisely where firms lack the scale to reproduce those inputs privately. This does not imply that all SME support is productive. Rather, it highlights the potential value of broad public goods and well-targeted enabling services that lower operating frictions across a population of smaller manufacturers.

5. DISCUSSION AND POLICY IMPLICATIONS

The empirical evidence suggests that the conventional question of “more state or less state” is too coarse to evaluate the productive role of fiscal policy. The more relevant issue is how public resources are allocated and whether firms are in a position to use them.

The EHEA result indicates that expenditure associated with human capital, health and the economic environment has a stronger relationship with firm productivity than the aggregate size of the budget. In this sense, national economies face a composition problem before they face a scale problem. For European manufacturing policy, this has several implications. First, expenditure reviews should distinguish between functions according to their expected connection with productive capacity. Education, transport, energy networks, communication infrastructure, labour-market services and applied research are not interchangeable with other spending categories from the perspective of firm productivity. Protecting or improving the quality of these functions can matter even when the overall fiscal envelope is constrained. Second, the financial condition of firms should be treated as part of fiscal-policy design. If high indebtedness reduces the productivity response to EHEA expenditure by roughly 40%, then weak balance sheets can materially lower the effective return on public investment. Policies aimed at improving productivity may therefore be more effective when accompanied by measures that facilitate sustainable long-term financing, improve capitalization or reduce informational barriers in credit markets. Such measures should not shield persistently unproductive firms from market discipline; their purpose is to allow viable firms to undertake complementary investment when public infrastructure and human-capital conditions improve. Third, the strong small-firm response indicates that general productive public goods can have distributional consequences across the firm-size spectrum. Small firms can benefit strongly from improvements in external conditions because they rely on them more heavily. This is particularly relevant in countries whose manufacturing systems are dominated by SMEs. It also means that policy should distinguish between targeted transfers to individual firms and investments in common enabling conditions. The latter may support a broader set of firms without requiring the state to select individual corporate winners. Finally, the cross-country descriptive evidence shows why policy cannot be fully standardized. National financial systems, expenditure structures and firm populations differ substantially. The same increase in economic-affairs or education spending may have a larger effect in a country where firms can readily finance complementary investment than in an economy where high leverage and short-term debt are pervasive. The interaction between public spending and national financial architecture is therefore part of the policy transmission mechanism. A structurally informed fiscal strategy should combine productive expenditure with reforms that improve the capacity of firms to absorb it. These conclusions fit a broader interpretation of national economies between liberalization and intervention. Public intervention need not be understood as the opposite of private-sector dynamism. When it supplies productive inputs and is matched to the financial conditions of firms, it can strengthen the environment in which market activity takes place. Conversely, poorly targeted expenditure or interventions that ignore private-sector constraints may produce limited productivity effects even when fiscal resources are large. The distinction is thus between enabling and non-enabling intervention rather than simply between intervention and non-intervention.

6. CONCLUSION

This paper investigates how the functional composition of public expenditure relates to firm-level productivity in European manufacturing. By matching Orbis firm data with OECD COFOG expenditure and Eurostat macroeconomic indicators for 2015-2023, it connects national fiscal choices with microeconomic outcomes across a large and heterogeneous population of firms. Three findings emerge. First, a greater share of public expenditure allocated to Education, Health and Economic Affairs is positively associated with firm TFP. In the fully specified baseline model, a one-percentage-point increase in the EHEA share corresponds to an estimated productivity increase of about 0.5%, while the aggregate level of public spending is not statistically significant.

Second, financial fragility weakens this relationship: firms with high debt exposure capture about 40% less of the estimated productivity gain. Third, small firms show the clearest positive response to productive spending, suggesting that improvements in the external productive environment can be especially valuable for firms with limited internal capacity to substitute for public inputs. The productivity effect of fiscal policy depends on what governments spend on, how effectively those functions are delivered, and whether firms have the financial capacity to respond. Productive expenditure and healthy private balance sheets are therefore complementary elements of the same transmission process. In European economies characterized by diverse financial systems and firm structures, a uniform fiscal approach is unlikely to maximize firm-level productivity.

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WINNING THE MARKET: THE POWER OF BATTLE CARDS IN MARKETING

Arina Priscah
Budapest University of Economics and Business, Marketing Master's Programme
Arina.Priscah.44@unibge.hu

Emese Kurucz
Budapest University of Economics and Business, Marketing Master's Programme
Kurucz.Emese.29@unibge.hu

Sayfon Phapaseuth
Budapest University of Economics and Business, Marketing Master's Programme
Phapaseuth.Sayfon.21@unibge.hu

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business, Marketing Master's Programme
papp-vary.arpad@uni-bge.hu

ABSTRACT

In today's business environment, marketing dynamics change rapidly. Consumer needs and expectations evolve quickly, competition intensifies, and new market trends emerge continuously. Therefore, marketers must stay up to date with current market developments and competitors, not only through tools that provide insights but also through those that offer precision, such as battle cards. A battle card is a concise strategic document that equips marketers with key information comparing a company's products and services with those of its competitors to help them win target customers. Battle cards improve the effectiveness of marketing teams by providing quick access to essential information about a product, including its features, pricing, value propositions, common customer objections, and recommended responses. This gives organizations a competitive advantage in the marketplace. This paper discusses how marketing battle cards can be used as an effective tool in modern marketing teams. It examines the strategies, technologies, practical examples, best practices, and future trends behind battle cards, demonstrating how they help companies design more effective campaigns and promotional activities that differentiate them from competitors and strengthen their market position.

Keywords: *battle cards, competitive intelligence, sales enablement, marketing strategy, competitive advantage, artificial intelligence*

1. INTRODUCTION

The market environment today might feel crowded as new products emerge daily. Apart from keeping up with consumer needs and expectations, marketing teams should also understand their competitors, as they are an important factor when deciding which marketing strategies to use to navigate the market. Battle cards come in at this point and have proven to be a powerful marketing tool. They are concise, actionable summaries containing key information about a company's product in comparison with its competitors. They typically include information about customers, pricing, value propositions, customer objections, and recommended responses. Key information in battle cards can be categorized into four parts: the company and the product, the competition, customers and sales strategies, and case studies. Under the company and product section, the information usually begins with a company overview, explaining its vision, mission, core values, and history.

This is followed by product details, including key features and pricing, as well as the value proposition, highlighting the product's unique selling points. Competitor information is another essential element of battle cards. It includes an analysis of competitors' strengths, weaknesses, strategies, and target markets. This information helps companies make strategic marketing decisions and develop competitive differentiators that enable them to stand out in the market. Customer objections and recommended responses are also important components of battle cards. Marketing teams need to understand common customer needs and challenges and prepare appropriate responses. Finally, case studies and success stories can provide practical guidance and best practices. Battle cards have become an essential tool in modern marketing. As markets become more competitive and information-rich, marketing teams require tools that help them quickly interpret the competitive environment and confidently communicate product advantages. Battle cards help teams remain aligned with the company's competitive strategy. To begin with, battle cards provide marketing teams with valuable competitive intelligence. They summarize competitors' strengths and weaknesses, enabling marketers to develop strategies that effectively position their products against competing offerings. This, in turn, helps companies strengthen their customer base, increase sales, and improve business performance. Battle cards also promote consistency throughout an organization. They ensure that all departments—including brand managers, content creators, marketing professionals, and sales teams—communicate using the same key messages, differentiators, and value propositions. Research emphasizes that consistent, differentiated messaging is a key driver of strong brand performance and customer trust (Kotler & Keller, 2016; Sarkozi & Szabo, 2024). In addition, battle cards help companies remain proactive by identifying changes in competitors' activities. This awareness enables organizations to adjust their campaigns and continuously refine their value propositions. This paper examines battle cards as strategic marketing tools in today's competitive environment. It discusses their role in competitive intelligence and sales enablement, presents real-world examples and technological developments, and highlights best practices and future trends that contribute to more effective marketing and sales performance.

2. COMPETITIVE INTELLIGENCE IN BATTLE CARDS

Competitive intelligence is the systematic and ethical process of gathering and analyzing information about competitors, broader markets, and trends to inform strategic decisions and gain a competitive edge. It provides actionable insights that guide companies in making appropriate strategic decisions by understanding expected market shifts, competitor behaviour, opportunities for differentiation, and emerging market trends. According to Fleisher and Bensoussan (2015), effective competitive intelligence is not espionage but relies on publicly available information and structured analysis. It focuses on the 7Ps of marketing: Product, Price, Place, Promotion, People, Process, and Physical Evidence. When this intelligence is organized into battle cards, it becomes a practical tool that teams can use in real time to refine messaging, anticipate objections, and position their offerings more effectively (Szabó et al., 2014; Fleisher & Bensoussan, 2015). Battle cards transform competitive intelligence into concise summaries that guide the company and serve as a bridge between competitive intelligence and actual sales activities. Competitive intelligence plays a significant role in creating battle cards and can be regarded as their backbone. Competitive intelligence processes are the primary source of information for marketing teams when developing battle cards. The tools used continuously monitor and gather competitor information, such as pricing changes, new product features, and market shifts, ensuring that the information remains current and can be used for real-time decision-making. Effective battle cards are built on reliable data rather than assumptions. When the information included in battle cards is accurate, companies can develop their strategies with greater confidence while reducing the risk of overestimating or underestimating competitors' capabilities. Furthermore, most competitor information is initially available only as raw data.

Competitive intelligence analyses and organizes these data by identifying the key insights that can be transformed into actionable battle cards. Research consistently shows that companies using structured competitive intelligence outperform those that do not because competitive intelligence strengthens strategic alignment and improves organizational decision-making (Calof & Wright, 2008).

3. SALES ENABLEMENT STRATEGY

Marketing teams develop the messaging, positioning, and competitive insights, while sales teams use these insights in their interactions with customers. Battle cards are designed to help organizations win in the marketplace by acting as a bridge between strategy and execution. When battle cards are developed for sales enablement, they become tools that not only guide marketing decisions but also directly support customer-facing teams that rely on fast and accurate information. For sales enablement to be effective, salespeople must provide accurate, real-time information to customers at the right moment. Research shows that effective sales enablement improves message consistency, strengthens buyer engagement, and increases win rates because teams are better equipped to articulate value and handle objections (Dixon & Adamson, 2011; Peterson & Dover, 2021; Peterson et al., 2021; Lauzi et al., 2023; Hamlet & Rangarajan, 2021). By embedding the core elements of sales enablement into battle cards, marketers ensure that salespeople can communicate confidently and convincingly in any competitive situation. The integration of battle cards with sales enablement strengthens alignment between marketing and sales teams. Instead of operating independently, both teams share a common source of market information. This alignment leads to more effective campaigns, clearer customer experiences, and smoother handoffs across the sales funnel. Studies show that organizations with strong alignment between sales and marketing perform better because communication is more consistent and they respond more strategically to competitive pressures (Andrade et al., 2014; Pacsi & Szabó, 2018). Finally, when feedback from sales flows back into marketing, it makes battle cards even stronger. Sales teams interact directly with the market and therefore understand how competitors position themselves and which objections they encounter most frequently. When these insights are incorporated into marketing's competitive intelligence, they help keep battle cards relevant, accurate, and easy to use. This creates a continuous improvement cycle in which marketing provides structure, sales contributes real-world insights, and battle cards become high-impact tools that support both teams.

4. STRUCTURE OF AN EFFECTIVE BATTLE CARD

As a document designed to equip marketers and sales teams with comparative information to win target customers, battle cards should be built for speed. Effective battle cards have a clear structure and contain distinct components that allow salespeople to navigate competitive conversations quickly without getting lost in unnecessary detail.

4.1. The Anatomy of a Battle Card: Key Sections

While every industry is slightly different, the basic structure of a successful battle card remains the same. To transform raw competitive intelligence into a practical tool, several key sections are essential. It begins with the Competitor Overview, or "At-a-Glance" section, which provides a quick snapshot of the competitor's market positioning, target audience, and pricing model. Once these basics are established, the card moves to the core offensive strategy: Win Themes and Value Propositions. This section explains where the company's product stands out by emphasizing customer benefits rather than simply listing technical features. The most dynamic parts of the card are often referred to as the "Shield" and the "Sword." The Shield focuses on objection handling.

Since competitors will inevitably plant seeds of doubt in customers' minds, this section lists common objections together with ready-made responses. In contrast, the Sword—often called "Landmines"—contains strategic questions designed to shift the conversation toward competitors' weaknesses. By asking carefully selected questions, salespeople encourage customers to recognize limitations in competing offerings. Finally, every battle card should include Proof Points, such as testimonials, case studies, or audit results, that validate the proposed value propositions and provide evidence to support the sales conversation.

4.2. Formats and Visual Hierarchy

Content is important, but if the design is cluttered, salespeople are unlikely to use the battle card. It must remain readable while someone is actively listening to a prospective customer, making format and visual hierarchy essential. The most important characteristic is scannability. Information should be organized logically with clear headings so that users can find answers within seconds. While many organizations still rely on traditional side-by-side comparison charts, modern battle cards increasingly organize information around specific customer problems or "Jobs to Be Done." Strong visual cues, such as colour coding and icons, further improve usability. For example, using green to highlight winning arguments and red to indicate danger zones transforms the document from a dense reference sheet into an intuitive decision-support tool.

5. REAL-WORLD EXAMPLES

The value of sales enablement becomes clearer through real-world applications of its principles. Organizations that successfully use battle cards treat them as active strategic tools rather than passive reference materials. Companies such as Gong, Kompyte, Salesforce, and HubSpot demonstrate how battle cards can strengthen competitive positioning and support sales teams in winning important deals.

5.1. Gong

Gong has transformed battle card management through its leadership in revenue intelligence. Rather than creating lengthy feature-comparison documents that overwhelm sales representatives, Gong's sales approach focuses on "pivoting". The Ultra-Competitive Deal template enables sales teams to shift customer discussions from product features to the actual business needs of their clients. Gong also develops battle cards containing concise "Soundbites" that enable sales representatives to deliver short, natural statements during live customer conversations without sounding scripted. Instead of apologizing for a competitor's advantage in a particular feature, Gong's battle cards provide scripts that reposition that feature as less relevant to the customer's strategic objectives, thereby changing the purchasing criteria used in the decision-making process (Gong.io, 2023).

5.2. Kompyte

Kompyte promotes the development of multiple battle card types because a single competitor card is rarely sufficient. According to Kompyte, now part of Semrush, the buyer journey requires nine different battle card types. Three of the most important include (Meredith, 2022):

- The Kill Card, which focuses on a competitor's most critical weaknesses.
- The Objection Handling Card, which provides evidence-based responses to common customer concerns, such as implementation time or cost.
- The Why We Win Card, which presents the company's unique value propositions supported by social proof and case studies.

5.3. Salesforce and HubSpot

At Salesforce and HubSpot, battle cards have evolved into dynamic resources that sales teams access as part of their daily workflow. Their contextual battle cards use real-time logic to provide relevant information whenever sales representatives add competitors to opportunities or update CRM stages. Instead of remaining static documents stored in shared folders, battle cards deliver marketing insights precisely when they are needed during the sales process.

6. ACADEMIC INSIGHTS

While professional blogs are useful for providing quick, practical advice, academic research helps explain the theoretical foundations behind battle cards. It demonstrates why battle cards are more than simple reference sheets and highlights their role as strategic tools for sustaining a competitive advantage.

6.1. Sales Enablement as a Dynamic Capability

In management theory, the concept of **dynamic capability** refers to an organization's ability to remain flexible and adapt to changing market conditions. Research by Proksch suggests that battle cards should not be viewed as static documents. A PDF becomes outdated the moment a competitor changes its pricing or launches a new feature. Therefore, researchers argue that the updating process is more important than the document itself. The real value lies in how quickly a company can detect market changes, update its competitive intelligence, and deliver that information to the sales team so they can adapt their approach.

6.2. Bridging the Marketing–Sales Gap

A common challenge in B2B organizations is the gap between marketing and sales. Marketing creates content, but sales teams do not always use it. Battle cards can serve as a practical bridge between these two functions. Research on organizational alignment shows that effective collaboration requires more than regular meetings; it also requires shared tools and resources. Battle cards developed solely by marketing often fail because they emphasize brand-related messages instead of practical sales conversations. The most successful battle cards are created collaboratively, ensuring that sales representatives receive information that is useful during real customer interactions.

6.3. The Shift from Support to Enablement

Historically, marketing played a supportive and reactive role, providing materials only when requested by sales representatives. Recent research, however, highlights a shift toward sales enablement, where support becomes proactive rather than reactive. Instead of waiting for a salesperson to ask, "How do I beat Competitor X?", enablement teams have already analysed competitors, identified their weaknesses, and prepared battle cards before customer interactions begin. This proactive approach helps new employees become productive more quickly while enabling all salespeople to perform more effectively.

7. PSYCHOLOGY OF PERSUASION

Why do battle cards work? Their effectiveness is not based solely on the information they contain, but also on how they align with the way people process information and make decisions.

7.1. Managing Cognitive Load

Selling is mentally demanding. During a sales conversation, representatives must listen carefully, navigate their systems, recall product information, and manage the flow of the discussion simultaneously.

According to Cognitive Load Theory, the human brain can process only a limited amount of information at one time (Sweller, 2011). If salespeople spend valuable mental effort trying to remember a competitor's pricing, they become less effective listeners. A well-designed battle card functions as an external memory aid, allowing salespeople to focus their attention on understanding and engaging with the customer rather than recalling facts.

7.2. Confidence and the "Halo Effect"

Battle cards not only educate customers but also increase the confidence of salespeople. Having accurate information readily available gives sales representatives what psychologists describe as informational power. This confidence contributes to the Halo Effect, whereby a positive impression in one area influences overall perceptions. When a salesperson answers difficult competitive questions quickly and accurately, customers are more likely to perceive both the salesperson and the product as competent, reliable, and trustworthy.

7.3. Framing and Priming

The language used in battle cards also relies on the psychological principles of framing and priming. The way information is presented influences how customers interpret it. For example, instead of stating that a product is "not expensive," a battle card may frame a competitor's solution as having a high total cost of ownership. Similarly, carefully designed questions, such as "How important is data portability to you?", encourage customers to focus on features where competitors may be weaker. Research suggests that these subtle changes in language can significantly influence customer preferences, even when competing products are technically similar.

8. TECHNOLOGY & TOOLS POWERING MODERN BATTLE CARDS

Modern battle cards are increasingly supported by advanced technologies and tools that enhance their effectiveness and accessibility.

8.1. Competitive Intelligence Platforms

The use of battle cards provides several significant benefits for organizations. It strengthens sales teams by equipping them with precise, evidence-based counterarguments while also facilitating the training of new employees through clear and relevant information. In addition, battle cards create a shared understanding of the company's strategy that employees can easily access, leading to more informed decisions that support both organizational objectives and team alignment. Moreover, battle cards are not static documents but practical guides that can be continuously updated with market developments and feedback from sales teams. This enables organizations to stay aligned with industry changes and maintain a competitive advantage over time (Brereton, 2024).

8.2. CRM and Sales Enablement Tools

The integration of battle cards into CRM and sales enablement platforms provides a significant advantage for modern sales teams. With battle cards embedded in platforms such as Salesforce, HubSpot, and FreshSales, teams can conveniently access essential competitive intelligence and product messaging throughout their daily activities. This integration eliminates the need to search for information outside sales dashboards, as relevant battle cards are displayed automatically according to specific customer accounts, opportunities, or competitors. Automated synchronization also ensures that battle cards remain up to date with the latest market insights and competitor developments, providing salespeople with accurate and timely information to handle objections and highlight key differentiators.

Ultimately, this seamless integration makes battle cards more accessible and widely used while improving sales agility and increasing win rates (Carter, 2025).

8.3. The Role of AI and Automation

AI-generated battle cards are changing the way organizations create and manage competitive intelligence.

AI has become an important tool for product marketing and competitive intelligence teams, enabling them to accelerate the battle card creation process significantly. Research that previously required several hours can now be completed within minutes.

AI Advantages for Battle Cards

Teams using AI to create battle cards benefit from several important advantages:

- Speed: Detailed battle card content can be generated in less than a minute instead of requiring hours of manual work.
- Fresh Perspectives: AI identifies insights from customer feedback and interviews that might otherwise be overlooked.
- Consistency: AI helps ensure that all battle cards follow a consistent structure and quality standard.
- Real-time Updates: AI enables organizations to obtain the latest information about competitors from multiple sources almost instantly (Pajkovic, 2025).

9. BEST PRACTICES FOR CREATING EFFECTIVE BATTLE CARDS

Even with the best technology, battle cards provide value only when they are designed effectively. The following best practices are commonly used by high-performing sales organizations.

9.1. Clarity, Simplicity, and Customer Focus

To ensure they are highly usable, battle cards should be clear, concise, and free from excessive text. They should be logically organized and use bullet points and headings to facilitate quick scanning. The content should focus on customers by highlighting their pain points and needs, enabling sales representatives to engage with them more effectively through relevance and empathy during sales conversations (Welch, 2025).

9.2. Objection Handling and Regular Updates

One of the main advantages of effective battle cards is their ability to address customer objections through well-prepared responses. Including common objections together with suggested answers enables salespeople to handle conversations with greater confidence. In addition, battle cards require regular updates to reflect changes in competitors' products, pricing, and market trends, ensuring that the information remains accurate and relevant (Welch, 2025).

9.3. Proof Points and Persona-Based Versions

Battle cards should incorporate credible evidence, such as customer testimonials, case studies, and third-party audits, to strengthen claims and build trust. In addition, developing customized battle cards for different buyer personas or market segments enables sales teams to tailor their messaging more effectively, increasing their ability to influence different decision-makers and improving their chances of success (Chapman & Garanhel, 2025).

10. FUTURE TRENDS OF BATTLE CARDS

Battle cards are evolving rapidly in response to emerging technologies and changing buyer behaviour. The following trends are expected to shape their future.

10.1. AI-Generated and Adaptive Battle Cards

AI-generated and adaptive battle cards represent the next generation of sales enablement tools, leveraging the power of artificial intelligence to create competitive intelligence more quickly and efficiently. Marketing and sales teams no longer need to reinvent the wheel each time, as AI tools can filter and compile vast amounts of information—from product features and pricing to customer reviews and win/loss feedback—into comprehensive battle cards within minutes. AI-enhanced battle cards include win themes, objection-handling scripts, competitor summaries, and proof points supported by both internal resources and public reviews. Adaptive battle cards can also update themselves based on real-time market developments and sales interactions, adjusting their content and emphasis to match each buyer's situation. This flexibility enables sales teams to deliver timely and relevant insights when they are needed most, increasing their ability to outperform competitors and close deals more effectively. Although AI-generated battle cards significantly accelerate content creation and improve personalization, they complement rather than replace human expertise, which remains essential for ensuring accuracy and strategic depth (Pajkovic, 2025; Morgan, 2024).

10.2. Interactive and Visual Enhancements

Interactive marketing battle cards, such as dashboard-based solutions, provide sales and marketing teams with a clear and intuitive view of competitive intelligence. These dashboards often include real-time visualizations, such as charts, graphs, heat maps, and sales funnel views, illustrating competitor activities, pricing, customer sentiment, and sales performance. Interactive features allow users to explore specific data points, customize views according to their needs, and analyse competitive scenarios more effectively. This approach helps teams better understand complex information, identify opportunities and risks, and respond more quickly to market changes. Furthermore, integration with CRM and sales enablement platforms allows these dashboards to become part of everyday workflows, providing decision-makers with context-specific intelligence at the right moment. Interactive and visual battle cards not only improve the usability of competitive intelligence but also make it more engaging, memorable, and effective during sales conversations (Morales, 2023; Somanathan, 2024).

10.3. Collaboration Features

Improved collaboration features are also shaping the future of marketing battle cards. They encourage closer cooperation among sales, marketing, product, and sales enablement teams when creating, updating, and refining content. This collaboration ensures that battle cards reflect the latest competitive intelligence, product developments, and customer feedback. Team-based platforms enable multiple stakeholders to contribute their expertise and practical sales experience, making battle cards more relevant and useful. Many collaborative platforms also include feedback loops that allow users to suggest improvements based on their field experience, supporting continuous refinement. This collaborative approach strengthens strategic consistency across departments while ensuring that messaging remains consistent throughout the buyer's journey. At the same time, it equips sales representatives with the latest and most comprehensive resources, improving both their confidence and their effectiveness in competitive selling situations (Presicci, n.d.; Brereton, 2023; Morales, 2023).

11. CONCLUSION

Battle cards are no longer just basic comparison tools but strategic bridges that connect high-level marketing insights with day-to-day sales execution. Organizations are increasingly adopting competitive intelligence and sales enablement platforms, and battle cards are evolving into dynamic capabilities rather than remaining static reference documents.

They reduce cognitive load by giving salespeople quick and reliable access to the information they need, allowing them to focus on listening and responding effectively during customer interactions. In addition, battle cards, especially for less experienced team members, help build confidence through structured guidance and support, reinforcing the positive effects associated with the Halo Effect. One of the most important transformations is the shift from listing technical features to communicating customer value, ensuring that sales conversations focus on solving buyers' problems rather than simply presenting products. Thanks to artificial intelligence, battle cards now support real-time updates, adaptive intelligence, and direct integration with CRM systems, making them more accurate, accessible, and actionable than ever before. In conclusion, battle cards have become strategic tools that empower sales teams, align marketing and sales efforts, and help organizations maintain a competitive advantage in rapidly changing markets.

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ARTIFICIAL INTELLIGENCE IN URBAN PARTICIPATORY PLATFORMS: CHALLENGES FOR INCLUSIVE DIGITAL GOVERNANCE

Luis Alberto Libanio Lima
Federal University of Technology – Paraná (UTFPR), Ponta Grossa Campus, Brazil
luisalbertolima@alunos.utfpr.edu.br

Cristina Rodrigues Piazer Turcato
Federal University of Technology – Paraná (UTFPR), Ponta Grossa Campus, Brazil
piazercristina@gmail.com

Vitor Hugo dos Santos Filho
State University of Maringá (UEM), Goioerê Regional Campus (CRG), Brazil
vhsfilho@uem.br

Claudia Tania Picinin
Federal University of Technology – Paraná (UTFPR), Ponta Grossa Campus, Brazil
GOVCOPP – University of Aveiro, Portugal
claudiapicinin@utfpr.edu.br

David Nunes Resende
School of Technology and Management of Águeda (ESTGA), University of Aveiro, Portugal
GOVCOPP – University of Aveiro, Portugal
david@ua.pt

ABSTRACT

O The advancement of Artificial Intelligence (AI) and digital platforms has transformed the management of smart cities, expanding interaction between governments and citizens while strengthening data-driven decision-making processes. In this context, the growing use of algorithms has intensified debates related to transparency, accountability, ethics, and public trust. Against this backdrop, this study analyzes the challenges of Artificial Intelligence in urban participatory platforms, focusing on the implications of algorithmic governance for the development of inclusive digital governance. The research adopts a qualitative and exploratory approach based on a literature review conducted in the Scopus and Web of Science databases. Using the Methodi Ordinatio methodology, a final portfolio of 20 scientific articles was selected. The results indicate that Artificial Intelligence can enhance urban management efficiency, automate processes, and improve decision-making. However, the literature also highlights challenges related to algorithmic transparency, digital exclusion, technological biases, and citizen participation. It is concluded that inclusive digital governance depends on balancing technological innovation, institutional transparency, social participation, and the protection of citizens' fundamental rights.
Keywords: *Artificial Intelligence; Urban Participatory Platforms; Algorithmic Governance; Digital Governance; Smart Cities; Citizen Participation*

1. INTRODUCTION

Digital transformation has been reshaping the way cities are planned, managed, and experienced. In this context, the concept of smart cities has emerged as an approach capable of integrating digital technologies, intelligent systems, and new governance models to address complex urban challenges.

Almulhim and Yigitcanlar (2025) emphasize that smart governance constitutes one of the pillars of sustainable cities, while Sanchez-Gallegos et al. (2025) highlight that the integration of the Internet of Things (IoT), digital platforms, and Artificial Intelligence enhances urban monitoring and management capabilities. Among the technologies driving this transformation, Artificial Intelligence (AI) occupies a prominent position. According to Yigitcanlar et al. (2024), its application in the public sector has evolved from administrative automation to systems capable of supporting strategic data-driven decisions. Furthermore, Liu et al. (2024) argue that the most effective outcomes of digital governance are achieved when AI is combined with human intelligence and social participation. Urban participatory platforms have expanded interactions between governments and citizens, strengthening mechanisms of digital engagement (Berigüete et al., 2024; Sieber et al., 2024). However, the increasing use of algorithms in urban management has also intensified concerns regarding algorithmic governance. Bruun (2021) argues that algorithms influence participation and decision-making processes, while Fontes et al. (2024) contend that the legitimacy of such systems depends on transparency, social participation, and accountability. In addition, Hacker and Neyer (2020) emphasize the importance of protecting fundamental rights and promoting digital justice. Against this background, this study analyzes the challenges of Artificial Intelligence in urban participatory platforms, focusing on the implications of algorithmic governance for the development of inclusive digital governance. To achieve this objective, a qualitative and exploratory study was conducted based on a structured literature review in the Scopus and Web of Science databases, applying the Methodi Ordinatio methodology to select the most relevant studies.

2. LITERATURE REVIEW

The literature review examined studies on smart cities, urban participatory platforms, algorithmic governance, and inclusive digital governance, aiming to identify the opportunities and challenges associated with the use of Artificial Intelligence in urban participatory processes.

2.1. Smart Cities and Digital Governance

The concept of smart cities is associated with the integration of digital technologies, data, and governance to support decision-making and the delivery of public services. In this context, the convergence of the Internet of Things (IoT), Artificial Intelligence (AI), urban sensors, and digital platforms enhances cities' monitoring and management capabilities, strengthening data-driven governance models (Almulhim & Yigitcanlar, 2025; Sanchez-Gallegos et al., 2025). Furthermore, the effectiveness of these solutions depends on governments' institutional capacity and cooperation among different social actors (Haraguchi et al., 2024). At the same time, urban participatory platforms expand channels of interaction between governments and citizens, fostering civic engagement and digital participation. However, factors such as accessibility, trust, and institutional responsiveness directly influence the effectiveness of these participatory mechanisms (Ogie, 2017). Therefore, digital governance should be understood not only as a process of technological modernization but also as a mechanism aimed at promoting transparency, social participation, and collaboration between governments and society.

2.2. Urban Participatory Platforms and Citizen Engagement

Urban participatory platforms have become important instruments for interaction between governments and citizens within the context of digital governance in smart cities. These platforms enable citizens to report demands, share urban information, and participate in decision-making processes.

In this context, Berigüete et al. (2024) highlight that advances in digital technologies have significantly expanded opportunities for citizen engagement, while Sieber et al. (2024) emphasize that AI-mediated civic participation has become a central topic in debates on digital governance and contemporary democracy. However, the expansion of digital channels does not, by itself, guarantee effective and inclusive participation. Ogie (2017) demonstrates that factors such as accessibility, trust, motivation, and institutional responsiveness directly influence citizen engagement in digital platforms. Similarly, Hacker and Neyer (2020) argue that participation in smart cities should be analyzed beyond its technological dimension, incorporating issues related to social inclusion, fundamental rights, and democratic legitimacy. Thus, although participatory platforms expand opportunities for interaction between governments and society, they may also reproduce inequalities, digital exclusion, and power asymmetries.

2.3. Artificial Intelligence and Algorithmic Governance

Artificial Intelligence (AI) has transformed public administration and digital governance models by enhancing urban monitoring, data analysis, and decision-making capabilities. According to Yigitcanlar et al. (2024), its application has evolved from administrative automation mechanisms to systems capable of supporting strategic data-driven decisions, consolidating information-driven governance models. However, the incorporation of algorithms into public administration represents more than a technological shift. As intelligent systems increasingly influence urban diagnostics, priority setting, and governmental decisions, they also intensify debates on algorithmic governance. In this context, Liu et al. (2024) argue that the best outcomes in public management result from the combination of Artificial Intelligence, human knowledge, and social participation, forming hybrid intelligence models. Despite its potential, the growing dependence on these technologies raises concerns regarding transparency, public accountability, and citizen participation. Bruun (2021) argues that algorithms are not neutral tools, as they organize priorities, filter information, and influence participation channels. Similarly, Fontes et al. (2024) contend that AI-related challenges should be addressed through a people-centered perspective that prioritizes inclusion, transparency, and public responsibility in the development of smart cities.

2.4. Ethical and Social Challenges

Despite the potential associated with smart cities and digital governance, the literature highlights that the advancement of these technologies also generates ethical, social, and institutional challenges. Ziosi et al. (2024) emphasize that the expansion of digital infrastructures and Artificial Intelligence has intensified debates concerning ethics, surveillance, privacy, and public accountability. Likewise, Fontes et al. (2024) argue that AI-related challenges should be examined not only from a technological perspective but also in terms of their impacts on society, institutions, and democratic processes.

In this context, privacy, data protection, social inclusion, and public trust emerge as key challenges of contemporary digital governance. Rasoulzadeh Aghdam et al. (2024) demonstrate that sustainable smart cities depend on balancing technological innovation, data protection, citizen participation, and social inclusion, while Hacker and Neyer (2020) stress the need to align these initiatives with fundamental rights and democratic legitimacy. Furthermore, Bruun (2021) highlights that the acceptance of intelligent systems is directly related to transparency in decision-making processes and citizens' understanding of how algorithms influence public decisions. Therefore, the development of inclusive digital governance requires not only technological innovation but also mechanisms capable of ensuring transparency, social participation, and the protection of citizens' rights.

3. METHODOLOGY

This study is characterized as a qualitative and exploratory research based on a literature review addressing Artificial Intelligence, urban participatory platforms, and digital governance in smart cities. The bibliographic search was conducted in the Scopus and Web of Science databases using terms related to Artificial Intelligence, algorithmic governance, digital participation, and smart cities. This process identified 52 scientific articles, of which 6 were duplicates, resulting in 46 publications for further analysis.

Database	Search String	Results
Scopus	("artificial intelligence" OR "algorithmic governance") AND ("urban participatory platforms" OR "digital participation" OR "e-participation" OR "citizen participation" OR "public participation") AND ("digital governance "OR "urban governance "OR "smart cities" OR "inclusive cities" OR "urban sustainability")	42
Web of Science	TS=(("artificial intelligence" OR "algorithmic governance") AND ("urban participatory platforms" OR "digital participation" OR "e-participation" OR "citizen participation" OR "public participation") AND ("digital governance" OR "urban governance" OR "smart cities "OR "inclusive cities" OR "urban sustainability"))	10

Table 1 – Search strategy and number of documents retrieved (Source: Authors' own elaboration, 2026).

After the removal of duplicate records, 46 publications remained for analysis. Subsequently, the Methodi Ordinatio methodology, proposed by Pagani, Kovaleski, and Resende (2015), was applied to select and rank the most scientifically relevant studies. The method considers criteria such as publication year, number of citations, and journal impact factor, providing greater rigor and transparency to the bibliographic selection process. As a result, a final portfolio of 20 scientific articles aligned with the research objectives was established, forming the theoretical and analytical foundation of this study. The work of Pagani, Kovaleski, and Resende (2015) was also adopted as the methodological reference to support the selection and ranking process of the portfolio.

Filtering Procedure	Number of Articles
Articles identified in Scopus and Web of Science databases	52
Duplicate articles removed	6
Articles remaining for analysis	46
Articles selected for the final portfolio (Methodi Ordinatio)	20

Table 2 – Article filtering and selection procedure (Source:Authors' own elaboration, 2026).

Although the final portfolio consisted of 20 articles selected through the Methodi Ordinatio methodology, the studies were analyzed thematically throughout the discussion. Accordingly, each section prioritized the works most closely aligned with the respective analytical dimensions, including algorithmic governance, citizen participation, urban participatory platforms, and inclusive digital governance. This approach enabled a more coherent and critical analysis aligned with the objectives of the study.

4. RESULTS AND DISCUSSION

This section presents the main findings identified in the literature selected through the Methodi Ordinatio methodology. The discussion was organized into four analytical dimensions: (i) opportunities of Artificial Intelligence in urban governance; (ii) citizen participation and digital engagement; (iii) algorithmic governance and public trust; and (iv) challenges for inclusive digital governance.

4.1. Opportunities of Artificial Intelligence in Urban Governance

A The literature highlights that Artificial Intelligence has played a strategic role in the modernization of urban governance by enhancing governments' capacity to process data, automate tasks, and support decision-making in complex urban environments. In this context, Yigitcanlar et al. (2024) emphasize that the integration of AI, digital platforms, and Big Data facilitates pattern identification and the optimization of strategic decisions. Similarly, Sanchez-Gallegos et al. (2025) argue that the convergence of Artificial Intelligence, the Internet of Things (IoT), and urban sensors significantly improves cities' monitoring and management capabilities, while Haraguchi et al. (2024) highlight the potential of urban digital twins to support more sophisticated decision-making processes.

The studies analyzed also indicate that AI contributes to administrative efficiency and the improvement of public services. Vrabie (2024) demonstrates that intelligent systems can enhance the responsiveness of local governments, while Almulhim (2024) emphasizes their potential to support monitoring, forecasting, and sustainable urban management. Furthermore, Liu et al. (2024) argue that the most effective outcomes of digital governance are achieved when Artificial Intelligence complements human knowledge, strengthening hybrid intelligence models. However, the literature emphasizes that the benefits associated with AI depend on the existence of mechanisms for supervision, transparency, and institutional accountability. According to Strielkowski et al. (2023), the increasing digitalization of public services improves urban management efficiency but also increases dependence on technological infrastructures. Therefore, the opportunities offered by Artificial Intelligence can only be fully realized when accompanied by governance practices that ensure social oversight and alignment with public interests.

4.2. Citizen Participation and Digital Engagement

Citizen participation has assumed a strategic role in digital governance models for smart cities. Urban participatory platforms have expanded channels of interaction between governments and citizens, enabling individuals to report demands, monitor public services, and contribute to urban decision-making processes. In this context, Berigüete et al. (2024) highlight that digital technologies have strengthened communication and collaboration mechanisms between society and public authorities, thereby expanding opportunities for citizen engagement. At the same time, the incorporation of intelligent systems into digital platforms has transformed the dynamics of civic participation. Sieber et al. (2024) argue that AI-mediated environments expand opportunities for interaction between citizens and governments, fostering more agile and decentralized participatory processes.

However, the literature demonstrates that the existence of such channels does not, by itself, guarantee effective democratic participation. In this regard, Ogie (2017) emphasizes that factors such as accessibility, trust in digital systems, and institutional responsiveness directly influence levels of citizen engagement. Similarly, Hacker and Neyer (2020) argue that digital participation should be examined beyond its technological dimension, incorporating issues related to social inclusion, fundamental rights, and democratic legitimacy. Thus, although participatory platforms expand opportunities for interaction between governments and society, they may also reproduce inequalities and exclusion when not supported by adequate mechanisms of accessibility, transparency, and representativeness. The analysis of the selected studies indicates that urban participatory platforms are valuable instruments for strengthening digital governance and bringing citizens closer to decision-making processes. However, their effectiveness depends not only on the technology employed but also on the institutional capacity to promote inclusive participation, transparency, and responsiveness to societal demands.

4.3. Algorithmic Governance and Public Trust

Although Artificial Intelligence enhances administrative efficiency and strengthens data-driven decision-making, the literature highlights that the expansion of algorithmic systems also creates challenges related to transparency, accountability, and the distribution of power in urban decision-making processes. Bruun (2021) argues that algorithms are not neutral tools, as they incorporate technical, institutional, and social choices capable of influencing priorities, public decisions, and mechanisms of citizen participation. In this context, public trust emerges as a central element of algorithmic governance. According to Bruun (2021), limited understanding of how algorithms operate may reduce social oversight and hinder citizen participation in decision-making processes. Similarly, Fontes et al. (2024) argue that the legitimacy of Artificial Intelligence depends on the adoption of transparency, explainability, and social participation mechanisms capable of making digital systems more understandable and auditable. Furthermore, the literature highlights concerns related to privacy, digital surveillance, algorithmic bias, and the protection of fundamental rights (Ziosi et al., 2024; Hacker & Neyer, 2020). Thus, the studies converge in indicating that the effectiveness of algorithmic governance depends not only on technological capabilities but also on the existence of mechanisms for human oversight, transparency, and social control capable of strengthening public trust and the legitimacy of decision-making processes.

4.4. Challenges for Inclusive Digital Governance

The studies analyzed demonstrate that the development of inclusive digital governance represents one of the main challenges facing contemporary smart cities. Although Artificial Intelligence and digital platforms enhance the capacity of governments to manage and deliver public services, the literature shows that technological innovation alone does not guarantee social inclusion, citizen participation, or digital justice. In this context, Fontes et al. (2024) argue that the development of intelligent systems should be grounded in people-centered approaches capable of balancing technological efficiency and social responsibility. The literature also warns of the risk of increasing digital inequalities. Rasoulzadeh Aghdam et al. (2024) argue that the sustainable development of smart cities depends on balancing technological innovation, data protection, and social inclusion, while Hacker and Neyer (2020) emphasize that disparities in access to digital technologies may limit the participation of vulnerable groups and compromise the legitimacy of participatory processes. Another central issue concerns public trust. According to Bruun (2021), the acceptance of digital systems is directly related to the transparency of algorithmic processes and citizens' ability to understand how these technologies influence public management.

Thus, the literature converges in indicating that the development of inclusive digital governance requires mechanisms of transparency, accountability, citizen participation, and the protection of fundamental rights. Figure 1 summarizes the main dimensions associated with this process.

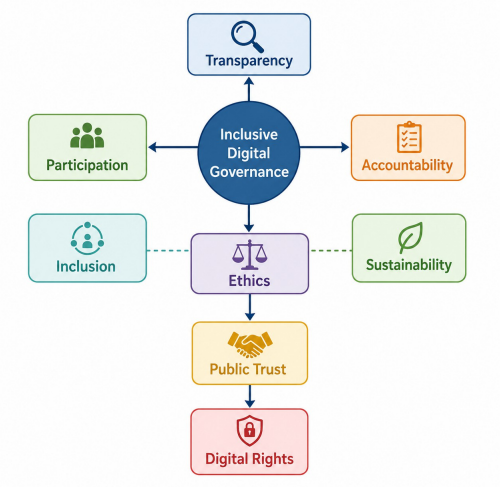

Figure 1 – Dimensions of Inclusive Digital Governance (Source: Prepared by the authors with the assistance of Artificial Intelligence, 2026).

The integrated analysis of the selected studies reveals a convergence regarding the key elements required to strengthen inclusive digital governance. Table 1 summarizes the main dimensions identified in the literature and their contributions to the development of governance models that are more transparent, participatory, and socially legitimate.

Table ends on the next page

Dimension	**Evidence from the Literature**	**Contribution to Inclusive Digital Governance**
Social Inclusion	Fontes et al. (2024) advocate people-centered approaches to AI development.	Promotes equitable access to digital technologies.
Democratic Participation	Hacker and Neyer (2020) emphasize the importance of fundamental rights and citizen participation.	Strengthens the legitimacy of decision-making processes.
Sustainability	Rasoulzadeh Aghdam et al. (2024) and Strielkowski et al. (2023) associate technological innovation with sustainable development.	Strengthens the legitimacy of decision-making processes.

Transparency and Accountability	Almulhim and Yigitcanlar (2025) identify smart governance as a foundation of sustainable cities.	Enhances public trust and institutional accountability.
Digital Rights	Furtado et al. (2024) highlight the need to align technological innovation with collective benefits.	Contributes to the protection of citizens in digital environments.

Table 3 – Key Elements of Inclusive Digital Governance Identified in the Literature (Source: Authors' own elaboration based on the analyzed literature, 2026).

The findings demonstrate that the challenges faced by smart cities extend beyond the adoption of advanced technologies, focusing on the development of governance models capable of ensuring inclusion, transparency, and institutional legitimacy. Therefore, inclusive digital governance depends on balancing technological innovation, citizen participation, public accountability, and the protection of digital rights.

5. CONCLUSION

The advancement of Artificial Intelligence and digital platforms has transformed the management of smart cities by enhancing data analysis capabilities, automating public services, and supporting decision-making processes. The findings of this study demonstrate that these technologies can contribute to urban management efficiency and strengthen digital governance. However, the literature shows that the benefits of Artificial Intelligence do not, by themselves, guarantee inclusive digital governance. The effectiveness of these models depends on addressing challenges related to algorithmic transparency, social inclusion, data protection, and public trust. It can be concluded that smart cities depend not only on the adoption of advanced technologies but also on the integration of innovation, citizen participation, transparency, and institutional accountability. As a future research agenda, further studies are recommended on algorithmic transparency, digital inclusion, and citizen participation mechanisms in urban digital platforms.

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AI LITERACY IN SECONDARY EDUCATION AND THE CROATIAN CONTEXT

A critical integrative review of assessment, responsible use and educational implications

Katarina Remenar
PhD Candidate, Doctoral Programme in Management
Faculty of Economics and Business in Osijek
Josip Juraj Strossmayer University of Osijek
Trg Ljudevita Gaja 7, 31000 Osijek, Croatia
remenar.katarina@gmail.com

ABSTRACT

This paper critically examines the relationship between the conceptualisation of AI literacy, its assessment and educational implications for Croatian secondary schools. A focused integrative review brings together conceptual and review papers, selected empirical studies of measurement instruments, AI use and acceptance, and official Croatian sources. Findings are analysed in terms of the construct assessed, the measurement approach and the limits of inference. The comparison indicates that frequency of use, favourable attitudes, self-assessment and objective knowledge represent distinct indicators, while ethical awareness alone does not establish responsible behaviour. Published findings from the BrAIn project and recent research on Croatian teachers are examined as secondary sources rather than original empirical research conducted for this paper. An analytical matrix is proposed to link perceived competence, demonstrated understanding and responsible action in school tasks. A research priority for Croatia is to examine the alignment of these dimensions through cultural adaptation of instruments, differentiation between educational programmes and assessment of competence transfer. The paper contributes to more precise interpretation of existing findings and the formulation of research questions. Given its purposive selection of sources, it does not provide an exhaustive systematic review or an estimate of the national prevalence of AI literacy.

Keywords*: AI literacy; competence assessment; Croatian secondary schools; integrative review; responsible use*

1. INTRODUCTION

Generative artificial intelligence raises the question of what students need to know to verify, justify and responsibly use outputs produced by digital systems. The educational value of these tools depends on their purpose and on how learning activities preserve students' capacity for judgement. In UNESCO's guidance, Miao and Holmes (2023) emphasise human agency, data protection and the pedagogical and ethical appropriateness of generative AI. For schools, this means aligning access to tools with learning objectives and the assessment of attainment. Long and Magerko (2020) associate AI literacy with critical evaluation, communication and collaboration with AI systems. This definition encompasses competencies beyond the use of an application. Accordingly, this paper considers knowledge of AI, self-assessed ability to use it and performance on specific tasks separately. This distinction is analytically significant: frequent tool use may accompany advanced competencies, but frequency alone does not establish that a student possesses them. The international literature already includes reviews of AI education in K–12 and secondary education (Casal-Otero et al., 2023; Ng, Su et al., 2024; Ghosh et al., 2026). Their scope and criteria differ, so they do not constitute a single corpus. Lintner (2024) further draws attention to the properties of AI literacy scales. The outstanding question is therefore not simply how often students use AI, but what available measures reveal about their understanding, judgement and responsibility.

The paper addresses a central research question: how can self-assessed competence, demonstrated understanding and responsible action be linked when assessing AI literacy in Croatian secondary schools? This is developed through three questions: (1) How does the conceptualisation of AI literacy inform instrument selection? (2) What conclusions are supported by indicators of use, attitudes, knowledge and ethical awareness? (3) How can these forms of evidence be integrated into a locally testable assessment framework? The contribution is conceptual: a comparison of measurement approaches informs a framework for linking evidence and a proposal for its evaluation. No claim is made that a new validated scale has been developed.

2. METHODOLOGICAL APPROACH

A focused critical integrative review was undertaken. An integrative approach enables the combination of theoretical and empirical sources employing different research designs (Whittemore and Knafl, 2005). Here, it provides a methodological basis for a reasoned comparison, without claiming to constitute an exhaustive systematic review. Sources were purposively selected for their contribution to defining AI literacy, evaluating measurement instruments, distinguishing use from competence and interpreting the Croatian context. The corpus comprises 18 sources listed in the final bibliography. Targeted online verification of selected bibliographic details and key claims was conducted on 12 October 2026. Publisher records and available texts on ScienceDirect, Wiley, Springer Nature, SAGE and MDPI were checked, alongside institutional repositories of Hong Kong universities and Masaryk University and the official BrAIn and UNESCO websites. Searches used exact titles and DOI identifiers, supplemented by targeted queries: “Design and validation” “AI literacy questionnaire” 363; “Evaluating AI literacy of secondary students” 1392; “What percentage of secondary school students do their homework” 548; “Examining teachers” 367 100328; and “Pedagogical approaches” “Letina” 322. This procedure verified and elaborated the existing corpus rather than conducting a new exhaustive search of the field. Inclusion criteria for the empirical synthesis were publication in 2024–2026, a secondary student sample or a teacher sample relevant to schooling, an identifiable measurement approach and direct relevance to competencies, ethical awareness, use or pedagogical conditions. Mixed educational samples were included, with their limitations explicitly identified. General commentaries and descriptions of tools without empirical data, as well as studies unrelated to the research questions, were excluded from the synthesis. Earlier conceptual and methodological studies were retained for their theoretical contribution. The date and complete log of the initial search were not documented in the source manuscript. Consequently, the numbers of identified and excluded records and a PRISMA flow are not reconstructed. The subscription databases Scopus and Web of Science were not searched. Age was not inferred from school grade. Where only an abstract or institutional record could be verified, conclusions were restricted to the available information. Coverage is justified by the representation of key measurement approaches and the Croatian context rather than by a claim of exhaustiveness.

For eight selected empirical studies, the population, sample size, measurement approach, findings and limits of inference were extracted (Table 1). The synthesis compares self-assessment, objective testing, ethical awareness, use and the teaching context. The appraisal of limitations focuses on sampling, alignment between measures and conclusions, cultural transferability and the distinction between association and causation. This is not a standardised risk-of-bias assessment. The two BrAIn sources concern the same project and were not treated as independent studies; review papers inform interpretation without aggregating the samples of primary studies.

Table 1: Comparison of selected empirical studies

Study and sample	Measurement approach	Finding and limit of inference
Ng, Wu et al. (2024) Hong Kong; 363 students	AILQ, 32 items; self-report across four dimensions.	Multidimensional assessment; self-report does not establish performance.
Chiu et al. (2024) Hong Kong; 2,390 students, Grades 7–9	25 multiple-choice questions; objective knowledge.	Correct responses assessed; limited evidence of open-ended processes and transfer.
Zhong and Liu (2025) China; 1,392 students	KAT, 48 items; knowledge, affectivity and thinking.	Scale structure developed; cultural transferability unconfirmed.
Kong and Zhu (2025) Hong Kong; 573 secondary and university students	AIEAS, 9 items and reflective writing; ethical awareness.	Improvement after the programme; mixed sample and limited evidence of behaviour.
Sok et al. (2025) Cambodia; 315 students, Grades 10–12	Online questionnaire on attitudes, challenges and opportunities.	Favourable attitudes with concerns; voluntary sample and indirect measure of literacy.
Turós et al. (2025) Hungary; 548 students, 20 schools	Survey and human coding of homework.	An estimated 16% used AI for text-based homework; dependence on coding criteria.
Kong, Yang and Hou (2024) Hong Kong; 367 teachers	Extended TAM questionnaire; intention to use.	Associations with acceptance; intention does not establish student outcomes.
Letina et al. (2026) Croatia; 322 teachers	Online questionnaire on pedagogical approaches.	Preference for integration with oversight; mixed school sample, no student assessment.

Source: author synthesis of the eight studies cited. Chronological age was not compared separately because it was not consistently available across samples.

3. AI LITERACY AS A MULTIDIMENSIONAL CONSTRUCT

AI literacy is understood here as the integration of conceptual understanding, application, critical evaluation and responsible action. Long and Magerko (2020) emphasise competencies for critically evaluating and interacting with AI systems. UNESCO's framework for students distinguishes a human-centred mindset, ethics, techniques and applications, and AI system design, across the levels of understanding, application and creation (Miao et al., 2024). The framework provides normative guidance but does not itself establish that students possess these competencies. Interpreting research requires distinguishing four concepts. Use describes an activity; acceptance describes an attitude or intention; literacy refers to competencies; and responsible action concerns decisions in situations with consequences for learning, privacy or academic integrity. Students may use a tool frequently while finding it difficult to evaluate the credibility of its responses. Similarly, they may endorse ethical principles without applying them in schoolwork. These possibilities are analytical propositions requiring empirical investigation, rather than conclusions about all students.

4. INTERNATIONAL FINDINGS AND MEASUREMENT LIMITATIONS

4.1. Self-assessment and objective understanding

The AILQ questionnaire (Ng, Wu et al., 2024) comprises 32 items across affective, behavioural, cognitive and ethical dimensions; its validation involves 363 secondary students in Hong Kong. It profiles reported competence and students' relationship with AI. The cognitive dimension of a self-report measure is not an objective knowledge test. Zhong and Liu (2025) develop a 48-item scale integrating knowledge, affectivity and thinking, using a sample of 1,392 students in China. Comparing instruments requires examining item content and response formats, rather than merely similarities between dimension labels. Chiu et al. (2024) develop an objective test comprising 25 multiple-choice questions with 2,390 students in Grades 7–9 in Hong Kong. This approach more directly assesses recognition of a correct answer but does not automatically capture all processes involved in an open-ended task. Differences in age and educational programmes also limit direct application to the later years of Croatian secondary schooling. Validation findings from one educational system should inform local testing rather than replace it. Lintner's (2024) review of scales supports the need to examine measurement properties. Reliability is not equivalent to validity: interrelated items may measure confidence well while inadequately capturing demonstrated understanding. An educationally useful assessment should therefore specify what a score means, the population to which it applies and the uses it supports. A total score without a profile may obscure the case of a student with considerable interest but weaker critical judgement. The AILQ and KAT self-report measures support a multidimensional understanding of literacy, whereas Chiu et al. (2024) focus assessment on verifiable responses. These approaches are complementary because they address different questions. Their results should not be converted into a common scale without testing comparability. Lintner (2024) highlights uneven evidence concerning measurement properties; instrument selection must therefore reflect the purpose of assessment and the target population.

4.2. Ethical awareness, attitudes and behaviour

Kong and Zhu (2025) validate the nine-item AIEAS, comprising autonomy, beneficence and justice dimensions, with 573 secondary and university students in Hong Kong. They report improved ethical awareness following a 14-hour programme. The mixed sample limits conclusions specific to secondary students, while awareness remains distinct from behaviour in a particular dilemma. A post-programme change alone does not justify attributing a causal effect exclusively to the programme. Sok, Heng and Pum (2025) find favourable attitudes towards AI among 315 Cambodian students in Grades 10–12, alongside concerns about privacy, dependence on tools and originality. Their questionnaire measures attitudes, challenges and opportunities rather than directly testing AI literacy. Voluntary online participation and the concentration of the sample in public schools in the capital limit generalisability. The findings identify issues students recognise, but do not establish their ability to resolve problems involving credibility or data protection. Turós, Nagy and Szűts (2025) estimate that 16% of a sample of 548 students from 20 Hungarian secondary schools wrote text-based homework using AI. This estimate relies on a survey and human coding of assignments and therefore depends on the criteria used to identify AI assistance. The indicator is not equivalent to the frequency of tool use for learning and cannot be compared directly with the BrAIn percentages. It does not support ranking countries by AI literacy.

4.3. Teachers as part of the educational context

Kong, Yang and Hou (2024) examine an extended technology acceptance model with 367 primary and secondary teachers in Hong Kong. Self-efficacy, perceived usefulness, attitudes and subjective norms are associated with the intention to use generative AI. Intention does not measure teaching quality or establish student outcomes.

Nevertheless, the findings justify incorporating teachers' beliefs and school support into research designs while measuring student competencies separately.

5. THE CROATIAN CONTEXT

The BrAIn project provides an important domestic empirical foundation. The research was conducted from January to May 2025, with findings published in March 2026. It covered 46 schools in 16 counties, including 24 primary and 22 secondary schools; the survey sample comprised 3,913 students, 924 parents and 382 teachers (CARNET, 2026a). The total student sample must not be presented as exclusively comprising secondary students. This paper analyses the project's published findings; its authors did not conduct that research. According to the official announcement, approximately 40–50% of secondary students use AI tools for learning almost daily, while teachers report a need for training and guidance (CARNET, 2026a). This indicates the importance of pedagogical guidance but does not measure task performance. Nor does it establish that a lack of teacher guidance causes a particular level of student literacy. The official summary addresses digital and AI literacy, including moderate self-assessed AI literacy and variation in students' explanations. It also notes limited representativeness due to voluntary participation, particularly among parents and teachers (CARNET, 2026b). Geographical coverage alone is therefore insufficient for national generalisation. The public summary does not provide all the information needed to assess measurement properties and performance-based competencies; this does not necessarily mean that such information is absent from the complete project documentation. Letina, Tomaš and Škugor (2026) provide an additional perspective through an online study of pedagogical approaches to AI among 322 Croatian primary and secondary teachers. Their findings indicate a preference for integration while retaining teachers' professional oversight. This sample is separate from the BrAIn findings presented here and does not assess students' AI literacy. Together, these sources raise the question of how students' everyday use relates to pedagogical guidance and criteria for assessing schoolwork. For Croatian secondary schools, it is necessary to distinguish general academic and vocational programmes, prior AI education, classroom use and use during independent learning. Seeking explanations, checking one's own solution and adopting a ready-made answer are different activities. Future questionnaires should therefore record purpose and verification practices alongside frequency, while performance tasks should reveal how students decide whether to accept, correct or reject a response.

6. DISCUSSION AND RESEARCH GAP

The synthesis indicates that the scope of AI literacy often exceeds what an individual measure captures. The instruments analysed provide different forms of evidence concerning knowledge, perceived ability and attitudes towards technology. Differences in populations and measurement procedures are therefore integral to interpreting results. Interest, frequent use and recognition of ethical principles may be educationally relevant, but conclusions about independent critical action require evidence from an appropriate task. Discrepancies between self-assessment and performance may have several explanations: overestimation of ability, differences in subject knowledge, misunderstanding of an item or unequal task difficulty. Associations between teacher support and competence may also reflect prior attainment, access to tools and student self-selection. These alternative mechanisms are not tested here. Frequent use is therefore not interpreted as a cause of literacy, nor are teachers' favourable attitudes treated as evidence of an effect on learning. The comparison informs the analytical framework in Table 2. Perceived competence describes students' accounts of their abilities; demonstrated understanding concerns verifiable responses and their justification; and responsible action concerns decisions in tasks with ethical or educational consequences.

The framework assumes that alignment and discrepancies between these dimensions have educational significance, but does not posit a causal sequence or a single aggregate score. It synthesises the approaches of Long and Magerko (2020), Ng, Wu et al. (2024), Chiu et al. (2024) and Kong and Zhu (2025).

Table 2: Analytical framework linking measurement approaches

Component	Evidence and operationalisation	Limit of inference
Perceived competence	Self-assessment and confidence in the accuracy of one's own response.	Self-report does not establish successful performance.
Demonstrated understanding	Concept test and verification of an AI claim, with justification and a source.	Success on one task does not establish transfer.
Responsible action	Data protection, disclosure of AI assistance and defence of one's own solution.	A situational response does not guarantee everyday behaviour.

Source: author synthesis drawing on Long and Magerko (2020), Ng, Wu et al. (2024), Chiu et al. (2024) and Kong and Zhu (2025).

For Croatia, the research gap concerns the alignment of perceived competence, demonstrated understanding and responsible action. The domestic sources analysed do not establish a nationally representative assessment of their relationships or their transfer across subjects and over time. This conclusion applies to the sources included in this review. Existing data on use and self-assessed literacy can inform subsequent research assessing competencies through school tasks. The proposed design would combine an adapted self-report measure, an objective test and open-ended tasks with a clearly specified rubric. Cultural adaptation should include translation, expert review of content and interviews with students about their understanding of items. Measurement invariance should be tested before comparing educational programmes, and inter-rater agreement should be examined for performance tasks. Teacher and student data should be linked at school or class level when examining the relationship between pedagogical guidance and outcomes. The framework generates three testable propositions for future research. First, self-assessment and demonstrated understanding will be associated but will not be interchangeable measures; this can be examined through correlations and comparisons of models specifying distinct constructs. Second, knowledge may be associated with responsible action after accounting for frequency of use, prior attainment and educational programme; a multilevel model would be appropriate. Third, guided evaluation of AI responses may improve performance on a delayed task; testing this requires a comparative longitudinal or experimental design. These are research propositions derived from the synthesis rather than confirmed hypotheses. Assessment before instruction, immediately afterwards and at a delayed follow-up would enable the examination of stability and transfer. An appropriate comparison group and attention to the clustering of students within schools would strengthen inferences about educational effects. Tasks should span multiple subjects and include source verification, distinguishing plausible from accurate claims, data protection and transparent disclosure of AI assistance. These proposals arise from the synthesis rather than from a completed intervention. Self-assessment and performance should be compared using tasks aligned in content. For example, students could rate their confidence before checking an inaccurate AI claim, after which accuracy, source quality and justification would be assessed. For responsible action, a rubric is proposed with levels 0 (action absent), 1 (partial action) and 2 (action justified and appropriate) for information verification, data protection and disclosure of AI assistance.

The criteria and thresholds require expert appraisal and empirical testing; performance in a specific situation does not replace observation of actual behaviour.

6.1. Pedagogical implications

In classroom practice, the proposed matrix entails assessing the quality of AI use through students' reasoning. In a credibility-checking task, students can compare a tool's response with an original document, identify a questionable claim and explain their decision to accept it. When producing schoolwork, they can disclose the extent of AI assistance, describe their own revisions and explain their solution orally. These procedures follow from the paper's analytical framework; their educational effectiveness has not been empirically tested here. Differences between self-assessment and performance can guide feedback: overestimation of ability calls for practice in verification and justification, whereas sound understanding combined with uncertainty suggests a need for gradually increasing independence. Consistent criteria for responsibility can apply across subjects, with task content adapted accordingly. Teachers assess students' knowledge and processes rather than merely the plausibility of the final text. This connects AI literacy with subject learning and preserves students' responsibility.

7. LIMITATIONS

Purposive source selection entails a risk of selection and publication bias. The table emphasises studies relevant to measurement and interpretation; its distribution of publication years and countries is therefore not a bibliometric finding about the entire field. Access to full texts varies across sources; abstracts and institutional records do not allow a complete assessment of all methodological details. Primary and secondary publications were not combined into a single numerical corpus, and overlapping samples were not added together. Differences between lower and upper secondary education, mixed samples, cultural conditions and measurement procedures limit generalisability. Neither a meta-analysis nor a formal risk-of-bias assessment was conducted. The Croatian analysis relies on publicly available sources and does not include original individual-level data. The analytical matrix requires empirical validation before use in student assessment.

8. CONCLUSION

AI literacy in secondary education should be assessed in terms of what students understand, how they verify outputs and how they make responsible decisions. The sources analysed demonstrate why use, acceptance, self-assessment, knowledge and ethical awareness should be distinguished before comparison. The proposed matrix brings these perspectives together within a research framework without assuming that a single instrument measures the full competence. Published BrAIn findings and Croatian research on teachers' approaches provide a basis for investigating the relationship between student use and pedagogical guidance. The next priority is a locally validated assessment of alignment between self-assessment, knowledge and responsible action, alongside monitoring transfer across subjects. The proposed matrix guides this process and helps connect assessment findings with specific instructional support.

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DRIVERS OF IPSAS IMPLEMENTATION IN ALBANIA: EVIDENCE FROM PUBLIC SECTOR ACCOUNTING PROFESSIONALS

Lindita Gjika
Faculty of Economics, University of Tirana, Albania
linditagjika@feut.edu.al

ABSTRACT

This paper examines the factors that may influence readiness to implement International Public Sector Accounting Standards (IPSAS) in Albania. Building on the World Bank PULSAR framework, it distinguishes four groups of reform drivers: internal technical, internal non-technical, external technical and external non-technical. The paper argues that pressures encouraging reform need to be examined separately from the practical capacity to deliver it. This distinction is particularly relevant to Albania, where earlier assessments identified challenges relating to accounting regulation, professional expertise, institutional coordination and financial information systems, alongside motivations linked to improved public financial management and European integration. Drawing on selected international studies and the Albanian context, the paper develops five hypotheses concerning the relationships between these drivers, implementation capacity and perceived IPSAS implementation readiness. It proposes a survey of public sector accountants, finance managers, auditors and other public financial management professionals, using five-point Likert-scale questions and descriptive and statistical analysis. The proposed approach aims to identify potential differences between reform priorities and institutional preparedness and to inform the sequencing of training, systems development and organisational support. As data collection has not yet been undertaken, the paper presents a research framework rather than empirical findings.

Keywords*: IPSAS; Albania; public sector accounting reform; implementation capacity; reform drivers; readiness*

1. INTRODUCTION

Implementation of IPSAS reforms leads to improvements in the financial information and the transparency of the financial information in respect of public assets, public liabilities, public expenditure, and the financial performance of public bodies. However, this type of reform does not ensure that the reformed rules are properly applied by public sector entities. Implementation of IPSAS rules, in addition to reporting requirements, depends on the technical skills and expertise of the staff, and the efficiency of the systems that provide and manage the public sector's financial and non-financial data, and the ability of public entities to work together (World Bank, 2021). In the case of the public sector, changes in the methods and principles for recognizing and measuring items also involve administrative and routine operational activities. Financial information relating to public assets and liabilities, including property and infrastructure, receivables and obligations, must be collected and compiled from different departments that have previously not even maintained records for the purposes of financial reporting. Consequently, such reforms extend beyond changing the methods of financial reporting to the actual information and the responsibility and the ways of compiling and using this information in budgeting and other managerial activities. In the absence of a better alternative, such an approach should be preferred in analyzing the factors of implementation readiness over formal support of international standards. Consider the example of Albania. As highlighted by the PULSAR case study in 2021, Albania faces issues of fragmented rules and lack of clarity about which organizations should be part of a consolidated set of financial statements.

Albania faces a chronic shortage of accounting expertise in the public sector. Additionally, public sector entities at the local and central levels in Albania have different financial information systems. These studies reflect the situation of that time, not of the current year 2026. Domestic demands for public financial management improvements and the demands of international reporting standards necessitate a study to explore what pressures result in change and what makes change possible. This study explores which categories of reform drivers are associated with perceived IPSAS implementation readiness in Albania and whether implementation capacity offers additional explanatory value. It adapts the PULSAR driver classification into a questionnaire-based research framework directed at accounting practitioners. The paper does not attempt to demonstrate that IPSAS would produce a specific fiscal outcome in Albania, nor does it rank reform drivers in advance. Instead, it offers a way to gather comparable assessments from professionals working with public-sector accounting, and to consider whether the motivations for change match the resources available to deliver it.

2. LITERATURE REVIEW AND ALBANIAN CONTEXT

2.1. Evidence from previous research

Research indicates that accrual accounting reform and IPSAS adoption are related but different policy choices. Christiaens, Reyniers and Rollé (2010) found considerable variation in how European governments modernised financial reporting, including reforms that did not rely on direct IPSAS adoption. Oulasvirta (2014) demonstrates, through the Finnish case, that domestic accounting traditions and institutional preferences can also shape responses to international standards. The variation documented by Christiaens, Reyniers and Rollé (2010) is important for the design of the Albanian study. Respondents may value fuller reporting of public assets and liabilities without necessarily viewing compliance with a particular international framework as the primary objective. A survey that treats better fiscal information and the influence of IPSAS as a single motivation would hide that distinction. The proposed framework therefore places domestic reporting needs among internal technical drivers, while the influence of international accounting requirements is considered separately. Other studies emphasise practical implementation. Adhikari and Gårseth-Nesbakk (2016) identify coordination and organisational challenges associated with public sector accrual reforms. Brusca, Gómez-Villegas and Montesinos (2016) show that the outcomes of IPSAS-related reform in Latin America depend on more than formal policy commitments. A review by Polzer et al. (2023) likewise points to the importance of national circumstances when studying IPSAS in emerging and lower-income economies. These studies also point to differences between an announced reform and the way it functions in organisations. Staff may understand the intended benefits of accrual reporting yet face inconsistent classifications, unclear responsibilities or difficulties obtaining data from other departments. Consequently, the study should not ask only whether respondents support IPSAS. It should also explore their perceptions of training, cooperation, resources and system preparedness. This emphasis follows the practical challenges discussed by Adhikari and Gårseth-Nesbakk (2016) and Brusca, Gómez-Villegas and Montesinos (2016), without assuming that experiences from other countries will necessarily be replicated in Albania. Schmidthuber, Hilgers and Hofmann (2022) distinguish the motivations for IPSAS adoption from the implementation process and its eventual outcomes. This supports the present study's decision to examine reform pressures separately from perceived readiness, rather than treating an intention to adopt standards as evidence of successful implementation. More recent literature highlights why the setting matters. Liberato, Paiva and Serrasqueiro (2024) find that reform incentives and constraints vary across developed and developing countries, while Scannell and Tawiah (2024) question the feasibility of uniform IPSAS implementation across different institutional settings. These findings reinforce the value of measuring professional skills, reporting systems and coordination in Albania.

Together, this literature motivates a specific question for Albania: are pressures favouring reform accompanied by sufficient institutional capability to deliver it? Rather than developing a broad new theory of institutional change, the present study uses this distinction to organise measurable practitioner perceptions.

2.2. Implications for Albania

Accounting regulation, the degree of professionalization of accountants, coverage of reporting entities and financial reporting systems have been problematic in the Albanian Public Sector Accounting Reform (World Bank, 2021). These weaknesses impede the ability to set up consistent opening balances and to perform coordinated reporting of consolidated financial information. Further obstacles are found in political leadership, domestic fiscal targets, and European Union (EU) requirements. Practitioner surveys help in the assessment of the relative priority of these issues, however documentary evidence is necessary to determine actual implementation. A particular situation in Albania draws attention to three points. First, uncertainty in the scope of the reporting entities and the links between them increases the complexity in the preparation of consolidated information. Second, differences between the central and the local systems result in additional reconciliation and exchange of data. Finally, the supply of employees with an understanding of both the reporting of public sector transactions and of accrual based reports may delay the introduction of the new procedures. These are all based on the historical case of the World Bank (2021), and the current situation must be analyzed to determine if and how far these obstacles are still active. These practical issues serve to illustrate the disparity between domestic and external motivators, and why they can often strengthen one another while retaining different objectives. Demand from various ministries and other public entities for a greater degree of fiscal detail could align with a demand for international reporting standards to be compatible with one another. Both objectives could either support or hamper the adoption of effective reforms depending on the individual agents and institutions that are tasked with implementation. Whether either influence leads to effective change depends in part on the people, systems and institutional arrangements responsible for producing the information.

3. PROPOSED FRAMEWORK AND HYPOTHESES

PULSAR groups public sector accounting reform drivers along two dimensions: internal versus external and technical versus non-technical (World Bank, 2021). In this study, the four groups are considered alongside implementation capacity as possible correlates of perceived readiness. Table 1 summarises how the categories are adapted to the Albanian setting. The categories are intended as a practical classification, not as mutually exclusive explanations of reform. An initiative may respond to several motivations at once: for example, improved information on public liabilities can serve domestic financial management while also supporting external reporting needs. The questionnaire should therefore measure each dimension through several statements, rather than requiring respondents to choose one exclusive reason for reform.

Dimension	Illustrative Albanian reform considerations
Internal technical	Financial transparency; information on assets and liabilities; fiscal management
Internal non-technical	Political commitment; Ministry of Finance leadership; stakeholder support
External technical	IPSAS; European statistical and reporting requirements; PFM assessments
External non-technical	EU accession; international institutions; donor and external stakeholder engagement
Implementation capacity	Professional skills; training; resources; inter-institutional coordination; IT systems

Table 1: Proposed study dimensions (authors' adaptation of World Bank, 2021).

The first four dimensions represent motivations and pressures for reform. Implementation capacity instead refers to the perceived ability of public institutions to put reform into practice. Readiness is defined as practitioners' assessment of institutional preparedness to initiate or advance IPSAS-oriented accounting; it is not a measure of verified IPSAS compliance. An important distinction in the model concerns the meaning of capacity. Training and professional competence determine whether staff can apply accounting requirements correctly; information systems determine whether transactions and balances can be captured and reported consistently; resources and coordination influence whether implementation can extend beyond isolated organisations. These elements may develop at different speeds. The research will accordingly examine perceived capacity through several aspects instead of relying on one general question about whether institutions are ready. The dependent concept—perceived implementation readiness—should also remain narrow. A respondent's confidence that a ministry or agency can undertake reform is informative but does not establish that standards have been adopted, accounts have been audited under a new framework or implementation targets have been met. Keeping these concepts separate helps make future findings more credible and easier to interpret. The following five hypotheses guide the empirical study:

H1. Internal technical drivers are positively associated with perceived IPSAS implementation readiness.
H2. External technical drivers are positively associated with perceived IPSAS implementation readiness.
H3. Internal non-technical drivers are positively associated with perceived IPSAS implementation readiness.
H4. External non-technical drivers are positively associated with perceived IPSAS implementation readiness.
H5. Implementation capacity is positively associated with perceived IPSAS implementation readiness.

The hypotheses do not assume which driver will be strongest. This remains a question for empirical testing. The four driver hypotheses allow a comparison of domestic and external motivations as well as technical and non-technical considerations. H5 addresses a different issue: even when there is substantial pressure for reform, are institutions perceived as having the necessary skills, coordination and systems? Examining the five relationships together can show whether implementation capacity adds information beyond the perceived strength of reform drivers. The model tests associations rather than a sequence of cause and effect.

4. PROPOSED METHODOLOGY

The study proposes a questionnaire for public sector accountants, finance managers, internal and external auditors, and professionals involved in public financial management in Albania. Respondents would assess statements on a five-point Likert scale covering the four driver categories, implementation capacity and perceived readiness. Questions on professional role, type of institution and experience would allow meaningful comparisons across groups. The questionnaire would contain short statements corresponding to each study dimension. Examples include whether improved information on public assets and liabilities is viewed as an important reason for reform; whether international reporting expectations influence accounting priorities; whether public institutions demonstrate visible leadership; and whether staff receive adequate preparation for revised accounting procedures. Separate readiness statements would assess the extent to which respondents consider their organisation prepared to undertake implementation tasks.

To make the responses interpretable, the survey should specify whether a question concerns the respondent's own organisation or the wider Albanian public sector. These levels may produce different answers. An accountant might report strong preparedness in their own institution without sufficient information to evaluate the entire government. The instrument should also permit respondents to indicate when they lack the knowledge needed to answer a question. The questionnaire should be reviewed by knowledgeable practitioners and piloted before wider distribution. Responses would first be analysed descriptively; reliability checks would examine whether items within each dimension work consistently. Subject to sample size and data quality, correlation and regression analysis could then explore the relationships proposed in H1–H5. Any observed associations would describe practitioner perceptions and could not, on their own, demonstrate causation. The sampling approach should aim to include professionals from different types of institutions and responsibilities, rather than relying solely on one central administrative group. This is important because everyday reporting problems and exposure to reform discussions can differ between central and local bodies or among accountants, auditors and financial managers. The achieved sample and recruitment method should be documented, and any imbalance acknowledged when discussing the results. The analysis should begin by comparing how frequently respondents identify particular reform motivations and implementation needs. Simple comparisons across roles and institutions may already be useful for policy discussion. More advanced statistical tests would be justified only if the collected responses are sufficiently numerous and the grouped survey items demonstrate acceptable consistency. In reporting the findings, the emphasis should remain on the direction and practical significance of relationships, not on technical complexity for its own sake. Table 2 below shows a preliminary analysis plan and expected associations.

Hypothesis	**Construct / item codes**	**Expected association**
H1	Internal technical drivers: IT1–IT4	Positive with readiness
H2	External technical drivers: ET1–ET4	Positive with readiness
H3	Internal non-technical drivers: INT1–INT4	Positive with readiness
H4	External non-technical drivers: ENT1–ENT4	Positive with readiness
H5	Implementation capacity: CAP1–CAP6	Positive with readiness
Dependent variable	Perceived institutional readiness: RDY1–RDY4	Outcome

Table 2: Construct-to-hypothesis mapping and preliminary analysis plan (authors' adaptation of World Bank, 2021).

Note: Suggested coding: 1–5 as indicated; N/K as missing (not neutral). Construct scores are computed only after checking item distributions, reliability and missingness.

5. DISCUSSION AND PRACTICAL RELEVANCE

The main contribution of this framework is to clarify the difference between the motivations for reform and the conditions necessary for its implementation. For instance, respondents might view international standards or EU integration as compelling reasons for change, while also pointing out issues like a lack of trained personnel or inadequate IT systems. On the flip side, there could be plenty of technical expertise available, yet still face challenges due to weak political or organizational backing. These are the kinds of scenarios the survey aims to explore, rather than conclusions drawn in this paper. For policymakers, looking at the different categories of drivers alongside perceived capacity can help prioritize actions such as specialized training, standardized reporting procedures, enhanced information systems, and clearer institutional roles.

This comparison might also reveal differing viewpoints among accountants, auditors, and financial managers. These insights would be particularly valuable when considered alongside updated Albanian policy documents and implementation milestones. One potential policy application is to differentiate between actions that build support and those that facilitate implementation. Strengthening institutional commitment or improving communication about reforms could tackle issues of weak ownership, while a lack of accounting expertise might necessitate professional education and hands-on training. If data systems are a primary concern, priorities could include consistent use of a chart of accounts, maintaining reliable records, and ensuring information flows smoothly between institutions. While the survey can't provide definitive solutions, it can highlight which issues practitioners feel warrant further exploration. Another important contribution is that it amplifies the voices of the professionals tasked with implementing new requirements. While policy documents may outline the official reasons for reform, practitioners can share whether the procedures are clear, if information is accessible, and how institutional support plays out in their daily work. Comparing these perspectives could help fine-tune the order in which implementation measures are rolled out. The approach is also consistent with research distinguishing the adoption decision from the practical reform process (Schmidthuber, Hilgers and Hofmann, 2022; Liberato, Paiva and Serrasqueiro, 2024). Its intended contribution is a country-specific assessment of perceived implementation conditions, not a universal explanation of IPSAS adoption. One key limitation here is that the survey focuses on perceptions instead of actual compliance with IPSAS. Moreover, the background information specific to Albania mainly relies on the 2021 PULSAR case study, which really needs an update before we can draw any solid policy conclusions about the current reform status. To enhance our understanding, future research should look at how these perceptions stack up against the latest laws, implementation plans, and actual reporting practices. Conducting interviews with policy officials and financial reporting staff could shed light on why certain areas score high or low. Plus, repeating the survey after significant reform milestones would give researchers a chance to see if perceptions of readiness shift over time. While these suggestions broaden the research design, they aren't findings from this current study.

6. CONCLUSION

When considering IPSAS implementation in Albania, it’s crucial to look at both what drives reform and what helps public institutions make it happen. This paper combines four categories of reform drivers with a distinct measure of implementation capacity into a clear, testable framework. A future survey targeting accounting professionals could pinpoint which factors are most linked to perceived readiness and highlight any gaps between reform goals and actual operational readiness. By mapping out the connection between reform drivers and implementation capacity, this proposed framework can assist policymakers in prioritizing actions that promote effective and sustainable IPSAS implementation in Albania.

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THE SCIENCE OF BEING SEEN: LINKEDIN VISIBILITY AND ENGAGEMENT STRATEGIES

Greta Farago
Budapest University of Economics and Business, Marketing Master's Programme
Farago.Greta.93@unibge.hu

Hain Sarg
Budapest University of Economics and Business, Marketing Master's Programme
Sarg.Hain.09@unibge.hu

Saadat Asekova
Budapest University of Economics and Business, Marketing Master's Programme
Asekova.Saadat.29@unibge.hu

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business, Marketing Master's Programme
papp-vary.arpad@uni-bge.hi

ABSTRACT

LinkedIn Visibility Optimization has emerged as a strategic discipline within digital marketing, reflecting a shift from follower-centric distribution models toward algorithmic, behavior-driven visibility systems. This paper synthesizes academic findings and industry analyses to explain how LinkedIn determines what content appears in users' feeds, emphasizing factors such as early engagement, dwell time, interaction quality, and contextual relevance. In addition to algorithmic mechanics, the study explores the role of profile optimization, content strategy, sustainable engagement frameworks, and professional branding techniques in shaping long-term visibility outcomes. Further attention is given to advanced drivers, including emotional tone, timing, engagement patterns, and employee advocacy, that extend beyond standard optimization practices. By integrating individual-level and organizational-level approaches, the paper provides a comprehensive overview of how visibility can be intentionally cultivated on LinkedIn. The findings highlight that visibility is not accidental but the result of strategic, continuous, and evidence-based actions across multiple dimensions of the platform.

Keywords: *LinkedIn; visibility optimization; content strategy; engagement methods; personal branding; algorithm; posting time optimization; 360Brew algorithm; employee advocacy; earned media value; engagement metrics; data-driven content strategy*

1. INTRODUCTION

In recent years, LinkedIn has transformed from a digital CV repository into a dynamic content platform where visibility plays a central role in professional communication, branding, and networking. As the platform's user base and content volume have expanded, visibility has become increasingly governed by algorithmic systems that evaluate behavioral and contextual signals rather than social connections alone. Researchers emphasize that LinkedIn's feed distribution is algorithmic rather than follower-based, meaning even large creators rely heavily on engagement quality, dwell time, and early interaction patterns to reach broader audiences (Hollensen & Saeidi, 2023). This shift has created a growing need for professionals to understand how visibility is generated and how it can be optimized. Existing studies and industry reports point to a complex interplay between algorithmic signals, profile quality, content strategy, and long-term engagement habits (Epstein et al., 2022; Lax, 2024; Thapa, 2025).

While algorithmic drivers such as early sampling, dwell time, and meaningful comments determine the initial performance of a post, strategic practices such as profile optimization, niche positioning, and consistent posting influence sustained visibility and personal branding effectiveness (Marin & Nilă, 2021; Martín, 2025). Beyond individual tactics, advanced research highlights the importance of emotional tone, timing, and organizational advocacy structures in shaping content distribution (Kim & Hwang, 2025; Saeidi & Hollensen, 2024). These deeper drivers suggest that LinkedIn visibility is not solely a technical outcome but also a social and psychological process shaped by human behavior, professional norms, and community interactions. The aim of this paper is to offer a comprehensive, research-based framework for understanding LinkedIn Visibility Optimization. By synthesizing algorithmic insights, behavioral patterns, and strategic communication methods, the study provides practical guidance for professionals, content creators, and organizations seeking to strengthen their presence on the platform.

2. THE ORIGIN AND MEANING OF LINKEDIN VISIBILITY OPTIMIZATION

LinkedIn Visibility Optimization (LVO) originates from the broader fields of digital marketing and social media optimization. Similar to Search Engine Optimization (SEO), visibility optimization focuses on increasing how often and to whom content is shown. On LinkedIn, visibility refers to the degree to which a post appears in users' feeds, a dynamic outcome shaped by algorithmic signals, user behavior, and content quality. Researchers highlight that visibility is algorithmic rather than follower-driven (Hollensen & Saeidi, 2023). Even large creators depend on early engagement, interaction depth, and behavioral signals such as dwell time.
LinkedIn's visibility ecosystem includes:

- appearance frequency in feeds
- ranking position among other posts
- user interactions and attention
- audience relevance and network strength

This makes visibility a measurable and optimizable construct.

3. HOW VISIBILITY IS DETERMINED ON LINKEDIN (ALGORITHMIC FACTORS, SIGNALS, AND RANKING LOGIC)

LinkedIn's visibility mechanism is best understood as a layered decision process in which the platform evaluates a set of behavioral and content signals before deciding whether to broaden a post's audience. Recent industry analyses (Thapa, 2025; Lax, 2024) and academic work on attention metrics (Epstein et al., 2022) together suggest a three-tiered model consisting of (1) an initial testing phase, (2) the evaluation of key behavioral signals, and (3) a distribution decision that either amplifies or curtails reach. The following sections examine each stage and its practical implications.

3.1. Initial test phase (the "5-7% rule" and early sampling)

When a user publishes a post, LinkedIn does not immediately expose it to the entire network. Instead, the algorithm performs a rapid initial test by showing the post to a small, targeted subset of the author's audience, commonly estimated at approximately 5–7% (industry analyses, Thapa, 2025). This sample is not random. LinkedIn typically selects users who are more likely to engage, such as close connections, recent interactors, or followers who have previously shown interest in similar topics. The purpose of this phase is to collect fast, low-cost signals about the post's baseline relevance before allocating additional distribution resources. Empirical observations suggest that the first 30–60 minutes are often decisive.

If the initial audience responds positively, the algorithm considers the content worthy of broader distribution; otherwise, its reach is likely to stagnate. For example, a post published by a mid-level marketing manager may initially be shown to colleagues, recent commenters, and followers who have recently engaged with marketing-related content. If these users click "see more," leave substantive comments, or spend more time reading the post, LinkedIn interprets these behaviors as positive early signals.

3.2. Key behavioral signals evaluated (quality over quantity)

During and immediately after the initial test phase, LinkedIn evaluates several interrelated behavioral and content signals. These signals serve both as inputs to the ranking decision and as factors that content creators can intentionally influence. *Dwell time* (attention depth) measures how long a user spends viewing a given post, including clicks on "see more," time spent viewing a document or carousel, and the duration of video views. Academic evidence shows that dwell time is a robust proxy for attention and is highly predictive of perceived content quality (Epstein et al., 2022). Unlike likes, which can be given in a fraction of a second, dwell time indicates whether users actually consumed the content.

As a result, LinkedIn's ranking logic places considerable weight on dwell time: posts that generate longer average dwell times during the initial test phase are more likely to receive broader distribution. *Early engagement* (velocity of reactions) refers to the number and type of interactions, such as likes, reactions, comments, and reshares, generated shortly after publication. Timing is particularly important, as reactions during the first 30–60 minutes act as strong signals when the algorithm decides whether to expand a post's reach. However, the number of interactions alone is insufficient, as the quality of those interactions further refines the evaluation. *Interaction quality* distinguishes superficial responses from more substantive ones. For example, a short "Nice!" comment carries much less weight than a multi-sentence comment that adds perspective or asks a thoughtful question. Industry analyses indicate that long, meaningful comments, for example those containing more than 15 words, are treated as particularly strong indicators of conversational value and community interest (Lax, 2024). This emphasis on quality reduces the algorithm's susceptibility to low-effort engagement tactics. The poster's profile completeness, topical signals, including the headline, skills, and recent activity, together with historical content performance, also contribute to the relevance model. A keyword-optimized, regularly updated profile that demonstrates topical authority can increase baseline visibility because the algorithm interprets such profiles as more likely to produce valuable content for a specific niche audience. The algorithm also records negative indicators, such as hiding a post, marking it as irrelevant, or quickly scrolling past it, all of which decrease the probability of further distribution. In addition, manipulative practices such as engagement bait, for example "Comment 'YES' to win," and patterns of spam-like posting are detected and filtered by LinkedIn's quality control mechanisms.

3.3. Distribution decision and quality filters (expand, limit, or suppress)

After aggregating signals from the initial test phase and the behavioral evaluation, LinkedIn makes a distribution decision: it either expands the post to a larger audience, keeps its exposure limited, or suppresses it entirely. If positive signals, particularly high dwell time and meaningful early comments, exceed internal thresholds, the audience is expanded in stages, first to a larger proportion of followers and then to second-degree connections and topic-relevant users outside the author's direct network. Conversely, if the signals are weak or negative, the algorithm stops further distribution to conserve feed space and maintain user experience.

In parallel with the distribution process, LinkedIn applies quality filters that remove or penalize content historically associated with low value, including engagement bait, spam, clickbait headlines, and excessive outbound linking. Where necessary, the platform lowers the ranking score of such content or limits its visibility.

4. KEY INDICATORS USED TO EVALUATE VISIBILITY

Modern analyses of LinkedIn performance (Thapa, 2025; Lax, 2024; Liu, 2024) show that visibility on the platform is not evaluated intuitively but through a consistent set of measurable indicators. These indicators reflect both the breadth and the depth of audience attention and are essential for understanding whether content successfully passes the algorithm's ranking thresholds. The four core metrics used across industry and academic studies are Reach, Impressions, Engagement, and Dwell Time. *Reach* measures the number of unique users who saw the post at least once. It reflects the size of the audience the platform exposed the content to. Industry practitioners use reach to understand how broadly the algorithm distributed the post (Thapa, 2025). A high reach indicates that the post successfully passed the initial test phase and gained additional distribution waves. A low reach often signals issues with early engagement or relevance, which limited algorithmic expansion. Reach is therefore a visibility indicator, not necessarily an engagement indicator, and is directly influenced by ranking logic. *Impressions* represent the total number of times the content was displayed, including repeated views by the same user. As Lax (2024) explains, impressions typically exceed reach because users may encounter the same post multiple times across different sessions or pages (e.g., feed, profile visit, notifications). High impressions relative to reach can indicate effective positioning in the feed or that users repeatedly returned to the post, which often correlates with content relevance. Thus, impressions help assess the intensity of distribution, not just the size of the audience. *Engagement* includes likes, comments, shares, link clicks, "see more" expansions, carousel swipes, and profile visits initiated from the post. According to Liu (2024), LinkedIn weighs engagement types unequally:

- Meaningful comments carry the highest weight, as they indicate deeper interaction.
- Likes and lightweight reactions serve as secondary signals.
- Shares, although relatively rare on LinkedIn, can significantly expand reach by exposing content to second-degree networks.

Engagement is a key indicator because it reflects not only attention but also content relevance, emotional resonance, and practical value.

Dwell time, the amount of time users spend reading or viewing a post, is widely regarded as one of the strongest predictors of post ranking. Academic work by Epstein et al. (2022) demonstrates that attention depth, measured through dwell time, is more reliable than likes or clicks in predicting content value. Long dwell time indicates that users found the content compelling enough to stay, whereas short dwell time, even when accompanied by many impressions, suggests that they quickly skipped the post, reducing its likelihood of broader distribution. Since dwell time cannot easily be manipulated through artificial engagement, industry analysts view it as one of the most authentic indicators of content quality. These four indicators collectively allow creators, marketers, and recruiters to evaluate:

- how widely the content was distributed (reach),
- how persistently it appeared across feeds (impressions),
- how audiences interacted with it (engagement),
- how valuable it was perceived (dwell time).

According to Thapa (2025), examining these metrics together helps identify specific visibility challenges. For example, high impressions but low engagement may signal weak content depth, whereas high engagement combined with low reach usually indicates limitations in algorithmic distribution. Thus, these Key Visibility Indicators serve as a diagnostic framework that explains not only how content performed but also why.

5. PROFILE OPTIMIZATION AS THE FOUNDATION OF VISIBILITY

Optimizing a LinkedIn profile is one of the most direct ways to increase visibility and make it easier for the algorithm to surface a user's content. A well-structured profile not only serves as a digital CV but also functions as the core of one's personal brand. According to EveryoneSocial (2024), a complete and strategically written profile increases the chances of appearing in searches and gaining more profile views. Even seemingly minor elements, such as a clear headline, a keyword-rich About section, or a professional profile photo, have measurable effects on visibility. A strong headline is especially important because it signals expertise and helps LinkedIn categorize the account. Instead of using generic job titles, many successful professionals use value-driven headlines that indicate what they do and whom they help. This practice aligns with research on personal branding, which highlights the importance of communicating a focused and consistent image across professional platforms (Marin & Nilă, 2021). Another critical element is the About section. Users who write in a clear, narrative style rather than simply listing tasks tend to perform better in terms of engagement and follow requests. This is because storytelling makes expertise more relatable and memorable, increasing the likelihood that others will interact with the profile or its content. Engagement and profile visits contribute to the quality signals that the LinkedIn algorithm considers when deciding what content to promote in the feed (Martín, 2025). The Experience section should include specific achievements supported by data whenever possible. Detailed descriptions enable LinkedIn's search system to better match profiles with relevant topics, industries, and keywords. A further aspect of profile optimization involves showcasing skills and collecting endorsements. Skills provide searchable keywords that LinkedIn's algorithm uses to match users with relevant content and connections. Endorsements from peers not only validate these skills but also increase credibility and trustworthiness in the eyes of the audience. Profiles that include multiple verified skills are more likely to appear in search results, thereby enhancing visibility across different networks (EveryoneSocial, 2024). The Featured section allows professionals to highlight posts, articles, or other media that reflect their expertise. Including examples of work, presentations, or media appearances can significantly increase engagement because it gives visitors immediate access to high-value content. Strategically curated media not only demonstrates competence but also encourages interaction, which further signals value to the algorithm (Marin & Nilă, 2021). Overall, profile optimization is a systematic process that strengthens credibility, makes an account more discoverable, and plays a key role in LinkedIn visibility optimization strategies.

6. CONTENT STRATEGY FOR MAXIMIZING REACH AND ENGAGEMENT

A well-planned content strategy can significantly boost visibility because the LinkedIn algorithm prioritizes content that creates early engagement, encourages discussion, and keeps users on the platform. For this reason, creators often focus on producing posts that are easy to understand, practical, and relevant to their target audience. Dripify (2025) highlights that posting consistently, using a clear structure, and staying focused on one or two core topics can help content perform better in the feed. Short, direct posts generally receive greater visibility because they match user behavior: professionals often consume content quickly during work breaks or commutes.

Another effective tactic is the use of storytelling, which makes posts feel more personal and engaging. Story-driven content captures attention within the first few seconds, increasing the likelihood that a post will generate comments, one of the strongest signals for the algorithm (Martín, 2025). Creators also benefit from using simple formatting techniques, such as spacing between lines or bolded phrases (for those with access to LinkedIn's text formatting tool). These techniques improve readability and can increase the average time users spend on a post, providing another positive signal for visibility. In addition, calls to action, such as asking a question or encouraging people to share their experiences, support higher engagement rates. This is important because impressions alone do not guarantee sustained visibility. Research shows that engagement quality, reflected in comments, saves, and meaningful reactions, has a stronger long-term impact on reach than impressions alone (Miller, 2025). Using diverse content formats, such as videos, carousel posts, and infographics, can improve both engagement and visibility. Multimedia posts often receive more impressions because they stand out in the feed and retain users' attention for longer. Videos, in particular, are prioritized by the algorithm when they generate early engagement, making them a useful tool for professionals seeking to expand their reach (Dripify, 2025). Incorporating relevant hashtags and keywords into posts helps LinkedIn categorize content and display it to users interested in similar topics. While overuse can appear spammy, the strategic use of three to five industry-specific hashtags per post can significantly increase discoverability. Keyword-rich content in both posts and article titles also improves search visibility, connecting content with relevant professional networks (Martín, 2025). A consistent content strategy helps professionals not only increase their visibility but also build a recognizable personal brand. Over time, this growing reputation contributes to a broader and more active network, which further reinforces visibility through repeated interactions.

7. METHODS AND FRAMEWORKS FOR SUSTAINABLE ENGAGEMENT

Sustainable visibility on LinkedIn requires more than occasional high-performing posts; it is built on structured, repeatable methods that support continuous engagement. Systematic approaches, consistent interaction habits, and a clear personal brand together form the foundation of long-term performance on the platform. These frameworks help users not only increase the reach of individual posts but also maintain a stable presence within their professional communities. By combining strategic planning, active engagement, and authentic communication, LinkedIn users can cultivate lasting and credible visibility that strengthens their professional positioning over time.

7.1. Systematic approaches

Visibility on LinkedIn does not depend on a single successful post but on long-term habits supported by a structured approach. One example is the "engage before you post" strategy, which is frequently used by experienced creators. By leaving comments on relevant posts before publishing their own content, users can activate their network and improve the likelihood that their upcoming post receives early interactions. Research confirms that early engagement within the first hour significantly increases content reach (Martín, 2025). Another systematic method involves maintaining a consistent posting schedule. Although there is no universal rule regarding frequency, many creators aim to publish two to four posts per week to maintain momentum without overwhelming their audience (Dripify, 2025). Monitoring post performance through analytics is also crucial for refining visibility strategies. LinkedIn provides metrics such as impressions, engagement rate, and demographic information about viewers. Regularly reviewing these metrics allows users to identify which types of content resonate most with their audience and adjust their posting strategies accordingly.

This data-driven approach ensures that visibility efforts are not random but targeted and continuously refined (Yu, Saint-Jacques, & Matsiras, 2021).

7.2. Engagement habits

Engagement plays a central role in visibility optimization. Meaningful comments, rather than simple reactions, strengthen weak ties, expand reach, and help users appear in the feeds of new audiences. Yu, Saint-Jacques, and Matsiras (2021) found that active engagement contributes to stronger professional networks and increases the likelihood of reciprocal interactions, which can lead to more impressions and profile views. Creators also tend to respond to comments on their posts within a short period. This practice signals to the algorithm that the conversation is active, helping the post remain in users' feeds for longer. Systematically building a network of relevant professionals can further enhance visibility. Connecting with peers, thought leaders, and industry-specific groups increases the likelihood that content will be seen by the right audience. Additionally, engaging with connections' posts through comments and shares reinforces visibility, creating a multiplier effect for one's own content (Saeidi & Hollensen, 2024). Developing consistent posting and engagement habits strengthens professional presence over time. Regular interaction, whether through posting, commenting, or reacting, signals active participation to the algorithm. Professionals who treat LinkedIn activity as a sustained habit rather than a sporadic effort tend to experience long-term growth in visibility and influence (Miller, 2025).

7.3. Personal branding and storytelling

Personal branding is an essential element of visibility optimization because it influences how others perceive and remember a user's content. LinkedIn users with a clear personal brand generally attract more followers and experience higher levels of engagement (Marin & Nilă, 2021). Personal branding includes expressing a consistent tone, developing a recognizable narrative, and demonstrating expertise in a specific field. Storytelling strengthens this process by making professional experiences more relatable. Posts that highlight personal lessons, challenges, or insights create an emotional connection and lead to more meaningful engagement. As Miller (2025) notes, authentic storytelling aligns with current social media trends, where audiences prefer personal, experience-based content over purely promotional messages.

8. LINKEDIN INFLUENCERS AND PROFESSIONAL ROLE MODELS

Analyzing the behavior of successful LinkedIn influencers provides valuable insights into visibility optimization. In Hungary, several creators have gained recognition by consistently applying effective content strategies and engagement practices. Favikon's annual report (Ahuja, 2025) highlights leading professionals who have built large audiences by focusing on authenticity, niche expertise, and frequent interaction with their communities. One notable example is Najoua Belayane, a PR and communication professional known for her practical, relatable content and consistent engagement style. Her approach demonstrates how personal branding, storytelling, and profile optimization interact to create strong visibility. Reflecting on how she would rebuild her LinkedIn presence from scratch, she emphasizes the importance of clearly defining one's message, demonstrating expertise through helpful posts, and engaging actively with others (Belayane, 2025). Her consistent, narrative-driven style and ability to simplify complex topics have positioned her as a recognizable creator with significant influence. Influencers like Belayane also highlight the role of community building. Their posts often encourage discussion, resulting in high comment rates, a key factor in LinkedIn's algorithm. Observing their strategies helps emerging professionals understand which types of content and engagement habits are most effective in increasing visibility on the platform.

Furthermore, the success of these creators shows that LinkedIn visibility is not limited to large corporations or executives. Individual professionals can also build strong influence by applying structured methods, producing consistent content, and developing meaningful relationships through active engagement. This reinforces findings in the academic literature, which link visibility to both personal branding practices and strategic communication (Saeidi & Hollensen, 2024).

9. ADVANCED DRIVERS OF LINKEDIN VISIBILITY

LinkedIn visibility is shaped not only by algorithmic logic and profile-level optimization but also by deeper emotional, behavioral, and organizational dynamics. These advanced drivers, including the emotional and temporal characteristics of posts, evidence-based engagement patterns, employee advocacy mechanisms, and structured measurement practices, provide a more comprehensive understanding of how content gains traction on the platform. By integrating insights from recent empirical studies and industry analyses, this section outlines how professionals and organizations can move beyond basic optimization tactics and apply research-supported frameworks that significantly enhance reach, engagement, and long-term influence on LinkedIn.

9.1. Emotional, temporal, and advocacy-based drivers of LinkedIn visibility

Building on the algorithmic and profile-level foundations outlined previously, this section shifts the focus to three additional drivers of visibility: the emotional and temporal characteristics of posts, evidence-based engagement patterns, and the role of employee advocacy systems. Together, these elements help translate the otherwise abstract concept of visibility optimization into a practical, data-driven framework for both individual professionals and organizations. Recent empirical work confirms that both the emotional tone of a message and the moment it appears in users' feeds substantially influence engagement outcomes. In their study *Predicting Social Media Engagement from Emotional and Temporal Features*, Kim and Hwang (2025) demonstrate that emotional valence (the positivity or negativity of a message) and arousal (its level of activation), combined with temporal metadata, allow machine-learning models to predict likes with remarkable accuracy ($R^2 \approx .98$), whereas comments remain far more variable ($R^2 \approx .41$). Two practical insights emerge from these findings. First, emotional content tends to generate quick, low-effort interactions, whereas more substantive engagement requires greater cognitive involvement. Positive, high-arousal posts, such as success stories, announcements, or concise inspirational narratives, are especially effective in generating reactions and increasing dwell time.

Comments, however, depend on factors such as topic relevance, perceived informational value, and whether the post explicitly invites discussion. Second, the timing of publication is not a neutral backdrop but an active component of engagement performance. Because emotional and temporal features interact, the same message can produce very different results depending on when it enters the platform's circulation. Kim and Hwang's findings reinforce what many professional LinkedIn resources already emphasize: posting time is part of the engagement equation, not merely a tactical detail. Industry analyses support this perspective. Hootsuite's large dataset suggests that early-morning time slots, particularly between 4:00 and 6:00 a.m. on Tuesdays and Wednesdays, tend to yield the strongest overall performance, whereas evenings and weekends are generally less effective. Although these recommendations represent platform-wide averages, they align with a broader principle: posts perform best when audiences are already in a professional mindset rather than disengaging from work.

For practitioners, the practical implications are straightforward:

- Design posts to elicit an emotional response through storytelling, tension, or clear lessons, because early reactions help signal relevance to the algorithm and increase dwell time.
- Publish during empirically supported time windows, then refine your posting schedule using your own analytics rather than intuition alone.
- Pair emotional elements with explicit prompts for discussion, as comments depend more on cognitive engagement than on emotional characteristics alone.

9.2. Evidence-based engagement patterns on LinkedIn

Although emotional and temporal elements shape initial audience reactions, platform-specific evidence suggests that engagement on LinkedIn follows a more differentiated logic. Usera and Durham's (2025) study, What Predicts Engagement on LinkedIn? Engagement-Boosting Strategies for Professionals, demonstrates that no single configuration of factors explains all engagement outcomes simultaneously. Instead, different metrics respond to distinct strategic levers. Their results show that certain variable clusters, such as follower count, recency, and post format, are primarily associated with lightweight interactions, including likes and simple reactions. By contrast, question-driven copy, higher topical relevance, and more reflective post formats are stronger predictors of comments and saves, both of which require greater cognitive effort from users. This distinction reinforces a central insight of the study: engagement metrics cannot be treated as interchangeable because each reflects a different type of audience motivation. These patterns are consistent with recent algorithmic analyses for 2025. Donnelly's dataset of 318,842 LinkedIn posts highlights several notable shifts in how the platform distributes visibility. Saves and shares have become key performance indicators. While likes and comments remain valuable, posts that accumulate saves and shares achieve disproportionately higher reach and longer visibility windows. Story-based opening lines outperform purely contrarian hooks because posts that begin with a personal experience and develop into a broader insight generate more engagement than formulaic contrarian statements. Content structure also plays a decisive role. Story-focused carousels that embed a lesson outperform static educational decks, and Donnelly's analysis further shows that posts containing three or more relevant external links reach larger audiences, challenging the long-held assumption that outbound links suppress visibility. Taken together, these findings align with Usera and Durham's conclusion that "what predicts engagement depends on the metric." For practitioners, this means that creators should first define a primary objective, whether maximizing visibility, increasing saves, or driving profile visits, and then design the post around that objective rather than attempting to optimize all metrics simultaneously.

9.3. The 360Brew era: From reach to conversation quality

Industry analyses suggest that LinkedIn's 2025 algorithm update represents not only a quantitative adjustment but also a qualitative redefinition of how content circulates on the platform. Damjanovich (2025) characterizes the new AI engine, 360Brew, as a system that evaluates posts within a broader "relationship ecosystem" rather than treating them as isolated units of content. Under this model, three elements gain particular strategic relevance. The algorithm increasingly rewards thematic consistency. Profiles that maintain a clear topical focus, what Damjanovich describes as "authentic expertise," are easier for 360Brew to categorize and recommend. By contrast, accounts that regularly shift between unrelated subjects risk becoming algorithmically ambiguous, resulting in lower distribution. Early conversational activity has become decisive. Instead of relying on hashtags or keyword-based optimization, post visibility is strongly influenced by the depth and timing of initial interactions.

When substantive comments and replies appear within the first 60–90 minutes, the system reintroduces the post to wider segments of the network. If this early momentum is absent, visibility declines rapidly. The platform increasingly prioritizes the quality of conversation over the quantity of superficial reactions. The algorithm examines comment chains, nested replies, and the sustained pace of interaction. A smaller number of long, thoughtful comments can outperform a much larger number of short, low-effort responses such as "Nice post!". Damjanovich also highlights an important structural insight: mid-sized personal accounts (approximately 15,000–25,000 followers) may outperform very large accounts (50,000+ followers) in reach by up to 2.3 times, likely because their audiences are more dialogic and less oriented toward one-way broadcasting. His benchmarks for company pages further illustrate a shift in effective content formats:

Text-only posts	+10% reach
Image + text	+5.9%
Articles	+27.9%
Videos	-40%
Polls	-21%

Table 1. Differential Reach Effects by LinkedIn Post Format
Source: Data adapted from Damjanovich's (2025) analysis of LinkedIn reach performance across post types and account sizes.

This pattern suggests that LinkedIn in 2025 is used less for entertainment and more for educational, narrative, and practical content. For visibility optimization, the implications are clear: thought leadership formats, colleague-driven stories, and case studies grounded in concrete data should be prioritized over generic branding messages. Equally important is treating the first 90 minutes after publication as a critical launch window and actively responding to every meaningful comment to sustain early engagement. Entertainment-oriented formats, such as long videos or polls, should be used selectively and only when they demonstrably serve audience needs.

9.4. Employee advocacy as a visibility engine: The Bolt case

In 2024, Bolt's employer branding team conducted a small experiment. They published the same recruitment video on the company's LinkedIn page with 260,000 followers and on the personal profile of an employee with around 7,000 connections. The results were striking: the corporate post reached 58,000 impressions, whereas the employee's version surpassed 7.4 million, generating extensive comments, shares, and profile visits. This outcome reflects a broader shift in how visibility functions on LinkedIn. Traditional marketing logic, according to which reach follows audience size, no longer fully applies. Instead, visibility emerges from behavioral signals, emotional triggers, content structure, dwell time, and evolving algorithmic priorities. As LinkedIn continues to evolve, particularly following the 2024–2025 algorithm updates emphasizing conversation depth and topical relevance, professionals increasingly face a central question: why do some posts spread widely while others disappear almost immediately?

Despite LinkedIn's growing role in recruitment, personal branding, employer branding, and B2B communication, academic research has not kept pace with these developments. Existing insights remain largely practitioner-driven, fragmented, and anecdotal, leaving no unified framework explaining how LinkedIn visibility is created, measured, or optimized. This represents a clear research gap at a time when visibility on the platform carries significant professional and organizational consequences.

This paper addresses that gap by introducing and analyzing the concept of LinkedIn Visibility Optimization (LVO). It defines the term, examines the algorithmic and behavioral factors that shape visibility, explores practical levers such as profile strength and content strategy, and reviews emerging trends, including the 360Brew algorithm shift and the growing importance of save-based engagement. Finally, the Bolt case demonstrates how individual creators can outperform corporate pages and how organizations can leverage employee advocacy at scale. Together, these elements provide a structured, evidence-based understanding of how LinkedIn visibility can be systematically managed and optimized. Algorithmic insights have limited value unless organizations can translate them into scalable practice. Kadi Poll's case study (2025) of Bolt's €0 employee advocacy initiative demonstrates how a company can transform individual LinkedIn profiles into a coordinated visibility engine. Her approach highlights how strategic design, clear documentation, and simple tools can generate disproportionate impact without requiring major financial investment. The first pillar of the program involved building on existing user behavior. Bolt had observed that employees' personal posts regularly outperformed the official corporate page. Rather than imposing a formal, top-down communication mandate, Poll framed the initiative as the "LinkedIn Challenge," emphasizing voluntary participation and intrinsic motivation. This approach allowed the program to grow organically while maintaining authenticity, one of the core drivers of platform engagement. A second foundational element was strategic clarity from the outset. Poll developed an internal 11-page framework that defined Bolt's understanding of advocacy, including platform choice, goals, and scope. The document also established measurable objectives and KPIs, such as increases in impressions, reactions, comments, followers, and referral traffic to the careers site, which increased by nearly 30% after implementation. It further outlined an execution plan detailing guidelines, training resources, and support channels, ensuring coherence as participation expanded. Third, the program relied on simple, accessible tools rather than expensive advocacy software. Slack served as the community space (#linkedin-challenge-2024), Google Sheets was used to track ambassadors' posts, impressions, and earned media value (calculated using CPM), and Confluence functioned as a centralized knowledge base containing examples, templates, and reusable assets. Despite this modest infrastructure, the results were striking.

In its first year, approximately 40 ambassadors generated 24.5 million impressions and €183,000 in earned media value at a conservative €7 CPM, a figure that would exceed €735,000 using more recent €30 CPM benchmarks. They also contributed 68,000 new followers, with employee profiles outperforming the corporate page by a factor of six. As participation grew to 60–70 active ambassadors, the program sustained more than one million impressions per month, with over ten million impressions recorded between January and November 2025 alone. Based on these outcomes, Poll argues that running employer branding initiatives without an advocacy component in the modern era effectively amounts to "burning money," given that employee-generated content combines low cost, high trust, and compounding reach.

Beyond the specifics of Bolt's program, the case highlights several principles that are broadly applicable to visibility optimization on LinkedIn. Users place greater trust in individual voices than in corporate channels. Poll illustrates this vividly: the same video posted on Bolt's company page with 260,000 followers generated approximately 58,000 impressions, whereas her personal account, with just 7,000 followers, reached 7.4 million impressions. The content remained identical; only the source changed. This asymmetric outcome reinforces a central dynamic of social platforms: credibility and reach are often amplified when messages originate from people rather than brands.

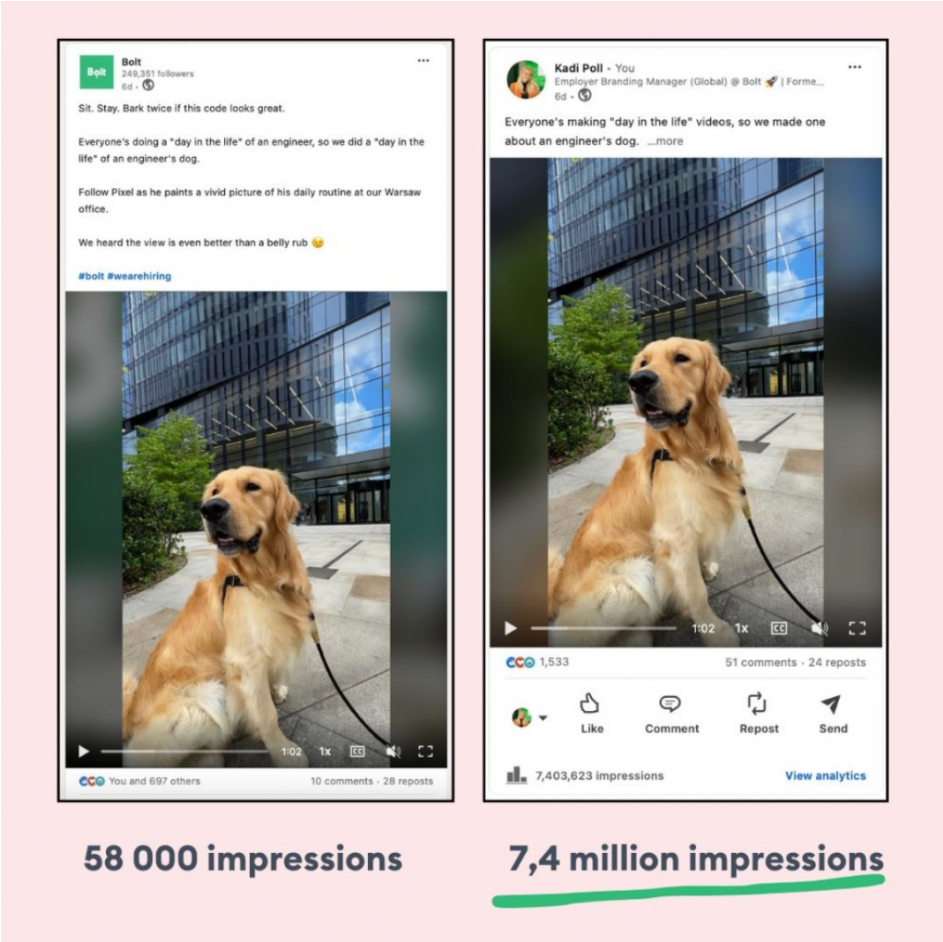

Figure 1. Reach comparison between Bolt's corporate LinkedIn page and an employee's personal profile during the employee advocacy campaign. Source: Based on Poll (2025).

Effective advocacy programs rely on autonomy and intrinsic motivation. Bolt did not impose scripts or require employees to promote the company. Instead, ambassadors were encouraged to create content aligned with their own professional goals and audiences. The program focused on developing capabilities in storytelling, personal branding, and copywriting, thereby supporting participants' individual growth while advancing organizational visibility. Systematic measurement is essential for establishing the legitimacy of advocacy efforts. By transparently tracking impressions, follower growth, and earned media value, the program translated what might otherwise be perceived as "soft" visibility into quantifiable outcomes that leaders could use in budget and resource allocation discussions. This analytical foundation made the program not only impactful but also defensible. When viewed alongside Damjanovich's emphasis on conversational depth within the 360Brew ecosystem, the Bolt example underscores why employee advocacy is particularly effective under LinkedIn's 2025 algorithm. It generates authentic, niche-relevant conversations at scale, exactly the type of interaction the updated model is designed to promote.

9.5. Turning visibility into a manageable KPI system

The preceding sections share a common assumption: visibility must be measurable before it can be optimized. Thanks to native platform analytics and third-party dashboards, even small teams can now monitor performance with a level of precision that was previously available only to large marketing departments.

Sprout Social's LinkedIn analytics suite, for example, consolidates page- and post-level data into comprehensive dashboards that track follower growth, engagement patterns, audience characteristics, and competitor benchmarks. These insights enable practitioners to evaluate how different content formats perform over time, identify which posts drive profile visits or website clicks, and detect temporal patterns by weekday or hour that inform future scheduling decisions. Similarly, Hootsuite's "best time to publish" heatmaps are based on an account's own historical engagement rather than platform-wide averages, allowing users to align emotional and temporal strategies with the specific behavior of their audience. To integrate these analytics into a practical workflow, particularly when combined with employee advocacy, professionals can rely on a simple four-part E-T-A-M framework for optimizing LinkedIn visibility:

Emotion	**Timing**	**Advocacy**	**Measurement**
Craft posts that evoke a clear emotional response such as curiosity, surprise, admiration, or even frustration, to boost initial reactions and dwell time, as shown in Kim and Hwang's (2025) findings.	Begin with evidence-based posting windows, such as early weekday mornings, and refine them iteratively using platform-specific analytic insights (Hootsuite, 2024; Sprout Social, 2024).	Encourage employees to publish under their own names, supported by light-touch guidelines, training, and simple tracking systems, following the principles of Poll's €0 advocacy model (Poll, 2024).	Systematically monitor reach, impressions, and engagement composition, with particular attention to comments, saves, and shares, and calculate earned media value to evaluate not only the volume but the *type* of visibility being generated (Usera & Durham, 2025; Donnelly, 2025).

Table 2. E-T-A-M framework
Source: Definitions by the author, based on academic literature, economic commentary, and media discourse

Taken together, emotional and temporal design, platform-specific engagement insights, and structured advocacy initiatives form a coherent, research-based strategy for LinkedIn visibility optimization. When combined with continuous measurement, these components help professionals move beyond algorithmic speculation toward a test-and-learn approach capable of adapting to, and even benefiting from, LinkedIn's ongoing "silent revolutions" in content distribution.

10. CONCLUSION

This paper demonstrates that LinkedIn Visibility Optimization is a multidimensional process shaped by algorithmic evaluation, strategic profile construction, content quality, behavioral engagement, and emotional and temporal factors. Evidence consistently shows that visibility is determined less by follower count than by early performance signals such as dwell time, meaningful comments, and relevance indicators (Epstein et al., 2022; Hollensen & Saeidi, 2023). These algorithmic mechanisms highlight the need for creators to focus on value-driven, easy-to-consume content that encourages sustained attention and authentic interaction (Lax, 2024; Thapa, 2025). Beyond the algorithm, the findings underscore the critical role of profile optimization as the foundation of discoverability and personal branding.

A clear headline, a narrative-driven About section, verified skills, and strategically selected media elements together increase search visibility and signal topical authority (EveryoneSocial, 2024; Marin & Nilă, 2021). Similarly, a consistent content strategy supported by storytelling, effective formatting, and the strategic use of hashtags enhances both reach and long-term engagement (Martín, 2025; Miller, 2025). Advanced drivers further expand our understanding of visibility by demonstrating that emotional tone, posting time, engagement habits, and employee advocacy networks can significantly amplify content performance. Research indicates that emotional and temporal characteristics help predict engagement, while structured advocacy systems create multiplier effects that extend visibility beyond direct networks (Kim & Hwang, 2025; Saeidi & Hollensen, 2024). Overall, the evidence suggests that LinkedIn visibility is not the result of isolated tactics but of an integrated, strategic, and sustained approach. Professionals and organizations that combine algorithmic awareness with strong personal branding, consistent engagement, and data-driven refinement are best positioned to achieve long-term influence and strengthen their professional presence on the platform.

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GENERATIVE ARTIFICIAL INTELLIGENCE AND THE BUSINESS SUSTAINABILITY OF THE MUSIC INDUSTRY

Vito Tursic
University North
104. brigade 3, 42000 Varaždin, Croatia
vito.tursic@unin.hr

ABSTRACT

Generative artificial intelligence marks a new phase in the transformation of the music industry, whose production, distribution and consumption paradigms have already been reshaped by digitisation and platformisation. Accordingly, this paper examines business sustainability through the industry's evolution, focusing on dominant scarcities, consumer habits, production and distribution costs, and monetisation. It aims to explain how generative AI extends these disruptive processes and affects long-term value creation and distribution, while preserving creative work as the foundation of the creative industries. The discussion follows four phases that continue to coexist, with newer models becoming dominant and older ones acquiring characteristics of exclusivity. Initially associated with physical formats, ownership-based consumption persists in early digitisation as distribution costs fall. iTunes marks a turning point by retaining the experience of possessing recordings while introducing individual track purchases and personal playlists as precursors to platform-based consumption. Platformisation subsequently replaces ownership with access to licensed content, separating price from individual consumption and placing recommendations, playlists and user attention at the centre of the business model. Generative AI adds the prospect of production abundance to distribution abundance, lowering creation costs and expanding user participation. However, its rapid diffusion reveals a discrepancy between abundant supply and actual consumption. According to figures published in April 2026, fully AI-generated recordings accounted for approximately 44% of new recordings delivered daily to Deezer, but only 1–3% of total streams on the platform. This discrepancy provides the paper's analytical starting point for explaining why easier music creation does not necessarily improve access to audiences or increase authors' and performers' earnings. The discussion therefore considers platforms' role in shaping visibility, alongside copyright, revenue distribution and the overall sustainability of the emerging business model.

Keywords: *generative artificial intelligence, music industry, platformisation, business sustainability, streaming*

1. INTRODUCTION

During the twenty-first century, the music industry has undergone substantial changes in the production and distribution of musical content and in its consumption and monetisation. Generative artificial intelligence represents a new phase in this process, building on the disruptive effects of digitisation and platformisation. Its application should therefore be understood against the shift from the dominance of physical sales towards licensing and continuous access to music catalogues. Separating price from individual consumption directs business interests towards sustained service use and the retention of user attention. This paper argues that this model reshapes production requirements by encouraging diverse content suited to different tastes, activities and listening situations, including relaxation, running and sleep. Production constraints concern the capacity to continually renew and adapt this offering, while attention remains a scarce resource. Generative AI can address these requirements by lowering organisational and financial barriers to music creation and adding production abundance to distribution abundance.

Tools such as Suno, Udio and Boomy enable participation without prior musical training or production experience. According to Suno's guide, original lyrics, a textual description of the desired sound or a recording of a sung melody can provide the starting point for generating a song with vocals and instrumental accompaniment (Minvielle, 2026). This process allows users to produce a developed audio draft within the application, with less need to engage performers and studio facilities. An indication of its reach comes from Suno co-founder Mikey Shulman's February 2026 announcement that more than 100 million people had used the application and that paid subscribers had reached two million (Shulman, 2026). Forbes journalist Conor Murray also relays Billboard's November 2025 report that approximately seven million songs were being generated on Suno each day (Murray, 2026). These figures illustrate the scale of user-generated content (UGC), although generated songs must be distinguished from recordings distributed and played on streaming platforms. More content and alternative versions expand opportunities for selection and further development but do not themselves ensure access to audiences or higher earnings for creators. An analysis of business sustainability must therefore consider changing relationships among authors, performers, record companies and platforms, particularly their influence over visibility and the collection and distribution of payments. The paper traces the music industry's transformation and explains how generative AI builds on earlier changes in its business models. Business sustainability refers here to the long-term capacity to finance music production and distribution and enable participants to share in the resulting value. This definition draws on the emphasis on value creation for a wider range of stakeholders in the discussion of sustainable business models (Schaltegger et al., 2016, p. 6) and applies it to participants in the music industry. The paper combines a thematic synthesis of scholarly literature with descriptive analysis of secondary data. Source selection follows the methodological principle that conceptual articles should explain their theoretical foundations and the role these play in the analysis (Jaakkola, 2020, pp. 19–20). Research on digitisation and platformisation explains changes in production, distribution and consumption, studies of computational creativity address the possibilities and limitations of generative production, and sustainability research connects these changes to value creation and distribution. Academic sources are supplemented by IFPI reports[1], official announcements by technology and music companies, Luminate data and media reports. Data are considered with reference to their period, scope and limitations. The analysis focuses on recorded music, while live performance is excluded from financial comparisons. The discussion follows four phases, from physical formats and digital sales to platformisation and generative production. Their comparison addresses consumer habits, production and distribution costs, monetisation and the dominant source of scarcity, understood as the constraint that most restricts market participation. The phases identify changes in prevailing business models while acknowledging their coexistence. This approach connects expanding production capabilities to audience access, rights exploitation and revenue distribution.

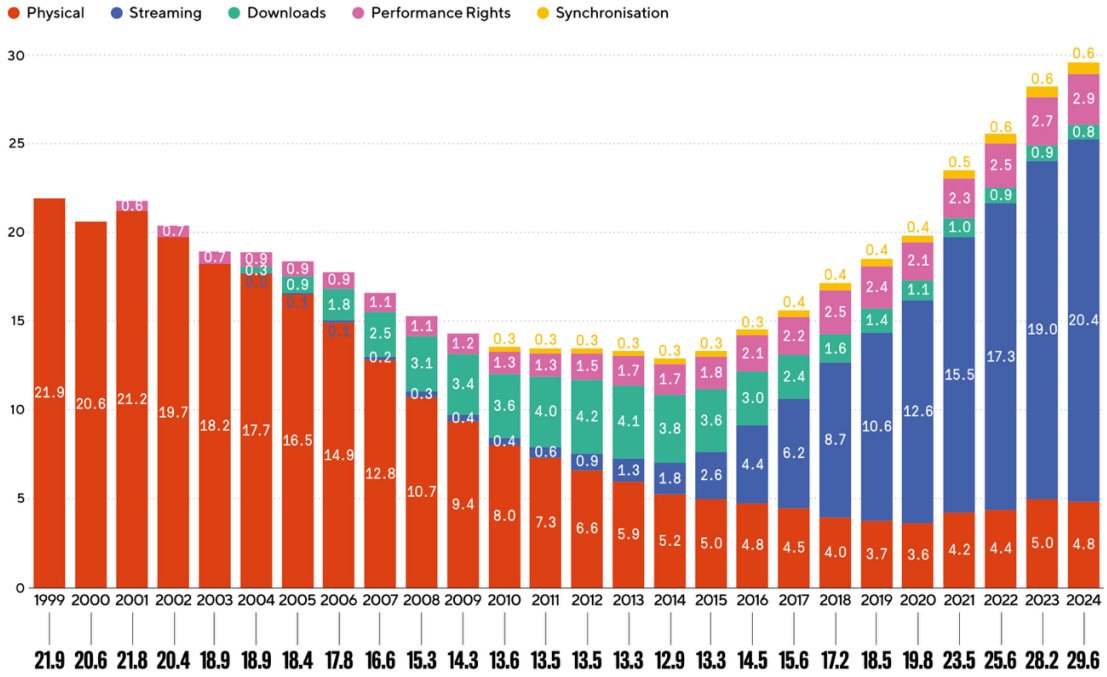
2. PHYSICAL FORMATS AND OWNERSHIP-BASED MUSIC CONSUMPTION

The industrial production of recorded music rests on capturing a performance, reproducing the recording and distributing it to a wider audience. In the physical-format model, dominant during the twentieth century, this entails investment in recording, production and promotion, alongside the material costs of manufacturing copies, storage, transport and retailing. Record companies combine financing with the organisation of these activities, while physical sales provide the principal means of recouping investment.

1 IFPI (International Federation of the Phonographic Industry) represents the recording industry worldwide. It publishes the Global Music Report on revenues and market structure and Engaging with Music on listening habits.

Scarcity primarily concerns access to production capacity and distribution infrastructure, since recordings must be reproduced, stocked and presented to potential buyers. Audience attention also matters in this phase, but the material and organisational conditions of market participation strongly shape the ability to reach listeners. Lowering these barriers becomes a defining feature of digitisation, associated with falling production and distribution costs and an expanding supply of products (Waldfogel, 2017, pp. 195–201). For consumers, this relationship constitutes an ownership-based model in which a single payment secures a physical copy and the ability to listen repeatedly. Changes from vinyl to cassette and CD improve technical characteristics and convenience while retaining the same transactional basis. The digital recording on a CD does not alter the dependence of access on possession of a material copy. The purchased object is the carrier containing the recording, while copyright remains distinct from ownership of that copy.

Figure 1. Global recorded music revenues, 1999–2024 (US$ billions)



Source: IFPI (2025, p. 7). The chart shows revenues by format, rather than formats' shares of total listening.

The album bundles several songs into a product, allowing one popular track to encourage the purchase of the entire release. Alongside its use value, a physical recording acquires collectible and identity-related value, helping to explain its continued presence after losing its dominant position. Figure 1 illustrates the changing relationship among formats. By 2024, streaming accounted for 69% of global recorded music revenues and physical formats for 16.4%, demonstrating coexistence alongside a substantial shift in economic importance (IFPI, 2025, p. 7).

3. DIGITISATION AND THE CHANGING UNIT OF SALE

Digital distribution makes recordings available without manufacturing and delivering physical copies, substantially lowering reproduction and transmission costs and removing dependence on individual retailers' inventories. It does not eliminate investment in authorship, performance, production, promotion and rights management. Expanding supply also heightens uncertainty over commercial success (Waldfogel, 2017).

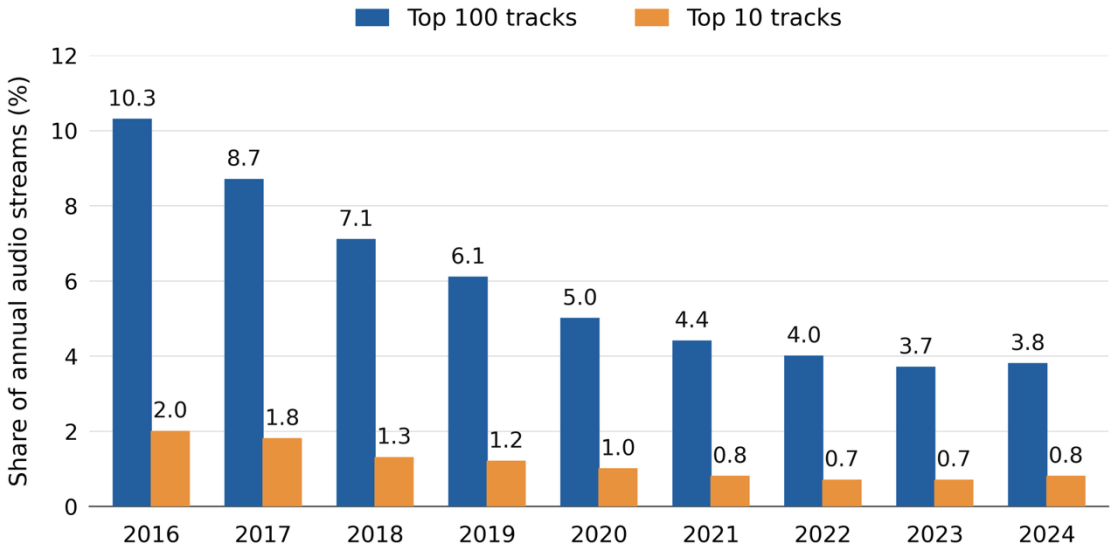
The iTunes Music Store marked an important turning point. Launched on 28 April 2003, it offered more than 200,000 songs at US$0.99 each, without a compulsory subscription (Apple, 2003). Consumers retained the functional experience of possessing music, building personal collections through purchases while transferring them from shelves to computers and portable devices. Payment remained tied to an album or song, extending ownership-based consumption into the digital environment. By combining a catalogue, search, payment and delivery, the digital store assumed an important intermediary role, while its revenues continued to depend on individual purchases. In IFPI's historical series, revenues in the downloads and other digital category rose continuously from approximately US$0.3 billion in 2004 to US$4.2 billion in 2012, their peak within the period shown (IFPI, 2025, p. 7). The changing unit of sale also affected consumer habits. Purchasing individual songs allowed listeners to organise collections around personal preferences, weakening the hit's role in encouraging purchases of entire albums. Catalogue searches and personal playlists enabled consumption in which recordings by different artists and from different periods were grouped around moods, activities or listening situations. The subsequent development of the digital environment also expanded music discovery through other media. The FIFA series illustrates the role of video games, with musical selections becoming part of the user experience and extending beyond the game through associated playlists (Spotify, 2021). These applications create additional opportunities for monetisation through synchronisation licensing, which connects music with audiovisual content. Revenues from recorded music used in films, television, advertising and games increased for a fourth consecutive year to US$650 million in 2024 (IFPI, 2025, p. 9). Beyond licensing income, incorporating an existing recording into new media content can stimulate rediscovery and extend its commercial life. This possibility underpins what the paper terms the refreshment model, in which older hits are recontextualised through connections with the experiences of new generations of consumers.

4. PLATFORMISATION, ATTENTION AND THE COEXISTENCE OF FORMATS

Platformisation shifts the focus of monetisation from individual sales to continuous service use. Subscribers pay for catalogue access without being charged separately for each play, while advertising-funded services generate revenue by connecting user attention with advertisers' interests. Platforms also collect data on consumption habits, determine conditions for releasing content and influence visibility through recommendations. Producers consequently become dependent on the rules and decisions of intermediaries connecting content with audiences (Nieborg & Poell, 2018). User retention becomes central to revenue generation, while contractual relationships and platform rules govern its distribution. Separating price from individual consumption also changes the hit's role in monetising music production. Whereas hits previously encouraged purchases of records, cassettes and albums and attracted concert audiences, the platform model seeks to maintain continuous listening. This paper argues that reliance on a constant supply of hits becomes a constraint for a model seeking to accompany more of the user's everyday life. This logic encourages ambient and situational consumption, connecting listening with work, travel, exercise or relaxation. Playlists assume part of the hit's role in directing consumption by grouping songs according to their contribution to mood and listening continuity. This creates space for recordings that lack widespread popularity but fit particular listening circumstances. BPI data[2] indicate a decline in the relative dominance of the biggest hits. The top 100 tracks' share of annual audio streams in the United Kingdom fell from 10.3% in 2016 to 3.7% in 2023, recovering slightly to 3.8% in 2024 (Cirisano, 2025). Figure 2 illustrates this trend.

2 BPI (British Phonographic Industry) is the UK recording industry's trade association. It represents record companies and publishes data and analyses of the UK recorded music market.

Figure 2. Top tracks' share of annual audio streams in the United Kingdom, 2016–2024



Source: Author's chart based on BPI and Official Charts Company data reported in Cirisano (2025). The top 10 tracks are included in the top 100.

This pattern supports an interpretation of increasingly dispersed consumption but does not itself establish a connection with situational playlists. Changing consumer habits include greater listening volume and diversity and the discovery of unfamiliar music (Datta et al., 2018). Playlists extend beyond personal collections to direct consumption through a combination of editorial selection and algorithmic recommendations (Bonini & Gandini, 2019). Playlists for travel, parties, work or exercise group songs around listening circumstances and moods. Their association with recurring activities may encourage repeated use and consumption of the songs they contain (Wlömert et al., 2025, pp. 8, 22). Part of the charts' role in guiding consumption thus shifts to selection practices in which a song's position also depends on its contribution to the overall listening experience. The dominant scarcity lies in limited audience attention, giving influence over recommendations and content visibility increasing commercial importance (Prey, 2020). Inclusion in Spotify's Today's Top Hits playlist was estimated to generate almost 20 million additional streams during the period studied (Aguiar & Waldfogel, 2018, p. 3). Although this estimate concerns a specific playlist, it demonstrates that availability does not ensure audience access. Intermediation rules also feed back into production, encouraging adaptations to content and its presentation in response to the conditions of platform visibility (Morris, 2020). The commercial significance of recommendations and attention retention becomes clearer when changes in listening habits are connected with streaming's increasing share of recorded music revenues. Table 1 traces the changing economic importance of selected formats using a single historical IFPI series. The dominance of the platform model coexists with earlier forms of consumption within the industry's revenue structure.

Table following on the next page

Table 1. Global recorded music revenues by selected format, 1999–2024 (US$ billions)

Year	Physical	Downloads and other digital	Streaming	Total revenue
1999	21.9	—	—	21.9
2005	16.5	0.9	0.1	18.4
2010	8.0	3.6	0.4	13.6
2015	5.0	3.6	2.6	13.3
2020	3.6	1.1	12.6	19.8
2024	4.8	0.8	20.4	29.6

Source: Author's compilation based on IFPI (2025, p. 7). Figures are rounded. Total revenue also includes performance rights and synchronisation. A dash indicates a category not reported separately. Selected formats therefore do not sum to total revenue.

In 2024, streaming accounted for 69% of global revenues, physical formats for 16.4%, and downloads and other digital revenues for 2.8%. Although physical revenues declined by 3.1%, vinyl grew by 4.6%, its eighteenth consecutive annual increase (IFPI, 2025, pp. 6–9). The newer model's dominance therefore accompanies the survival and, in some segments, growth of older formats. Collectible and material value can differentiate particular releases. Coexistence is also evident in the aggregate indicators of Engaging with Music 2023, based on 18 core markets. Average weekly listening amounted to 20.7 hours, of which audio streaming represented 32%, video streaming 31%, radio 17% and purchased music 9% (IFPI, 2023, pp. 4–7). Revenue shares must nevertheless be distinguished from shares of listening time. Access to earlier releases further expands opportunities to sustain interest. In the first half of 2023, recordings more than 18 months old accounted for 73.57% of US on-demand audio streams, a category that also includes relatively recent releases (Murphy, 2023). Reconnecting these recordings with films, television series, games and social media creates opportunities for the refreshment model. Audience attention can be described metaphorically as a "hungry animal" that abundant supply alone cannot permanently satisfy. Generative AI appears to offer a solution through hyperproduction, enabling faster and cheaper creation of content tailored to listening situations. Whether such production translates into actual listening and sustainable revenues remains an open question.

5. GENERATIVE AI AND PRODUCTION ABUNDANCE

Generative AI adds accelerated music production to distribution abundance. Its significance also lies in making creation part of the consumption experience, with users helping to shape what they wish to hear. Computer-generated music predates contemporary applications. A review of computational music generation encompasses systems based on predefined rules, statistical combinations of elements and learning from existing examples (Carnovalini & Rodà, 2020). Markov chains[3] generate melodic sequences using the frequency of transitions between notes in an analysed repertoire, while neural networks learn more complex musical patterns. Automation can therefore address individual components of a work. The authors also distinguish imitation of musical expression from creative value, meaning that technical plausibility alone cannot establish creativity (Carnovalini & Rodà, 2020).

3 Markov chains are probabilistic models in which, in the first-order case, the probability of the next state depends only on the current state. In music generation, states can represent notes, with transition probabilities estimated from existing compositions and used to generate new sequences (Carnovalini & Rodà, 2020 section 3.2.1).

Anantrasirichai and Bull (2022, pp. 610–611) examine the analysis of harmonic and rhythmic patterns, melody suggestions, the completion of compositions and direct audio generation. Flow Machines supports the development of musical ideas in collaboration with an author, while Coconet[4] fills gaps in musical structures. AI can assist composition, support sonic exploration or generate more extensive content. Automating individual production tasks must therefore be distinguished from generating a recording in which both the instrumental accompaniment and vocal performance are computer-produced. Contemporary tools such as Suno combine these capabilities in a process accessible to users without developed musical skills. Users generate songs from lyrics, descriptions or melodic ideas, select outputs and develop alternative versions (Minvielle, 2026). Initial investment in developing an idea falls, while some work shifts towards directing, selecting and refining outputs. Promotion, distribution and audience development still incur costs, and some expenditure moves towards subscriptions to generative tools. User participation in production is therefore considered an extension of platformisation. User-created content expands supply, while creation itself becomes a reason to return to the service. Listening to one's own song, changing an arrangement or producing another version may retain attention independently of wider audience interest. Service providers can derive value from users' willingness to pay to create, edit and listen to their own music. In a possible advertising-funded version, such participation could also create opportunities to monetise attention. This interpretation is supported by the October 2025 agreement between Universal Music Group (UMG) and Udio, announcing a subscription service for creating, customising, streaming and sharing music, using models trained on authorised and licensed repertoire (Hinkel, 2025). The May 2026 agreement between Spotify and UMG announces a generative tool for user-created covers and remixes of songs by participating authors and performers, offered as a paid add-on for Spotify Premium subscribers. Authors and performers are also intended to share in revenues (Murtagh-Hopkins, 2026). These announcements describe planned services, but indicate a direction in which catalogue access is combined with paid participation in reshaping music. Existing repertoire thereby acquires an additional economic function. In the licensed models described, it provides training material or content that users can rework. The agreements cover both recordings and musical works, linking generative capabilities to the conditions of commercial use. Lower production barriers therefore do not remove the importance of rights holders but create a new area of negotiation over repertoire use and revenue distribution. Business sustainability increasingly depends on how value is allocated among authors, performers, rights holders, tool developers and users. AI applications already include projects that extend artistic expression. On her 2019 album PROTO, Holly Herndon combined a vocal ensemble with Spawn, a system developed and trained through human participation. Generated material became part of an artistically shaped work released in digital and physical formats (Herndon, 2019). In completing the Beatles' Now and Then, released in 2023, machine learning enabled Lennon's vocals to be isolated from a home recording with piano. The voice was extracted from an existing performance rather than newly generated (The Beatles, 2023). AI can thus contribute both to new expressive possibilities and to the renewed use of previously recorded work. Xania Monet illustrates the commercial potential of generated vocals and instrumental accompaniment. The project's creator, Telisha “Nikki” Jones, turns her lyrics into songs using Suno, directing the sound and selecting among generated versions (Quinn, 2025). In November 2025, MusicRadar reported more than 44 million US streams over the preceding months and US$52,000 in earnings for the creator.

4 Flow Machines is a research project in AI-assisted music composition. Its tools model stylistic patterns in selected musical repertoires and generate melodic and harmonic suggestions that musicians can select, modify and incorporate into their own compositions (Pachet et al., 2021). Coconet is a convolutional neural network designed to complete partially specified musical scores. Trained on four-part Bach chorales, it can harmonise a supplied melody or rewrite selected passages while taking the surrounding musical context into account (Huang et al., 2017, pp. 211–212).

Without an accounting statement or precise revenue scope, this remains a media-reported figure for an individual project (Simpson, 2025). Jones also signed a multimillion-dollar agreement with Hallwood Media (King & Earl, 2025). Contract value must be distinguished from streaming income, although both indicate opportunities to commercialise this type of production. Individual successes do not establish that consumption grows proportionately with production. On 20 April 2026, Deezer reported receiving almost 75,000 fully AI-generated tracks daily, approximately 44% of new recordings added to its catalogue, while these tracks represented 1–3% of total streams. Shares of new supply and of streams across the entire catalogue do not directly measure the success of the same release cohort. Platform rules also affect the relationship, since Deezer excludes fully AI-generated tracks from algorithmic recommendations and editorial playlists. It identified up to 85% of their streams in 2025 as fraudulent and excluded them from royalty calculations (Khouwes, 2026). Evidence from one platform therefore cannot establish market-wide acceptance of generated music. This discrepancy raises the question of how abundant production becomes visibility, actual listening and income. A song without a wider audience may nevertheless motivate its creator to pay for a tool, develop alternative versions and return to the service. Monetisation thus extends from the finished recording to the experience of creation, connecting user activity with content production and attention retention. Generative music's future role may emerge through connections among professional production, user creation and content tailored to moods, activities and media applications. The need to continually stimulate interest creates opportunities for hyperproduction, but its economic value depends on connecting content, audiences and payment mechanisms. Sustainability therefore also rests on who controls those connections and how participants share in the resulting value.

6. CONCLUSION

The music industry's transformation shows how technological change reshapes relationships among production, distribution and consumption, alongside the basis of revenue generation. Physical formats and digital sales link consumption to the purchase of selected content, whereas streaming separates price from individual listening and centres business activity on continuous service use. IFPI data confirm that changes in the dominant model coexist with earlier forms of consumption. Generative AI extends this process by expanding production capabilities and involving consumers in music creation. Distribution abundance is thus joined by production abundance, while audience attention remains scarce. Deezer illustrates the discrepancy between generated recordings' share of new supply and their share of total streams, although differing denominators and platform rules limit direct comparison. The analytical focus consequently shifts towards the conditions under which available music gains visibility, attracts listeners and generates revenue. Generative production continues the industry's transformation within the established attention economy. At the same time, monetisation expands to the experience of creation. Users may pay to shape their own music independently of its wider listenership, making production itself a form of service consumption. This connection demonstrates the continuity of platformisation, which turns user activity into content, engagement and a basis for payment. Business sustainability therefore extends beyond the volume of recordings produced. Its central question becomes who controls the connection between music and audiences and how the resulting value is distributed among participants.

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GREEN TRANSITION AS A DRIVER OF SUSTAINABLE ECONOMIC DEVELOPMENT IN THE REPUBLIC OF CROATIA

Ivana Miklosevic
Department of Economics, University of Slavonski Brod, Slavonski Brod, Croatia
imiklosevic@unisb.hr

Anica Vukasinovic
Brod-Posavina County, Slavonski Brod, Croatia
avukasinovic1@unisb.hr

Zeljko Sudaric
University of Applied Sciences "Lavoslav Ružička" Vukovar, Vukovar, Croatia
zeljko.sudaric@vevu.hr

ABSTRACT

Economic growth and rising living standards remain fundamental objectives of contemporary economic policy, yet climate change, environmental degradation and mounting pressure on natural resources have called the traditional growth model into question. This paper examines whether the green transition acts as a constraint on, or a driver of, sustainable economic development in the Republic of Croatia. Using annual data for 2000–2023 drawn from Eurostat, the European Environment Agency, the World Bank, the Energy Institute and national energy reports, the study combines descriptive statistics, Tapio decoupling analysis, Pearson correlation and ordinary least squares (OLS) regression, supported by Jarque–Bera normality tests and pre-/post-EU-accession comparisons. The results show that between 2000 and 2023 Croatia's real GDP expanded by roughly 67% while fossil-fuel CO_2 emissions fell by about 6%, yielding an overall decoupling elasticity of −0.09 (strong decoupling). The renewable-energy share is strongly and significantly associated with lower carbon intensity ($r = -0.68$, $p < 0.001$), and regression estimates confirm that a higher renewable share reduces the carbon intensity of output after controlling for energy intensity. A clear structural improvement follows EU accession in 2013, with carbon intensity falling from 0.30 to 0.20 kg per dollar of GDP. The evidence supports the premise that the green transition need not impede growth; rather, through renewable deployment, improved energy efficiency and eco-innovation, it can reconcile economic and environmental objectives. Policy implications for investment, institutional capacity and the use of European Union funds are discussed.

Keywords: *green transition, sustainable economic development, competitiveness, natural resources, energy efficiency, Republic of Croatia*

1. INTRODUCTION

The reconciliation of economic prosperity with environmental sustainability is among the defining policy challenges of the twenty-first century. For most of the modern era, economic growth has been tightly coupled with the expansion of fossil-fuel use and the accumulation of greenhouse gases in the atmosphere. The European Union has responded by placing the green transition at the centre of its development agenda: the European Green Deal commits the Union to climate neutrality by 2050, while the intermediate framework requires a reduction of net greenhouse-gas emissions of at least 55% by 2030 relative to 1990 (European Commission, 2019). These commitments give operational content to the objectives set out in the Paris Agreement (UNFCCC, 2015) and to the broader idea, advanced by the OECD and others, that growth can be made "green" rather than being abandoned (OECD, 2011).

The intellectual case for this position rests on the observation, formalised in the Stern Review, that the long-run economic cost of unmitigated climate change substantially exceeds the cost of early mitigation (Stern, 2007). Nevertheless, a persistent public and political concern is that the measures associated with the green transition, carbon pricing, renewable-energy mandates, efficiency standards and the phasing-out of fossil capacity, impose additional costs, erode competitiveness and constrain development, particularly for smaller and catching-up economies. The central question addressed in this paper is therefore whether the green transition functions as a brake on, or as an engine of, sustainable economic development. The Republic of Croatia offers an instructive setting for this question. As a European Union member state since 2013, a high-income but comparatively small and energy-import-dependent economy, and a country whose electricity system is already dominated by hydropower, Croatia embodies the tension between the pursuit of competitiveness, investment and resilience on the one hand and the obligations of decarbonisation and sustainable resource management on the other. The purpose of this paper is to examine the relationship between the green transition and sustainable economic development in Croatia and to assess the scope for reconciling economic and environmental objectives. Its specific aim is to test empirically whether green-transition indicators, principally the renewable-energy share and energy efficiency, are associated with a decoupling of economic output from emissions, and to interpret the findings in the context of European Union and national policy. The remainder of the paper is organised as follows: Section 2 develops the theoretical framework and reviews the relevant literature; Section 3 describes the data and methodology; Section 4 presents and discusses the empirical results; and Section 5 concludes with policy implications, limitations and directions for future research.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Decoupling and the green-growth debate

The concept of decoupling lies at the heart of the green-growth debate. Decoupling occurs when the growth rate of an environmental pressure is lower than that of the associated economic driver; it is termed relative (weak) when emissions still rise but more slowly than output, and absolute (strong) when emissions fall while output continues to expand. Tapio (2005) provided the most widely used operationalisation of this idea, defining a set of decoupling states on the basis of the elasticity between emissions and output and distinguishing, among others, weak decoupling, strong decoupling and recessive decoupling. The framework is attractive because it is transparent, requires only two series, and maps directly onto the policy question of whether growth and emissions can be separated. Critics of green growth argue that historical decoupling has been insufficient and that absolute reductions consistent with climate targets may be difficult to sustain; proponents counter that decoupling is both observed and achievable where policy, technology and investment align (Jacobs, 2013).

2.2. The Porter hypothesis and directed technical change

A second strand of literature concerns the effect of environmental regulation on competitiveness. The Porter hypothesis holds that well-designed environmental regulation can stimulate innovation, improve resource productivity and, under some conditions, more than offset compliance costs, thereby enhancing rather than diminishing competitiveness (Porter & van der Linde, 1995). This mechanism is reinforced by models of directed technical change, which show that policy can redirect innovation away from polluting and towards clean technologies, and that early intervention lowers the long-run cost of the transition (Acemoglu et al., 2012). Together these arguments provide the theoretical basis for treating the green transition as a potential driver of development: renewable deployment and efficiency improvements are not merely abatement expenditures but investments that can raise productivity, reduce exposure to volatile fossil-fuel imports and create new economic activity.

2.3. The Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) hypothesis, associated with the early empirical work of Grossman and Krueger, posits an inverted-U relationship between per-capita income and environmental degradation: pollution rises in the early stages of development and falls once a threshold income is passed, as economies shift towards services, cleaner technologies and stronger environmental preferences (Grossman & Krueger, 1995). For an upper-middle to high-income European economy such as Croatia, the EKC framework predicts that further growth should be accompanied by declining emission intensity, especially where it is reinforced by the policy architecture of the European Union. The decoupling and EKC perspectives are complementary: the former measures the observed separation of emissions from output, while the latter offers a structural explanation for why that separation should intensify as income rises.

2.4. Green transition in the European and Croatian policy context

The European Union has translated these ideas into an unusually dense policy framework. The "Fit for 55" package operationalises the 2030 target through reforms to emissions trading, effort-sharing, renewable-energy and energy-efficiency directives (European Commission, 2021a), while the Recovery and Resilience Facility ties post-pandemic fiscal support to green and digital objectives, requiring that at least 37% of national plans contribute to climate goals, a design consistent with evidence that recovery spending can either accelerate or retard climate progress depending on its composition (Hepburn et al., 2020). Croatia has embedded these obligations in its Integrated National Energy and Climate Plan (NECP), which raises the 2030 target for the renewable share in gross final energy consumption to 42.5% and envisages a coal phase-out by 2033 (Ministry of Economy and Sustainable Development, 2023), and in its national Recovery and Resilience Plan, a substantial part of which is allocated to energy, buildings and sustainable transport (European Commission, 2021b).

This institutional context is central to the interpretation of the empirical results, because it implies that Croatia's green transition is not a purely domestic choice but is embedded in a binding supranational framework that shapes investment and expectations.

3. DATA AND METHODOLOGY

3.1. Data and variables

The analysis uses annual time-series data for the Republic of Croatia over the period 2000–2023. Real GDP growth is taken from the World Bank World Development Indicators (World Bank, 2024). The renewable-energy share, energy intensity and fossil-fuel CO_2 emissions are drawn from the Our World in Data energy and emissions datasets, which compile figures from the Energy Institute Statistical Review of World Energy, Ember and the Global Carbon Project on a consistent basis (Ritchie et al., 2024).

These are complemented and cross-checked against official European sources: Eurostat renewable-energy statistics (Eurostat, 2024), the European Environment Agency's greenhouse-gas inventory for Croatia (European Environment Agency, 2024), the annual national energy report Energy in Croatia 2023 (Ministry of Economy and Sustainable Development, 2024), and the International Energy Agency (International Energy Agency, 2023) and IRENA (International Renewable Energy Agency, 2023) databases. Where policy targets and the officially reported renewable share in gross final energy consumption are cited, the Eurostat basis is used; the econometric renewable-share variable is measured on a primary-energy basis for internal consistency across the full period. Table 1 defines the variables and their sources.

Variable	Definition	Unit	Source
GDP growth	Annual real gross domestic product growth	%	World Bank (2024)
GDP index	Real GDP index, 2000 = 100 (constructed)	index	Authors, from World Bank (2024)
RES	Renewable energy share of primary energy	%	Ritchie et al. (2024)
CO_2	Fossil-fuel carbon-dioxide emissions	Mt	Ritchie et al. (2024)
CO_2 intensity	CO_2 emissions per unit of GDP	kg/$	Ritchie et al. (2024)
Energy intensity	Primary energy per unit of GDP	kWh/$	Ritchie et al. (2024)

Table 1: Variables, definitions and data sources.
(Source: Authors' compilation.)

3.2. Methodology

The empirical strategy proceeds in five complementary steps, chosen so that the abstract's central premise can actually be tested rather than merely asserted. First, descriptive statistics and trend analysis summarise the evolution of each series and establish the broad direction of change. Second, the Tapio decoupling framework is applied to measure the relationship between fossil CO_2 emissions and real GDP over successive sub-periods. The decoupling elasticity is defined as

$$e = (\%\Delta CO_2) / (\%\Delta GDP),$$

where $\%\Delta CO_2$ and $\%\Delta GDP$ denote percentage changes over the interval. Following Tapio (2005), $e < 0$ with rising GDP indicates strong (absolute) decoupling, $0 \leq e < 0.8$ indicates weak (relative) decoupling, and $0.8 \leq e \leq 1.2$ indicates expansive coupling. Third, a Pearson correlation matrix quantifies the bivariate associations among the green-transition indicators, output and emissions. Fourth, two ordinary least squares (OLS) regressions are estimated: a log-linear emissions model, $\ln(CO_2) = \beta_0 + \beta_1 \ln(GDP) + \beta_2 RES + \varepsilon$, and a carbon-intensity model, CO_2 intensity $= \alpha_0 + \alpha_1 RES + \alpha_2$ (energy intensity) $+ \varepsilon$. The normality of residuals is assessed using the Jarque–Bera test (Jarque & Bera, 1980). Fifth, a structural comparison of the pre-accession (2000–2012) and post-accession (2013–2022) sub-periods is conducted using a

Welch two-sample t-test of means and an F-test of variance equality, EU accession in 2013 serving as a natural policy break. Given the modest sample size inherent in single-country annual data, the regression results are interpreted as descriptive associations rather than strict causal estimates, and are read alongside the decoupling and correlation evidence.

4. RESULTS AND DISCUSSION

4.1. Descriptive statistics and trends

Table 2 reports the descriptive statistics for the 2000–2022 window. Over this period real GDP growth averaged 2.33% per year, with pronounced volatility (standard deviation 4.43) reflecting the 2009 financial crisis, the prolonged recession of 2009–2014, the 2020 pandemic contraction and the sharp 2021 rebound. The renewable-energy share averaged 20.2% and rose over time, while both carbon intensity (mean 0.26 kg per dollar) and energy intensity (mean 1.28) declined markedly, signalling a structural improvement in the environmental efficiency of the economy.

Variable	Mean	Std. dev.	Minimum	Maximum
GDP growth (%)	2.33	4.43	−8.31	12.63
Renewable share (%)	20.21	4.71	11.75	28.68
Fossil CO_2 (Mt)	20.17	2.49	16.87	24.80
Energy intensity (kWh/$)	1.28	0.24	0.91	1.76
CO_2 intensity (kg/$)	0.260	0.061	0.172	0.360

Table 2: Descriptive statistics, Croatia 2000–2022.
(Source: Authors' calculations.)

Figure 1 makes the central pattern visible. Between 2000 and 2023 the real-GDP index rose by roughly two-thirds, whereas fossil CO_2 emissions ended the period slightly below their 2000 level. The two series, tightly coupled before the 2009 crisis, visibly separate thereafter, and especially after EU accession in 2013. Figure 2 shows the renewable-energy share climbing from below 20% in the early 2000s towards the high-20s, comfortably surpassing the 20% Europe-2020 target while remaining well short of the 42.5% target set for 2030 in the national plan. Figure 3 documents the steady decline of both carbon and energy intensity, the clearest single indication that Croatian output has become progressively cleaner and less energy-hungry.



Figure 1: Decoupling of the real-GDP index from fossil CO_2 emissions, Croatia 2000–2023.
(Source: Authors' calculations.)

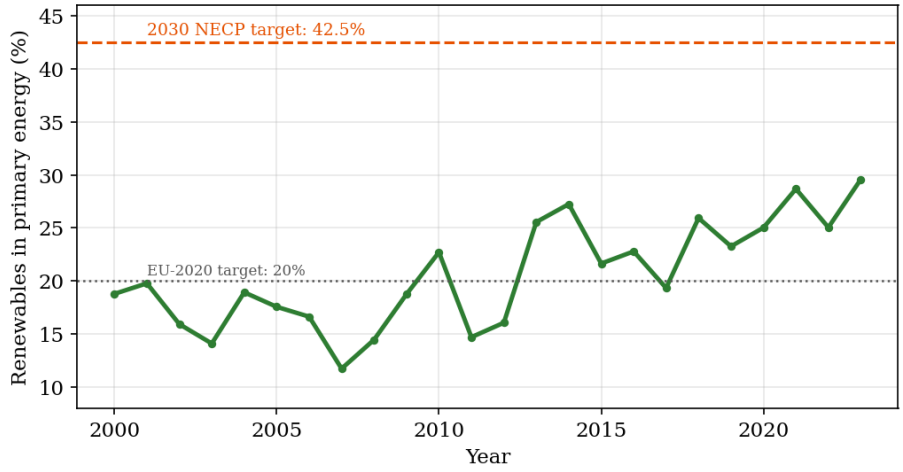

Figure 2: Renewable-energy share in primary energy with policy targets, 2000–2023.
(Source: Authors' calculations.)

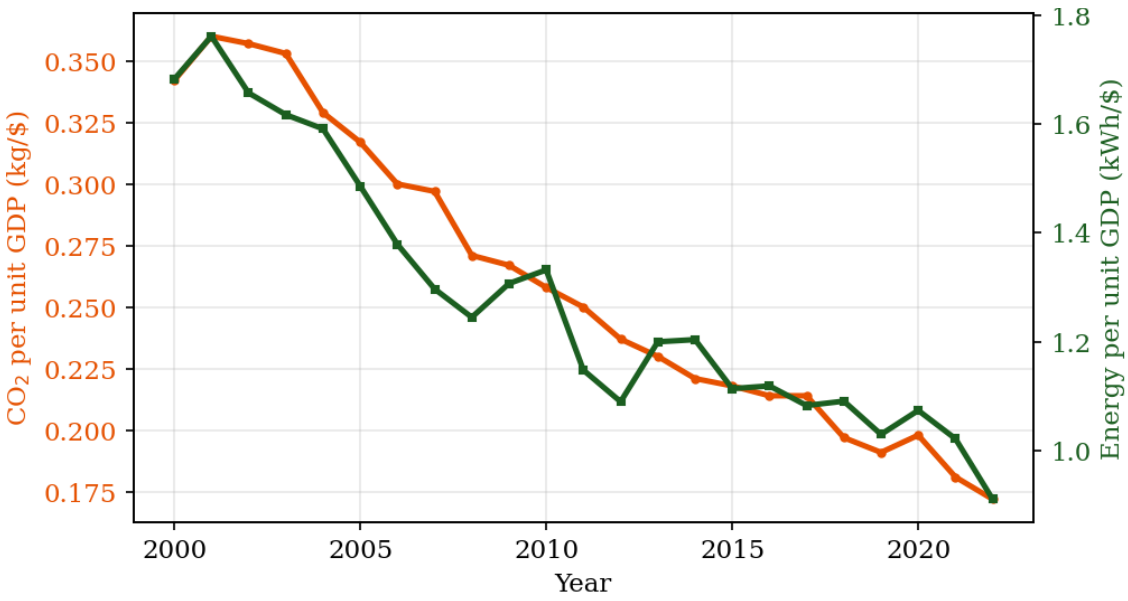

Figure 3: Carbon intensity and energy intensity of the Croatian economy, 2000–2022.
(Source: Authors' calculations.)

4.2. Decoupling analysis

Table 3 reports the Tapio decoupling results. Over the full 2000–2023 period the elasticity is −0.09: GDP grew by 66.8% while fossil emissions fell by 6.0%, a state of strong (absolute) decoupling. The sub-period detail is revealing. In the pre-crisis expansion of 2000–2008 growth and emissions rose together in a state of weak decoupling (e = 0.48). The recession of 2008–2013 produced recessive decoupling (e = 2.11), in which emissions fell faster than a shrinking economy, an environmentally favourable but economically undesirable outcome. Crucially, the post-accession recovery of 2013–2019 delivered strong decoupling (e = −0.21): emissions declined even as output expanded by more than 15%. The most recent interval, 2019–2023, spanning the pandemic and the energy-price shock, returned to weak decoupling (e = 0.25), with emissions rising far more slowly than output.

The contrast between the recessive decoupling of the crisis years and the strong decoupling of the recovery is the single most important finding of the paper: it indicates that Croatia's emission reductions since 2013 have been driven by structural greening rather than by economic contraction. Figure 5 summarises these states.

Period	%Δ GDP	%Δ CO_2	Elasticity	Decoupling state
2000–2008	+40.9	+19.7	0.48	Weak decoupling
2008–2013	−10.3	−21.8	2.11	Recessive decoupling
2013–2019	+15.4	−3.2	−0.21	Strong decoupling
2019–2023	+14.5	+3.6	0.25	Weak decoupling
2000–2023	**+66.8**	**−6.0**	**−0.09**	**Strong decoupling**

Table 3: Tapio decoupling of fossil CO_2 emissions from real GDP.
(Source: Authors' calculations.)

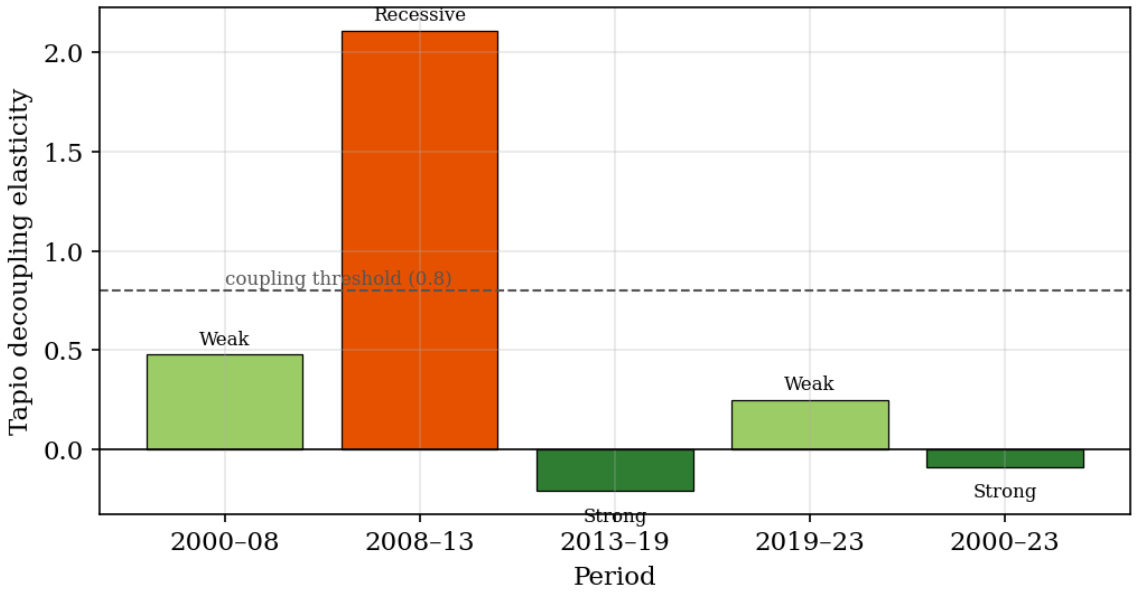

Figure 5: Decoupling elasticity between CO_2 and GDP by sub-period.
(Source: Authors' calculations.)

4.3. Correlation analysis

The correlation matrix in Table 4 confirms the expected relationships. The renewable-energy share is strongly negatively correlated with both the level of fossil emissions ($r = -0.83$, $p < 0.001$) and carbon intensity ($r = -0.68$, $p < 0.001$): periods of higher renewable penetration coincide with a cleaner economy.

Energy intensity and carbon intensity are almost perfectly correlated ($r = 0.97$), as expected, and both decline strongly as the GDP index rises ($r = -0.86$ and -0.81 respectively), consistent with the Environmental Kuznets Curve prediction that a richer Croatian economy is a less carbon-intensive one. Notably, the renewable share is essentially uncorrelated with the rate of GDP growth ($r = -0.01$, not significant), which provides no support for the claim that renewable expansion has acted as a drag on growth. Figure 4 illustrates the renewables–intensity relationship.

	GDP idx	**GDP gr.**	**RES**	**CO_2**	**En. int.**	**CO_2 int.**
GDP index	1.00					
GDP growth	0.16	1.00				
RES	0.37	−0.01	1.00			
CO_2	−0.32	0.14	−0.83	1.00		
Energy int.	−0.86	0.11	−0.49	0.64	1.00	
CO_2 int.	−0.81	0.12	−0.68	0.78	0.97	1.00

Table 4: Pearson correlation matrix, 2000–2022.
(Source: Authors' calculations.)

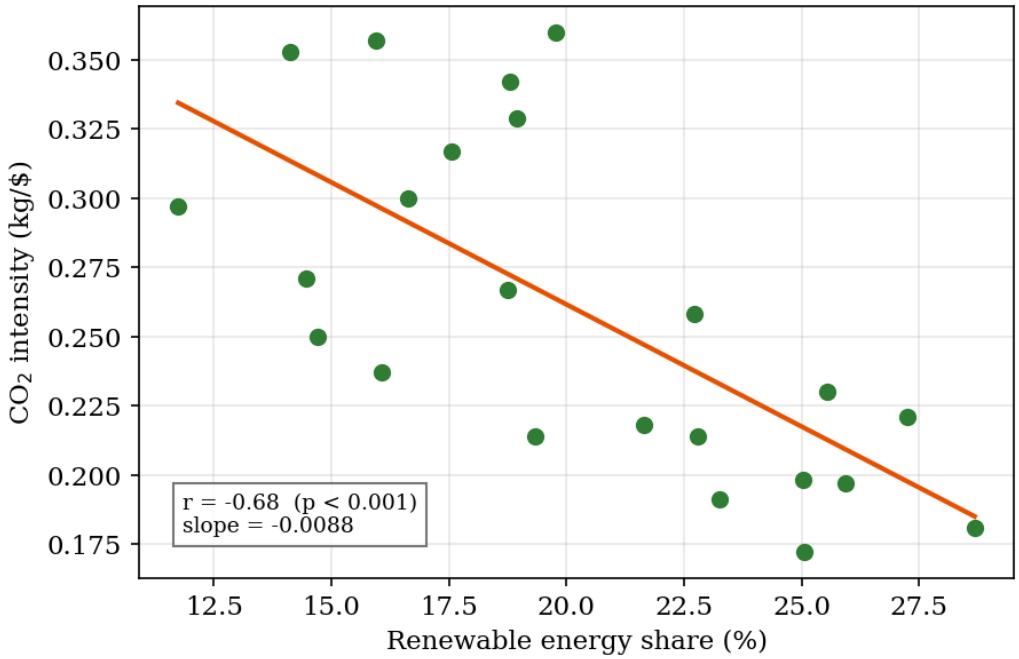

Figure 4: Renewable-energy share versus carbon intensity, with fitted line.
(Source: Authors' calculations.)

4.4. Regression results

Table 5 reports the two OLS models. In the emissions model, the coefficient on the renewable share is negative and highly significant (−0.020, $p < 0.001$): a one-percentage-point increase in the renewable share is associated with roughly a 2% reduction in fossil emissions, holding output constant. The coefficient on output is negative but statistically insignificant, indicating that, over this period, higher GDP was not systematically associated with higher emissions once the renewable share is accounted for. The model explains about 70% of the variation in emissions ($R^2 = 0.70$; $F = 23.7$, $p < 0.001$). The carbon-intensity model is even sharper: the renewable share again enters negatively and significantly (−0.0036, $p < 0.001$) while energy intensity enters positively, together explaining almost all of the variation in carbon intensity ($R^2 = 0.99$). The Jarque–Bera statistics for the residuals of both models are small and insignificant ($p = 0.59$ and 0.58), and the test on the GDP-growth series is likewise insignificant ($p = 0.41$), so the assumption of normally distributed disturbances is not rejected. Taken together, the regressions corroborate the correlation and decoupling evidence: the renewable share is a robust negative predictor of both the level and the intensity of emissions.

	Model 1: ln(CO_2)	**Model 2: CO_2 intensity**
Constant	5.743* (2.686)	0.0645*** (0.009)
ln(GDP)	−0.093 (0.108)	—
Renewable share	−0.020*** (0.003)	−0.0036*** (0.0002)
Energy intensity	—	0.209*** (0.005)
R^2	0.703	0.995
F (p-value)	23.73 (<0.001)	1990.9 (<0.001)
Jarque–Bera (p)	1.05 (0.59)	1.08 (0.58)

Table 5: OLS regression estimates (standard errors in parentheses).
**** $p < 0.01$, * $p < 0.05$; $n = 23$.*
(Source: Authors' calculations.)

4.5. Structural comparison: before and after EU accession

Table 6 formalises the visual impression from Figure 1 that the character of Croatia's development changed around 2013. Mean carbon intensity fell from 0.303 kg per dollar in 2000–2012 to 0.204 in 2013–2022, a difference that is large and highly significant (Welch $t = 7.40$, $p < 0.001$), while the accompanying F-test indicates a significant reduction in variance ($F = 5.36$, $p = 0.017$), consistent with a more stable, lower-emission regime. Over the same break the mean renewable share rose from 16.9% to 24.5% ($t = -6.35$, $p < 0.001$). EU accession, and the accompanying entry into the Emissions Trading System and alignment with the Union's climate and energy directives, thus coincides with a statistically detectable structural improvement in the environmental performance of the Croatian economy.

Indicator	2000–2012	2013–2022	Test statistic	p-value
CO_2 intensity (kg/$)	0.303	0.204	t = 7.40	<0.001
Variance (CO_2 intensity)	—	—	F = 5.36	0.017
Renewable share (%)	16.9	24.5	t = −6.35	<0.001

Table 6: Pre- versus post-accession structural comparison (Welch t-test; F-test of variance).
(Source: Authors' calculations.)

4.6. Discussion

The results consistently support the premise set out in the abstract: in the Croatian case the green transition has not obstructed growth but has accompanied a durable improvement in environmental performance. The strong decoupling of the recovery years, the significant negative association between the renewable share and emissions, and the structural break at EU accession together describe an economy that has grown while becoming cleaner. Several mechanisms plausibly underlie this pattern. First, Croatia's comparative advantage in renewable resources, an electricity system long dominated by hydropower and substantial wind, solar and geothermal potential, means that renewable deployment substitutes directly for imported fossil fuel, simultaneously lowering emissions and reducing an energy-import dependency that stands at over half of total consumption. Second, in line with the Porter and directed-technical-change perspectives, the European policy framework has channelled investment and innovation towards clean technologies, so that regulation has operated as an incentive rather than merely a cost. Third, the embedding of climate objectives in the Recovery and Resilience Plan and the NECP has provided a stable expectation of continued green investment, supporting the coal phase-out envisaged by 2033 and the 42.5% renewable target for 2030.

These findings should nonetheless be read with appropriate caution. The recessive decoupling of 2008–2013 is a reminder that not all emission reductions are benign: reductions achieved through contraction differ fundamentally from those achieved through greening, and only the latter are compatible with sustainable development. Moreover, the hydropower-dependent structure of Croatian renewables introduces climatic variability into the renewable share from year to year, and the most demanding part of the transition, decarbonising transport and heating, where fossil fuels still dominate final consumption, largely lies ahead. The gap between the current renewable share and the 2030 target implies that the pace of investment must accelerate rather than merely continue.

5. CONCLUSION

This paper set out to determine whether the green transition acts as a constraint on, or a driver of, sustainable economic development in the Republic of Croatia. Drawing on annual data for 2000–2023 and combining decoupling analysis, correlation, regression and structural tests, it finds robust and mutually consistent evidence that Croatia has decoupled economic growth from carbon emissions, that the renewable-energy share is a significant negative predictor of both the level and intensity of emissions, and that a statistically detectable structural improvement in environmental performance followed EU accession in 2013. The green transition, on this evidence, has reconciled rather than opposed economic and environmental objectives. The policy implications are threefold. First, because the observed decoupling since 2013 has been structural rather than recession-driven, sustaining it requires continued investment in renewable capacity, grid modernisation and energy efficiency rather than reliance on cyclical downturns. Second, the strength of the institutional framework, the NECP, the Recovery and Resilience Plan and alignment with the Fit-for-55 architecture has been central to translating targets into outcomes, which argues for maintaining and strengthening administrative and absorptive capacity for European Union funds. Third, since the largest remaining emissions lie in transport and heating, future effort should prioritise the electrification of transport, the decarbonisation of buildings and the diversification of renewables beyond hydropower to reduce climatic exposure. The study is subject to limitations that also indicate directions for future research. The analysis relies on single-country annual data, which restricts the sample size and means that the regression estimates are best interpreted as robust associations rather than strict causal effects; panel or cross-country designs, and time-series methods such as ARDL or structural vector autoregression on longer or higher-frequency series, could sharpen causal identification. Extending the analysis to employment, investment and eco-innovation outcomes would allow a fuller assessment of the developmental as opposed to purely environmental dividends of the green transition. Subject to these caveats, the Croatian experience offers an encouraging illustration that, within a supportive supranational framework, long-term economic development and the preservation of environmental and natural resources for future generations can be pursued together.

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FRANCHISE MODEL AS AN INSTRUMENT OF ENTREPRENEURSHIP DEVELOPMENT

Lovorka Blazevic
University of Applied Sciences Marko Marulić in Knin, Croatia
Krešimirova 30, 22300 Knin, Croatia
lovorka.blazevic@veleknin.hr

Damir Mihanovic
University of Applied Sciences Marko Marulić in Knin, Croatia
Krešimirova 30, 22300 Knin, Croatia
damir.mihanovic@veleknin.hr

Linda Martic Kuran
University of Applied Sciences Marko Marulić in Knin, Croatia
Krešimirova 30, 22300 Knin, Croatia
lmartic@veleknin.hr

ABSTRACT

This paper examines the opportunities and limitations of franchising in entrepreneurship development, focusing on the relationship between support from the franchise system and franchisee autonomy. It draws on an integrative review of 17 scholarly articles published between 2011 and 2026, organised in four thematic areas: theoretical explanations of franchising, franchisee entrepreneurship, success factors and risks, and development outcomes and digital transformation. The review suggests that access to business knowledge, an established brand and franchisor support can facilitate business entry and expansion, but the available findings do not justify a general claim that franchises face a lower risk of failure than independent businesses; potential benefits coexist with franchise fees, limited autonomy and dependence on the franchisor's decisions and reputation. The paper contributes an analytical framework distinguishing access to resources, the knowledge and decision rights needed to use them, and outcomes observed at the level of the franchisee, the network and the economy. The framework explains how network support and entrepreneurial autonomy can complement each other, while financial benefits remain conditional on the characteristics of each franchise system.

Keywords: *franchising, entrepreneurship, business model, critical success factors, digitalisation*

1. INTRODUCTION

Franchising expands a business concept through cooperation between a franchisor and a franchisee. The franchisee invests capital and manages the outlet with the right to use the franchisor's brand and business knowledge, but accepts contractual restrictions and system standards. The relationship between entrepreneurial initiative and these restrictions raises the question of the conditions under which franchising facilitates entrepreneurship development (Combs et al., 2011; Ketchen et al., 2011). The economic significance of franchising is examined at the level of firms and of national economies. Studies of business units address entrepreneurial behaviour and financial outcomes, whereas Lanchimba et al. (2024) analyse the association between franchising activity and development indicators in 49 countries. In the contemporary literature franchising is increasingly viewed through the lens of entrepreneurship, but the interpretation is not unambiguous: some authors treat it as constrained entrepreneurship because of standardisation and control, while others emphasise its potential to stimulate

entrepreneurial activity by combining individual initiative with system support (Ketchen et al., 2011; Dada et al., 2012). Digitalisation changes data collection, communication and the organisation of business (Calderon-Monge and Ribeiro-Soriano, 2024; Kreiterling, 2023). Because these studies address business and entrepreneurship in general, their findings are used here to consider possible changes in franchise networks, while recent empirical research on franchise networks (Pajić et al., 2025; Kukec, 2025) allows those considerations to be partly checked. For small open economies franchising is relevant because of knowledge transfer and access to international markets (Alon et al., 2021). Croatian research presents franchising primarily as a route into entrepreneurship (Erceg and Orban, 2020), while Croatian franchisors are only at an early stage of adopting new technologies (Kukec, 2025), so international findings cannot be transferred to Croatia without further verification (Lanchimba et al., 2024). The aim of the paper is to analyse, through an integrative literature review, the opportunities and limitations of the franchise model in entrepreneurship development. The research question is: how are franchisor support and business standardisation related to the entrepreneurial opportunities, autonomy and risks of franchisees? The possibility of reducing initial uncertainty is considered separately from the claim of lower financial risk or higher survival probability. The contribution of the paper is an analytical framework that distinguishes three questions: what the franchisee gains access to, whether the resources obtained can be applied, and by which indicators the result is assessed (Figure 1). The framework links the resource-based, governance and entrepreneurial perspectives and is intended for interpreting the literature and shaping research questions rather than as an empirically tested model. Section 2 reviews the literature, Section 3 describes the method and the analytical framework, Section 4 presents the results and their synthesis, and Section 5 concludes.

2. LITERATURE REVIEW

Theoretical literature explains franchising from the perspective of access to resources, alignment of interests and the organisation of a business network (Combs et al., 2011), while research on international franchising additionally addresses market selection, institutional differences and relationship management (Rosado-Serrano et al., 2018; Alon et al., 2021). The entrepreneurial perspective links these issues to the franchisee's initiative and scope for action within common standards. Individual findings of the reviewed studies are presented in Section 4.

2.1. Concept and typology of the franchise model

A franchise is a contractual business relationship in which the franchisor grants the franchisee the right to use its brand and, depending on the type of franchise, its business system and knowledge, in return for fees and compliance with agreed standards (Rosado-Serrano et al., 2018). In business-format franchising the cooperation typically includes initial training, operating standards, monitoring and franchisor support; the franchisee bears start-up and operating costs together with initial and ongoing fees. Common standards support a recognisable offer, while the room for local adaptation differs between systems (Combs et al., 2011; Dada et al., 2012). Several typologies are used. By the object of transfer, distribution, service and industrial franchises are distinguished; by the degree of system integration, business-format franchising and product and trade-name franchising (Rosado-Serrano et al., 2018). Business-format franchising, which involves the transfer of the entire business system, is most relevant to the question of entrepreneurial autonomy because the franchisee accepts rules covering a wide range of decisions, including assortment, suppliers and promotion (Combs et al., 2011).

By scope of rights, single-unit, multi-unit, area development and master franchising are distinguished; in international business, master franchising allows a local partner to be involved in developing the network but requires the coordination of an additional layer of relationships (Alon et al., 2021).

2.2. Theoretical foundations of the franchise model

Contemporary franchising research draws on several theoretical perspectives, among which resource scarcity theory, agency theory and plural form theory are most prominent (Combs et al., 2011). Resource scarcity theory holds that firms use franchising to overcome constraints of capital and managerial capacity: by involving franchisees who invest their own funds and manage units, the franchisor can expand with less own capital, although the allocation of investment transfers rather than removes financial risk. Agency theory addresses the alignment of interests and monitoring costs; the franchisee's ownership stake may increase engagement but does not eliminate conflict or opportunism, and the argument explains the choice of organisational form rather than proving better financial results for franchised units. Plural form theory explains the coexistence of franchised and company-owned units within one system: company-owned units secure standardisation, while franchised units contribute local adaptation and entrepreneurial dynamics, so franchise systems are interpreted as hybrid structures (Combs et al., 2011). Transaction cost theory and the institutional perspective add the costs of coordination and the conditions of contract enforcement, which are particularly useful for explaining international expansion (Rosado-Serrano et al., 2018; Alon et al., 2021).

2.3. Franchising as entrepreneurship, internationalisation and digitalisation

Franchising is increasingly analysed within the wider conceptual framework of entrepreneurship, with emphasis on its role in generating business opportunities and diffusing business models (Ketchen et al., 2011; Dada et al., 2012). Whether franchising can be unambiguously classified as entrepreneurship remains open. Ketchen, Short and Combs (2011) argue that the answer depends on the perspective: for the franchisor, franchising is clearly entrepreneurial because it involves opportunity identification, business model development and scaling through a network, whereas the franchisee's role is conditional on the level of autonomy a given system allows. The studies elaborating this debate, namely the model of franchisee entrepreneurship (Dada et al., 2012), franchising as a channel for spreading knowledge and innovation (Lewandowska, 2014), intentions to become a franchisee (Croonen et al., 2022) and the bibliometric structure of the field (Elango, 2019), are analysed in Section 4. International expansion involves market selection, relationships with local partners and adaptation of the business concept. Rosado-Serrano et al. (2018) find that research on international franchising remains fragmented, particularly regarding the effects of cultural differences, institutional frameworks and financial performance, while Alon et al. (2021) show that the effect of franchising on costs and results depends on the chosen entry mode and the capability to manage the network. For firms from small open economies these reviews provide a framework for assessment but do not establish the results of application in Croatia. Digitalisation changes data collection, customer communication and process management. Calderon-Monge and Ribeiro-Soriano (2024) synthesise research on business digitalisation and Kreiterling (2023) examines digital innovation and entrepreneurship. For the purposes of this paper, operational, market and managerial uses of digital tools are distinguished. Operational tools integrate data and monitor units; market tools support customer communication and raise the question of who controls customer data; managerial platforms facilitate performance monitoring but also expand the possibilities of control.

Whether such control reduces franchisee autonomy is treated here as a research assumption derived from linking the digitalisation literature with research on entrepreneurial action in franchise systems (Dada et al., 2012; Calderon-Monge and Ribeiro-Soriano, 2024).

3. METHODOLOGY

The paper is designed as an integrative literature review with thematic synthesis. This approach combines conceptual papers, literature reviews and empirical studies in order to connect different theoretical explanations and types of findings on the entrepreneurial role of franchising; it does not perform a meta-analysis or estimate a common effect size. Although the review does not have the features of an exhaustive systematic search, the procedure of selecting and interpreting sources is presented transparently because the assessment of its conclusions depends on it (Tranfield et al., 2003). The analytical corpus consists of 17 scholarly articles in English and Croatian published between 2011 and 2026 (Table 2). Fifteen directly address franchising, while two address digitalisation and entrepreneurship in general (Calderon-Monge and Ribeiro-Soriano, 2024; Kreiterling, 2023) and serve as a theoretical complement to the area of digital transformation; their claims are not transferred to franchising as direct evidence. The corpus was formed in two steps (Table 1). An initial corpus of 14 articles was identified by searching Web of Science and Scopus with the string franchise AND (entrepreneurship OR "business model" OR "SME" OR "small business") for the period from 2010 onwards, and by manually searching Croatian scholarly journals, with purposive selection of studies offering a theoretical explanation, a review or an empirical finding on at least one of the links between franchisor support, franchisee autonomy and entrepreneurial outcomes. In the second step, in September 2026, the corpus was supplemented by a targeted search of 2025–2026 publications combining franchising with knowledge transfer, sustainability, artificial intelligence and Croatia, with bibliographic data verified on publishers' websites and the Hrčak portal; this added Pajić et al. (2025), Raha and Windsperger (2026) and Kukec (2025). Promotional and practitioner texts without scholarly analysis were excluded. The number of studies results from purposive selection of complementary sources rather than exhaustive searching, which is noted among the limitations.

Step	Source and procedure	Selection criterion	No. of studies
1. Database search	Web of Science and Scopus; franchise AND (entrepreneurship OR "business model" OR "SME" OR "small business"); 2010 onwards	theoretical explanation, review or empirical finding on the link between support, autonomy and outcomes; verifiable data	13
2. Manual search of Croatian journals	Hrčak portal	Croatian context; same content criterion	1
3. Targeted update (September 2026)	publishers' websites and Hrčak; franchising + knowledge transfer / sustainability / artificial intelligence / Croatia	2025–2026 publications; same content criterion	3
Total			**17**

Table 1: Literature selection procedure
(Source: Authors. Note: the methodological source Tranfield et al. (2003) is not part of the corpus)

For each study the author, year, method, subject and relevant finding were extracted, and the unit of analysis, sample and measured variable were considered when comparing them. Intentions of prospective franchisees, behaviour of existing participants, credit outcomes, assessments of network performance and indicators of economic development are treated as distinct outcomes, so no common effect of franchising was calculated. The thematic synthesis covers four areas: theoretical explanations of franchising, franchisee entrepreneurship, success factors and risks, and development effects and digital transformation. Within each area converging and diverging findings are compared and then interpreted through the analytical framework in Figure 1, which distinguishes access to resources (brand, business knowledge, training and support), the ability to apply them (franchisee competence, decision rights, mode of cooperation) and outcomes assessed separately at the level of the franchisee, the network and the economy. The framework builds on the resource-based perspective (Combs et al., 2011), research on the allocation of decision rights in franchise networks (Pajić et al., 2025) and the entrepreneurial perspective of the franchisee (Dada et al., 2012), and by separating levels of analysis prevents the availability of support from being equated with business success. The evidential value of findings is assessed qualitatively by type of study, sample and measured outcome, without scoring methodological quality.

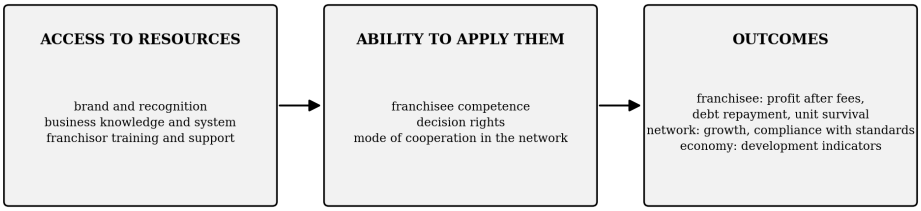

Figure 1: Analytical framework: access to resources, ability to apply them and outcomes (Source: Authors)

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Author	Year	Method	Focus	Main finding
Combs, Ketchen and Short	2011	Literature review	Theoretical foundations	Key theories identified: agency, resource scarcity and plural form
Ketchen, Short and Combs	2011	Conceptual discussion and expert survey	Franchising as entrepreneurship	Entrepreneurial character depends on the franchisor's or franchisee's perspective
Dada, Watson and Kirby	2012	Multiple case studies (UK)	Franchisee entrepreneurship	Franchisee networks and learning support entrepreneurial action
Lewandowska	2014	Theoretical-empirical analysis	Innovation in franchising	Franchising as a channel for entrepreneurship and innovation
Rosado-Serrano et al.	2018	Systematic review	International franchising	Research gaps and theoretical diversity identified
Elango	2019	Bibliometric analysis	Evolution of research	Analysis of 570 articles: intellectual foundations and thematic structure of the field

Author	Year	Method	Focus	Main finding
Erceg and Orban	2020	Business case analysis	Franchising and entrepreneurship development	Assessment of investment and profitability of a laundry franchise
Alon et al.	2021	Systematic review	Internationalisation	Links theoretical explanations and open questions of international franchising
Croonen et al.	2022	Survey (666 respondents)	Intention to become a franchisee	Motivation relates to intention through attitudes and perceived control
Michael	2022	Quantitative analysis of loan data	Credit risk	Higher default rates and lender losses for franchisees in the analysed sample
Hizam-Hanafiah et al.	2023	Focus groups (Malaysia)	Critical success factors	Franchisor capability, interconnection with franchisees and constant innovation
Kreiterling	2023	Literature review	Digital innovation and entrepreneurship	Digitalisation changes competitive conditions for entrepreneurs
Lanchimba et al.	2024	Panel analysis (49 countries)	Macroeconomic effects	Positive association between franchising and development indicators; causality requires further testing
Calderon-Monge and Ribeiro-Soriano	2024	Systematic review	Business digitalisation in general	Digital transformation changes operational and managerial patterns
Kukec	2025	Survey (35 Croatian franchisors)	Adoption of artificial intelligence	Perceived benefits accompanied by lack of knowledge; financial effect not established
Pajić, Gorovaia and Windsperger	2025	Survey of 168 networks; PLS-SEM	Knowledge transfer and decision rights	Suitable knowledge transfer mechanisms are associated with decentralisation of decisions
Raha and Windsperger	2026	Survey of 62 networks; PLS-SEM	Sustainability standards and performance	Internal and legal compliance are differently related to assessed performance

Table 2: Overview of the analysed studies
(Source: Authors, based on the cited studies. Notes: Calderon-Monge and Ribeiro-Soriano (2024) and Kreiterling (2023) address digitalisation in general and serve as a theoretical complement; PLS-SEM – partial least squares structural equation modelling)

4. RESULTS AND DISCUSSION

4.1. Theoretical explanations of franchising

The comparison of theoretical approaches shows that they answer different questions: the resource-based perspective explains why the network expands, the agency perspective how interests are aligned, and the entrepreneurial perspective how the franchisee recognises and exploits opportunities within given rules (Combs et al., 2011; Ketchen et al., 2011).

Combining them is more useful than seeking a single theory for all franchising outcomes, which is the starting point of the framework in Section 3. From this comparison follows the distinction between the efficiency of the organisational form for the franchisor and the benefit for the franchisee: franchisee capital and local knowledge facilitate network growth, whereas fees, financing and the allocation of decision rights determine the franchisee's own position. Growth in the number of units is therefore not a sufficient indicator of entrepreneurship development if the results and scope for action of unit owners are unknown. Elango (2019), in a bibliometric analysis of 570 articles, shows that franchising research has grown from economic and marketing foundations into an interdisciplinary field in which entrepreneurial and behavioural perspectives carry increasing weight. These differences are used here to delimit conclusions: intention to enter explains the attractiveness of the model, entrepreneurial behaviour its everyday application, and financial indicators the realised consequences.

4.2. The entrepreneurial dimension of the franchise model

The reviewed literature suggests that the franchise model cannot be unambiguously placed in traditional categories of entrepreneurship but represents a hybrid form combining independent entrepreneurial action with organisationally structured business, a position that follows from the coexistence of autonomy and control. Knowledge transfer and franchisor support ease the start of a business, as illustrated by Erceg and Orban's (2020) analysis of investing in a laundry franchise. This must not, however, be equated with lower credit risk: Michael (2022), using data on small business loans in the United States, finds higher default rates and larger lender losses among franchisees than among independent entrepreneurs. The result refers to the loans analysed, but it is sufficient to reject the claim of franchising as a safer alternative without verification. Autonomy is best examined by type of decision rather than as a single property of a franchise.

A common product standard can coexist with local decision-making on customer relations or work organisation (Ketchen et al., 2011; Dada et al., 2012), so the question of how much freedom the franchisee has becomes the question of which decision rights are needed to use local knowledge while preserving the common offer. Dada, Watson and Kirby (2012), on the basis of multiple case studies in the United Kingdom, highlight the role of formal franchisee networks, information exchange and learning in developing entrepreneurial behaviour within a standardised system; Hizam-Hanafiah et al. (2023) qualitatively identify success factors from both sides of the relationship; and Lewandowska (2014) interprets franchising as a channel for spreading business knowledge and stimulating innovation. Together these findings explain why access to the same business concept need not produce equal results in all units: innovativeness within the network depends on the possibilities of proposing and adopting improvements while respecting common standards. Croonen et al. (2022), in a survey of 666 respondents, find that need for achievement is related to attitude towards franchising in an inverted U-shape, with attitude and perceived control partly mediating the link between motivation and intention; the finding concerns intention to enter rather than realised performance. Pajić et al. (2025), using data on 168 networks in Germany, Austria, the Czech Republic and Slovakia, link suitable knowledge transfer mechanisms to the decentralisation of decision rights, which complements the discussion of learning and innovation (Dada et al., 2012; Lewandowska, 2014): support can enable autonomy rather than merely accompany control. As respondents were network headquarters, the finding does not capture franchisee experience or profitability. The franchise relationship thus redistributes entrepreneurial obligations and risks: the franchisee uses an existing concept but still bears investment and financing costs and depends on network reputation and the quality of franchisor support (Ketchen et al., 2011; Michael, 2022).

4.3. Critical success factors and risks

The comparison of studies isolates the problem of implementation: the existence of training, rules or a digital system says little about how participants use them, so success factors are treated as conditions for action, with realised results verified separately. In Hizam-Hanafiah et al. (2023) the success factors comprise franchisor capability, interconnection with franchisees and constant innovation, with training and operational support forming part of a broader cooperative relationship; as the study is qualitative, based on focus groups with franchisors and franchisees in Malaysia, the findings are conditions identified rather than measured effects on profitability. At the franchisee level it is important to distinguish scope for entrepreneurial action from deviation from common standards: Dada et al. (2012) show how networks and learning can support initiative, which implies that the development of initiative should be linked to the way improvements are proposed, assessed and adopted. Trust, communication and dispute resolution are important for cooperation (Rosado-Serrano et al., 2018; Hizam-Hanafiah et al., 2023). Raha and Windsperger (2026), on a sample of 62 Austrian franchise networks, distinguish compliance with legal requirements from compliance with internal sustainability standards. Internal compliance is positively related to assessed financial performance, whereas the relationship between legal compliance and performance is negative, which the authors link to compliance costs that do not create a direct market advantage. These are franchisors' survey assessments, but the finding shows that different kinds of rules must not be merged into a single measure of control when assessing their effect on entrepreneurial results. Alongside success factors, the analysis identifies the key risks of the model. For franchisees the most significant are limited autonomy, dependence on the franchisor's reputation and the possibility of unilateral changes to operating and contractual conditions, which may affect profitability and long-term viability, particularly where franchisees have no bargaining power (Ketchen et al., 2011; Rosado-Serrano et al., 2018). For the franchisor the question is how to maintain common standards without suppressing useful local knowledge; the comparison of studies on initiative and network relationships points to the need to distinguish deviations that threaten the common offer from proposals that may improve it (Dada et al., 2012; Hizam-Hanafiah et al., 2023).

4.4. Development effects and digital transformation

The fourth area links research on economic development with the discussion of digitalisation, which concern different levels of analysis: country development indicators, business processes and the autonomy of an individual franchisee cannot be interpreted as outcomes of the same kind. Lanchimba et al. (2024) analyse panel data for 49 countries and find a positive association between franchising activity and economic, social, institutional and infrastructural development, covering both the size and the duration of the franchise sector, while warning of data limitations and the need to test causality further. For small open economies these are starting points for research rather than evidence of guaranteed development benefits.

Recent empirical work allows digitalisation to be considered more concretely. Kukec (2025) analyses 35 complete responses from Croatian franchisors to a survey conducted in November 2023, to which 76 were invited: expectations of benefits from artificial intelligence are accompanied by a lack of knowledge and uncertainty about its contribution to franchise sales, so the finding describes adoption and perceptions rather than growth in revenue or productivity. Pajić et al. (2025) show that digitally supported knowledge transfer, for example through intranets and e-mail, is associated with decentralisation when combinations of explicit and tacit knowledge are transferred. Technology therefore needs to be analysed by mode of use, since knowledge-sharing and monitoring systems may relate differently to franchisee decision rights.

4.5. Applying the framework: support, autonomy and outcomes

Applying the framework in Figure 1 to the four areas yields three propositions. First, the benefit of support should be assessed together with the ability to apply it. Linking research on learning with findings on the allocation of decision rights points to the complementarity of knowledge and autonomy (Dada et al., 2012; Pajić et al., 2025): access to resources without adequate decision rights remains unused, while decision rights without knowledge increase the risk of deviating from the system. Second, managerial compliance and entrepreneurial results are not identical. Findings on different kinds of standards (Raha and Windsperger, 2026), together with credit outcomes (Michael, 2022), show why the evaluation of a system needs more than one measure of success. The proposed comparison includes profit after fees, the ability to service debt, unit viability and room for local initiative; these are criteria for future research rather than pooled results of existing studies. Third, conclusions must remain at the level at which they were obtained. Interest in entering a franchise (Croonen et al., 2022), perceptions of technology (Kukec, 2025), network growth and economic development (Lanchimba et al., 2024) describe different phenomena. The contribution of the framework is to connect them without equating them: franchising can be regarded as support for entrepreneurship when access to resources is accompanied by the franchisee's ability to use them, while realised benefits must be established separately at each level.

5. CONCLUSION

The integrative review shows that franchising can facilitate access to business knowledge, support and a recognisable brand. It is not, however, justified to conclude that choosing a franchise in itself secures lower financial risk or a higher probability of survival; initial operational support must be distinguished from credit outcomes, profitability and long-term viability. The main contribution of the paper is an analytical framework separating access to resources, the ability to apply them and realised outcomes. The franchisee's entrepreneurial position is determined not only by network membership but also by the knowledge and decision rights at their disposal, so support and autonomy are not necessarily opposed; their relationship should be assessed by the content of decisions and the mode of cooperation. At the level of the economy the reviewed literature indicates an association between franchising activity and development indicators without establishing causality. The 2025–2026 studies extend the discussion to knowledge transfer, artificial intelligence and sustainability standards; Croatian data complement the international literature but do not yet allow conclusions about the effect of digitalisation on the profit and survival of domestic franchised units, so applicability to Croatia requires separate research that takes into account the characteristics of the sector and the domestic business environment.

The limitations of the paper stem from the purposive selection of 17 studies and the interpretative synthesis. Differing samples, methods and outcomes limit comparability, part of the evidence rests on franchisors' survey assessments, and no formal quality scoring or pooling of effect sizes was performed. The framework should be tested with longitudinal data on franchisees and by comparing franchised and independent firms on separate financial and operational indicators, including the relationship between digital monitoring and franchisee autonomy. For franchisors the findings underline the importance of high-quality support and a clear definition of the room for local initiative; prospective franchisees should assess fees, required investment and available support rather than assume that network membership reduces risk; and development policy needs data on the actual results of franchised firms in the domestic economy.

LITERATURE:

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MAPS THAT SELL: MARKETING CARTOGRAPHY AS A STRATEGIC BUSINESS TOOL

Vo Thi Ngoc Thao
Budapest University of Economics and Business, Marketing Master's Programme
Vo.Thi.Ngoc.Thao.46@unibge.hu

Daniella Nicole Barandearan Cedeno
Budapest University of Economics and Business, Marketing Master's Programme
BarandearanCedeno.Daniella.78@unibge.hu

Zahra Yousefi
Budapest University of Economics and Business, Marketing Master's Programme
Yousefi.Zahra.50@unibge.hu

Chanthida Nalyvanh
Budapest University of Economics and Business, Marketing Master's Programme
Nalyvanh.Chanthida.64@unibge.hu

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business, Marketing Master's Programme
papp-vary.arpad@uni-bge.hu

ABSTRACT

This paper explores the application of cartography in contemporary marketing and examines how mapping techniques have become valuable strategic business tools in today's data-driven business environment. Rather than merely representing geographic space, marketing cartography enables organizations to visualize markets, identify business opportunities, analyse consumer behaviour, and support strategic decision-making through geospatial data. The paper addresses two key questions: How is cartography being applied in contemporary marketing strategy? and What are the main strategic benefits and challenges of marketing cartography? To answer these questions, it applies a narrative literature review complemented by illustrative business cases. The study demonstrates how mapping technologies such as ArcGIS, CARTO, and Mapbox help organizations analyse customer locations, optimise marketing activities, and improve market segmentation. The cases of Airbnb, Starbucks, and Uber illustrate how marketing cartography contributes not only to operational efficiency but also to brand identity, customer experience, and strategic decision-making. At the same time, the paper discusses key challenges related to data quality, inclusivity, ethical considerations, and privacy. Overall, the study demonstrates that marketing cartography has become an increasingly important strategic capability, supporting marketing analysis, strategic decision-making, and brand communication.

Keywords: *cartography, marketing cartography, strategic marketing, geospatial marketing, geographic information systems (GIS), data visualization*

1. INTRODUCTION

Cartography has traditionally been associated with the representation of geographical space. However, the rapid development of digital technologies, geographic information systems (GIS), and data analytics has considerably expanded its scope beyond navigation and spatial representation.

Today, cartographic principles and mapping technologies are increasingly applied in business and marketing to visualize complex market structures, customer relationships, competitive environments, and behavioural patterns. Marketing cartography can be defined as the practice of using mapping techniques to visualize and analyse relationships, structures, and patterns within markets (Verschuren, 2006). It enables organizations to transform large volumes of geographic and behavioural data into visual insights that support strategic decision-making. From a marketing perspective, cartography helps identify market opportunities, understand competitive environments, optimize customer segmentation, and reveal previously hidden market patterns (Ben Aissa et al., 2024). As a result, marketing cartography has evolved into an important analytical and strategic tool rather than remaining merely a method of geographic representation. The growing importance of this approach has also attracted increasing attention among marketing professionals. One notable example was Milan Janosov's presentation 'From Social Networks to Cartography: Unlocking Your Client's Digital Footprint' at the Marketing Summit Budapest 2025. The presentation demonstrated how cartographic thinking can be extended beyond physical geography to visualize social networks and business relationships. As an illustration, Janosov presented the network of relationships among characters in the television series Game of Thrones, showing how network cartography could even be used to predict future developments within the story (Janosov, 2021). This example illustrates that modern cartography is capable of mapping not only places but also complex systems of interactions. The practical relevance of marketing cartography is reflected in the strategies of global companies such as Airbnb, Starbucks, and Uber, all of which incorporate mapping technologies into customer experience, location planning, and strategic decision-making. Building on these developments, the present paper examines the application of cartography in contemporary marketing. As marketing becomes increasingly data-driven, visual tools capable of revealing relationships and patterns are gaining strategic importance (Janosov, 2025). The paper addresses two key questions: How is cartography being applied in contemporary marketing strategy? and What are the main strategic benefits and challenges of marketing cartography?

2. THE EVOLUTION OF MARKETING CARTOGRAPHY

Cartography has a history spanning several thousand years. The earliest maps depicted trade routes, settlements, and territories, appearing on parchment in ancient China and on clay tablets in Mesopotamia (Frangeš et al., 2002). Over time, maps became indispensable tools for governance, exploration, navigation, and military planning. A major transformation occurred during the Renaissance, when advances in surveying techniques and printing technologies significantly improved the accuracy, accessibility, and dissemination of cartographic information (Perkins, 2004). The emergence of Geographic Information Systems (GIS) during the second half of the twentieth century marked another fundamental milestone in the development of cartography. GIS enabled maps to integrate multiple layers of spatial, demographic, economic, and social data, transforming maps from static representations into dynamic analytical tools (Teoh et al., 2008). The subsequent digital revolution, driven by platforms such as Google Maps, further democratized access to mapping technologies and made interactive geospatial information an integral part of everyday business operations (Oliveira, 2020). These technological developments created entirely new opportunities for marketing. Instead of serving merely as navigational tools, maps became instruments for analysing market potential, identifying customer concentrations, evaluating competitor locations, planning distribution networks, and supporting strategic decision-making (Melnyk & Nyzhnyk, 2018). Spatial visualization enables marketers to identify patterns that are often difficult to detect using conventional tables or statistical reports alone.

Contemporary GIS platforms such as ArcGIS, QGIS, Google Maps, and Mapbox allow organizations to combine demographic, behavioural, and transactional data with geographic information. These capabilities support decisions regarding store location, campaign optimization, customer segmentation, and service coverage. Geofencing technologies further extend these possibilities by enabling organizations to deliver location-based marketing messages when consumers enter predefined geographic areas (Wasino et al., 2024). From the consumer perspective, cartographic technologies also enhance customer experience. Real-time delivery tracking, store locators, interactive event maps, and navigation services improve transparency, convenience, and engagement. Consequently, maps have evolved beyond their traditional descriptive function to become strategic communication and decision-support tools that connect geographic intelligence with marketing strategy.

2.1. Traditional cartography vs. marketing-focused cartography

As shown in Table 1, while traditional cartography focuses on the accurate representation of geographic reality, marketing-focused cartography emphasizes insight, interpretation, and strategic decision-making.

Traditional cartography	Marketing-focused cartography
Depicts physical space and geography	Visualizes customer behavior and strategic opportunities
Primarily static	Interactive and data-rich
Focused on accuracy, scale, and navigation	Focused on insight, targeting, and storytelling
One-way communication	Two-way, participatory experiences
Used for exploration, governance, and science	Used for branding, customer engagement, and market strategy

Table 1: Comparison between traditional cartography and marketing-focused cartography
Source: Authors' own compilation

Traditional maps primarily answer the question "Where is it?", whereas marketing maps address "What is happening there, and how can this information be used strategically?" Consequently, maps have evolved from descriptive representations into strategic tools that support marketing analysis and decision-making.

2.2. Cartography in data-driven marketing

Modern marketing is increasingly data-driven, and cartography plays an important role in transforming raw data into visual narratives and actionable insights. By integrating spatial analysis into marketing strategies, organizations can identify trends, segment audiences, and forecast demand (Janosov, 2025).

Common marketing applications of mapping include:

- Heat maps to identify high-engagement areas (Huynh, 2024)
- Segmentation maps to tailor messages to local audiences (Mailchimp, n.d.)
- Journey mapping to understand customer movements in physical or event spaces (Zdunek, 2025)
- Predictive mapping to anticipate changes in demand (Nalini, 2025)

Thanks to open-source platforms such as QGIS and OpenStreetMap, as well as commercial solutions including Google Maps and Mapbox, these applications are no longer limited to large corporations. Cartography therefore serves as a bridge between data and decision-making, transforming geographic information into a strategic marketing asset.

3. THE GEOSPATIAL BACKBONE OF MODERN CARTOGRAPHY

As geomarketing has grown in importance, numerous digital tools have been developed to support the analysis of consumers through geographic data. Among the most widely used are Mapbox, CARTO, and ArcGIS. Mapbox provides personalized maps, navigation services, and geospatial analysis in real time, enabling organizations to visualize location-based behavioural patterns and trends in a flexible and dynamic manner (Mapbox, n.d.). CARTO is a cloud-based geospatial platform that transforms geographic information into strategic business insights. By visualizing consumption trends and spatial patterns, it facilitates data-driven decision-making and supports strategic planning (CARTO, n.d.). ArcGIS offers a comprehensive geospatial platform for creating, managing, analysing, and sharing spatial data. Its advanced analytical capabilities help identify geographic patterns and trends, thereby supporting evidence-based planning and strategic marketing decisions (Esri, n.d.).

3.1. Data as the foundation of cartographic storytelling

The effectiveness of marketing cartography depends largely on the quality and richness of the underlying data. Tudor et al. (2025) argue that the integration of demographic, socioeconomic, mobility, and behavioural data increasingly drives contemporary geomarketing by enabling marketers to identify spatial consumption patterns and visualize relationships between customers and businesses. Demographic indicators such as population density, income levels, and purchasing power are particularly valuable for understanding local market potential. Mobility and traffic data collected from GPS devices, mobile technologies, and transportation sensors provide dynamic insights into how people move through urban and commercial environments. Furthermore, transactional and loyalty programme data connect geographic locations with actual purchasing behaviour, allowing marketers to perform more comprehensive behavioural analyses (Tudor et al., 2025).

3.2. Interactive and real-time map design

Modern geomarketing transforms static maps into interactive, real-time storytelling tools that enhance both marketing analysis and communication. Platforms such as ArcGIS, CARTO, and Mapbox enable marketers to visualize consumer mobility, accessibility, and spatial trends while supporting real-time monitoring and decision-making. According to Tudor et al. (2025), these technologies transform cartography from a static representation into a dynamic decision-support system. Yu (2023) further argues that three-dimensional and animated GIS visualizations improve storytelling by helping users intuitively understand spatial relationships. Similarly, Medyńska-Gulij et al. (2023) emphasize that successful cartographic storytelling combines analytical accuracy with visual clarity, transforming maps from simple data representations into compelling narratives. As a result, interactive cartography has become an effective tool for communicating brand stories and strategic marketing insights.

3.3. The importance of reliable data

Reliable, high-quality data form the foundation of effective geomarketing. As noted by Tudor et al. (2025), inconsistent or inaccurate spatial datasets may generate misleading customer insights and ultimately lead to poor business decisions. Likewise, Gartner et al. (2024) argue that design elements such as scale, colour, and symbolization are not merely aesthetic choices but strategic communication tools that significantly influence how maps are interpreted.

Consequently, both data quality and visual design are essential for creating trustworthy and effective marketing maps.

4. MAPPING THE MARKETING FUNNEL: STRATEGIC APPLICATION

4.1. Strategic planning

Treating geography as a strategic variable rather than an afterthought is the first step towards making maps valuable marketing tools. A strong foundation for this approach is created by integrating Geographic Information Systems (GIS) with Marketing Information Systems (MIS). Geographic layers enable organizations to combine competitor locations, purchase history, and demographic characteristics into a unified analytical framework. Segmentation becomes both visual and actionable when marketers can simultaneously analyse channel performance, competitor proximity, average household income, and customer density on a single map. This approach is particularly valuable when allocating limited resources, whether by redirecting field sales efforts, optimizing promotional spending, or selecting locations for new stores or pop-up outlets. Research on integrated GIS-MIS models suggests that this integration supports operational, tactical, and strategic decision-making by transforming scattered data into spatially coherent recommendations (Kester, Koumadi, & Quaynor, 2013).
Practical applications include:

- Market segmentation based on micro-regions rather than entire ZIP code areas.
- Target audience heat maps that reveal pockets of latent demand.
- Competitive landscape mapping that identifies market gaps and overcrowded areas.

4.2. Execution

Strategic planning is valuable only if it can be translated into location-specific marketing actions. Geofencing and targeted digital advertising make cartographic insights operational by creating virtual boundaries around locations such as shopping malls, transport hubs, or competitors' stores and triggering promotional messages when consumers enter these predefined areas (Storm, n.d.). Beyond digital marketing, cartographic analysis also supports out-of-home (OOH) advertising by identifying optimal locations for billboards, transit advertising, and experiential campaigns based on high-value foot traffic. Brands further enhance customer engagement through microsites and interactive maps that help users locate nearby stores, offers, and opening hours, thereby shortening the path from awareness to purchase. Effective implementation also requires selecting an appropriate geofence radius, scheduling messages according to purchasing patterns, and adapting offers to local conditions (Berry, 2025).
Key implementation practices include:

- Clearly defining marketing objectives (e.g., foot traffic, app installs, or coupon redemptions).
- Designing geofences and creative content based on actual behavioural patterns such as commuting routes or event schedules.
- Integrating digital geotargeting with out-of-home advertising to reinforce campaign effectiveness.

4.3. Measurement and optimization

One of the major advantages of map-driven marketing is its level of spatial granularity. Organizations can measure store visit lift within geographically defined areas, calculate return on investment (ROI) by trade area, and optimize regional sales activities based on actual local performance instead of relying solely on campaign-level indicators. By linking transaction data and foot traffic measurements with geofences and campaign timing, marketers can identify which neighbourhoods responded positively and which did not.

These insights support decisions regarding creative execution, media placement, and future resource allocation. In this way, spatial analytics transforms individual performance indicators into practical recommendations for subsequent marketing investments.
Key performance metrics include:

- Trade-area ROI, visits per impression, sales lift per geofence, and cost per visit by geographic zone.
- A/B testing across neighbouring geographic areas to isolate causal effects (Berry, 2025).

4.4. Place branding and storytelling

Maps can serve purposes far beyond navigation by communicating identity, culture, and brand values. Research on place branding demonstrates that mapping visualizations, curated itineraries, and artistic cartography strengthen place image and reputation by connecting local narratives with geographic locations (Foroudi et al., 2016). For example, an illustrated tourism map can communicate heritage, local identity, and emotional associations more effectively than a conventional brochure. Similarly, brands increasingly incorporate maps into advertising campaigns, product packaging, and retail environments, transforming geographic location into a recognizable component of brand equity (Foroudi et al., 2016).
Practical applications include:

- Thematic maps supporting campaigns focused on food, music, or cultural heritage.
- Story-driven microsites encouraging local exploration.
- Visually engaging in-store maps that reinforce a brand's local identity.

5. DESIGN PRINCIPLES AND ETHICAL CONSIDERATIONS

Effective cartographic design contributes not only to the accurate representation of geographic information but also to credibility and user engagement (Field, 2022). A well-designed map should communicate information clearly and intuitively, enabling users to interpret and apply the presented data with confidence. This requires that the visual structure accurately reflects the underlying data and its intended purpose, while colours, symbols, and layout facilitate rather than hinder interpretation. In addition, map design should always consider the context and needs of its intended audience (IMIA, 2023). According to cartographic ethics frameworks, every design decision conveys meaning and therefore carries responsibility (Field, 2022; Maplibrary.org, n.d.). In marketing applications, this means that maps used for segmentation, campaign execution, performance measurement, or storytelling must be perceived as trustworthy by both internal decision-makers and external users. Consequently, validity, consistency, and visual clarity are fundamental principles of effective cartographic communication (IMIA, 2023).

5.1. Visual design principles

5.1.1. Visual hierarchy

A map should guide the viewer's attention towards the most important elements first, such as high-potential customer zones or key market areas. Less important information, including basemap details or secondary geographic features, should remain in the background (Field, 2022). A clear visual hierarchy improves communication by emphasizing relevant information without overwhelming the user.

5.1.2. Colour use

Colour is one of the most powerful, but also one of the most sensitive, elements of cartographic design. Inappropriate colour combinations, such as red and green for neighbouring zones, may reduce readability or even mislead users.

Marketing maps should therefore consider colour-blind accessibility, particularly red-green colour vision deficiencies, and employ colour schemes that remain readable across different devices and viewing conditions (Maplibrary.org, n.d.).

5.1.3. Projections

Every flat map inevitably distorts reality. Consequently, selecting an appropriate map projection (e.g., equal-area or Mercator) should always depend on the intended purpose of the visualization. In marketing applications, an unsuitable projection may overrepresent or underrepresent particular regions, potentially leading to biased interpretations and suboptimal decisions (IMIA, 2023).

5.1.4. Data classification

The method used to classify data (e.g., equal intervals, quantiles, or natural breaks) strongly influences both the appearance of a map and the conclusions drawn from it. Marketing maps highlighting "high-potential" areas should therefore clearly justify the chosen classification method, as arbitrary thresholds or visually appealing classifications may result in misleading interpretations or inappropriate resource allocation (Maplibrary.org, n.d.).

5.2. Common pitfalls

5.2.1. Misleading choropleth maps

One common pitfall is the misleading use of choropleth maps, for example by shading large geographic areas based on only a limited number of observations or by selecting classification breaks that exaggerate differences (Field, 2022; Maplibrary.org, n.d.). Although such maps may appear visually persuasive, they can present an inaccurate or unbalanced picture of reality. As Kenneth Field notes, "All maps have the power to lie" (Field, 2022).

5.2.2. Data bias

Another significant challenge is data bias. If the underlying data are incomplete, distorted, or biased, the resulting map will inevitably reflect these shortcomings. Chen et al. (2024) argue that spatial aggregation and smoothing may conceal important local variations while creating an illusion of homogeneity. In marketing, this may result in inaccurate targeting, incorrect assessments of competitive environments, or misguided strategic decisions. Recent research on endogenous bias in spatial analysis further emphasizes the importance of visual analytics in identifying hidden biases rather than assuming data neutrality (Chen et al., 2024).

5.3. Accessibility and inclusivity in map design

Effective cartographic design should be accessible to all users. This includes designing maps for people with colour vision deficiencies, using patterns or textures in addition to colour, providing alternative text or screen-reader-compatible interactive maps, and ensuring usability across mobile devices (Fiveable, 2025; IMIA, 2023). As emphasized in discussions of cartographic ethics, maps should accommodate users with diverse needs and abilities, while minimizing barriers to interpretation (Maplibrary.org, n.d.).

In marketing applications, this principle is equally important. Whether interactive audience heat maps are presented on a microsite or segmentation maps are used in managerial decision-making, they should remain accessible and understandable to all intended users rather than only those with ideal viewing conditions (Fiveable, 2025).

5.4. Data privacy and geospatial ethics in marketing

The use of location data in marketing inevitably raises ethical and privacy concerns. Organizations should collect only the information necessary for their purposes, communicate transparently how location data are used, and avoid targeting practices that may reveal sensitive movement patterns or compromise individual privacy (IMIA, 2023; Fiveable, n.d.). These considerations are closely related to broader principles of cartographic ethics. Maps should avoid exposing individuals through unnecessarily detailed spatial representations while remaining accessible to users with diverse needs and abilities (Field, n.d.; IMIA, 2023).

6. MINI-CASES: MAPS THAT SELL IN ACTION

Marketing cartography has become an important strategic and creative tool for many leading brands. Beyond simple navigation, maps increasingly function as brand assets, storytelling devices, and decision-support tools. The following mini-cases illustrate how companies such as Airbnb, Starbucks, and Uber integrate cartographic thinking into their marketing strategies to improve both operational efficiency and customer experience while strengthening emotional connections with consumers.

6.1. Airbnb: Maps as a core brand experience

Airbnb's user interface is built around interactive maps that display listings, neighbourhoods, and local experiences. The company uses maps for purposes that extend well beyond navigation. Airbnb's design team focuses on how maps shape users' understanding of places and strengthen their connection to local communities (Shutsa, 2019). In addition, the company incorporates artistic cartography into its marketing communication through stylized city illustrations that highlight local culture and atmosphere (Kuang, 2014). Interactive maps help users discover experiences within specific neighbourhoods, reinforcing Airbnb's core brand promise of "Belong Anywhere". Developers continuously optimise map interactions because they directly influence search performance and content discovery (Haldar et al., 2024). Through soft colour palettes, minimalist icons, and neighbourhood-specific content, Airbnb transforms geographic information into an emotional brand experience rather than using maps merely as functional navigation tools.

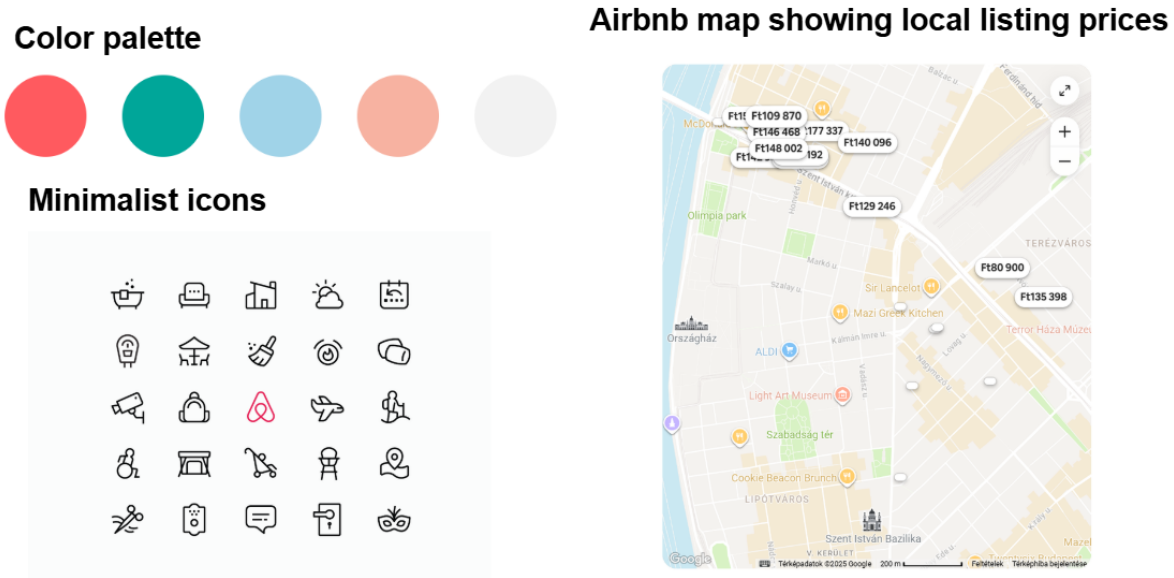

Figure 1: Airbnb's brand cartography: distinctive soft colour palette, minimalist icon set, and price display illustrating how these elements create a blended, humanised user experience. Source: Authors' compilation based on Airbnb design materials (5 November 2025).

6.2. Starbucks: Mapping store strategy and localized marketing

Starbucks uses geospatial analysis and mapping to support store location decisions, out-of-home (OOH) advertising, and localized marketing campaigns. By analysing demographic and behavioural data through heat maps, the company identifies suitable trade areas for new stores and regional promotional activities (You & Zhang, 2022). On the customer side, Starbucks integrates interactive store maps into its mobile application and website to promote nearby cafés, seasonal offers, and events. The company's signature colours and typography are consistently reflected in these maps, reinforcing Starbucks' visual identity. By combining geospatial analytics with brand aesthetics, Starbucks transforms location data into a communication tool that supports both operational decisions and brand storytelling (LinkedIn, 2025).

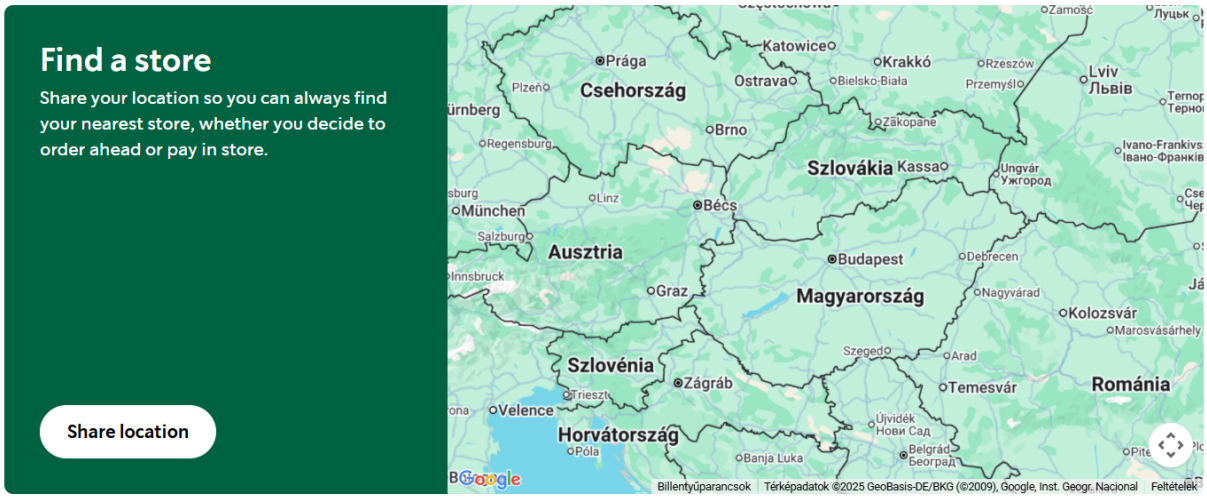

Figure 3: Starbucks' interactive map interface reinforces brand identity through consistent colour and typography.
Source: Screenshot from https://www.starbucks.hu/en (3 November 2025).

6.3. Uber: Cartography as brand language

For ride-sharing companies such as Uber, the map is not merely an interface; it is an essential part of the product itself. Uber invests heavily in custom cartographic design to ensure that every interaction is intuitive, visually consistent, and emotionally engaging (Babbs, 2023). Its maps employ simplified layers, customised colour palettes, and smooth motion design to communicate clarity and trust. Beyond the application itself, Uber also incorporates personalised journey maps into marketing campaigns, such as its Year in Review, transforming mobility data into personal storytelling (Uber for Business, 2025).

This illustrates an important shift in the role of cartography: rather than serving as a static background, maps have become an active medium through which the brand communicates reliability, identity, and customer value. The emotional impact of Uber's map design further demonstrates how visual geographic elements influence customer perceptions and brand loyalty (Janosov, 2021).

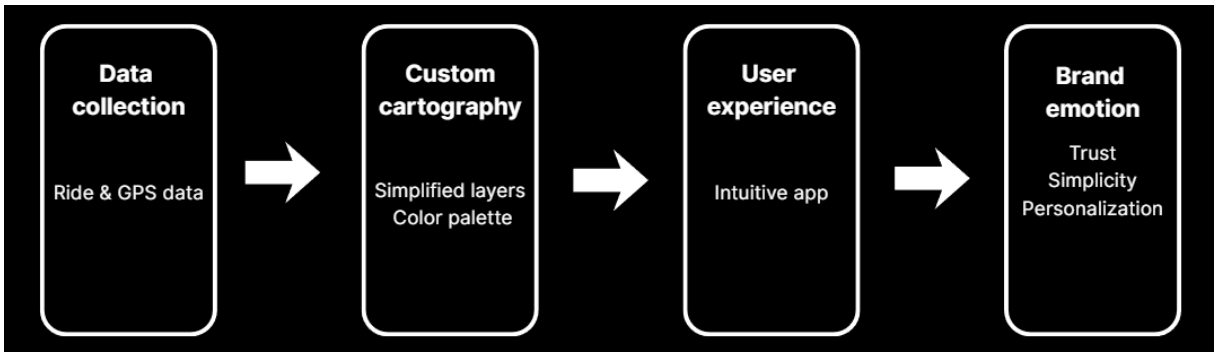

Figure 4: Conceptual model illustrating how Uber transforms cartography into brand communication and emotional identity.
Source: Process diagram created by the authors (3 November 2025).

Brand	Map type / data	Strategic marketing function	Impact / Result
Disney Parks – Live wait times map	Live data visualization (queue lengths, crowded zones, etc.)	Optimizing visitor flow and managing capacity	Optimizes the customer journey in real time, enhances visitor experience, and supports operational decision-making
Parking Douche App	Crowdsourced incident mapping (user photos, number plates, car type, etc.)	Streaming live information to influence driving behaviour	Drives substantial social engagement and brand visibility for the publisher
Snapchat – Snap Map	Social cartography (user location, global heat zones, etc.)	Identifying nightlife, concerts, and other hotspots	Provides rich visual data and helps identify current trends
Pokémon GO – Real-world player activity map	Gamified maps (real-world activity and movement data)	Gamified geomarketing (placing sponsored locations and attracting foot traffic)	Translates digital interaction into physical store visits and creates location-based promotional opportunities

Table 2. Additional examples of marketing cartography in practice
Source: Authors' compilation based on D&AD, Disneyland Paris, Pokémon GO, and Snapchat (30 November 2025).

7. CHALLENGES, RISKS, AND RESEARCH GAPS

Marketing cartography offers considerable strategic and creative opportunities; however, it also presents several challenges and ethical dilemmas. One of the most important concerns is data quality. Maps rely on accurate and representative data, while incomplete or biased demographic information may result in visualizations that mislead both consumers and decision-makers. Likewise, the perception of social trends may be distorted through selective geographic framing or exaggerated colour scales (Britannica, 2025). A second challenge concerns audience manipulation. Because maps are often perceived as objective representations of reality, persuasive or misleading geographic visualizations may influence consumer behaviour in unintended ways. This raises important ethical questions regarding the boundary between effective storytelling and data manipulation. Furthermore, the collection and use of location data for targeted marketing campaigns create concerns related to privacy and informed consent, particularly in an era of widespread geofencing and mobile tracking (LinkedIn, 2025). From an academic perspective, significant research gaps also remain.

Although marketing literature frequently discusses data visualization, relatively few studies specifically examine how cartographic design elements, such as colour, projection, or spatial framing, influence consumer perceptions, brand image, and decision-making (Janosov, 2021). Consequently, further multidisciplinary research integrating cartography, marketing strategy, and behavioural science is needed. Finally, there is a growing need for ethical frameworks and greater transparency in geospatial marketing. As companies such as Airbnb, Starbucks, and Uber increasingly adopt sophisticated map-based technologies, both researchers and practitioners should ensure that cartographic applications enhance rather than exploit consumers' sense of place. Looking ahead, emerging technologies such as augmented reality (AR) and virtual reality (VR) are likely to further expand the role of marketing cartography. Interactive city guides, immersive map experiences, and virtual store locators illustrate how geospatial technologies are evolving into increasingly interactive and multimodal marketing tools.

8. CONCLUSION

The integration of geographic, demographic, and behavioural data into visual representations enables maps to become not only analytical tools but also effective instruments of communication and customer engagement. Platforms such as Mapbox, CARTO, and ArcGIS help marketers transform complex geospatial information into actionable insights, supporting more precise market segmentation, strategic decision-making, and brand communication. At the same time, the growing use of marketing cartography requires responsible data management, ethical map design, and respect for user privacy. Accurate data, transparent visualization, and ethical use of location information are essential for maintaining consumer trust. As demonstrated by the cases of Airbnb, Starbucks, and Uber, marketing cartography has evolved beyond its traditional navigational function to become a strategic marketing capability that supports customer experience, brand differentiation, and business decision-making. As geospatial intelligence continues to develop alongside emerging technologies such as augmented reality, marketing cartography is likely to become an even more important component of future marketing strategies, creating increasingly immersive and interactive customer experiences.

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FINANCIAL LITERACY BEYOND KNOWLEDGE: EVIDENCE FROM FINANCIAL BEHAVIOR AND OUTCOMES IN CROATIA

Domagoja Buljan Barbaca
Department of Professional Studies, University of Split, Croatia
dobuljan@oss.unist.hr

ABSTRACT

Financial literacy is widely recognized as an important prerequisite for making sound financial decisions and achieving favorable financial outcomes at both the individual and household levels. Research conducted in the Republic of Croatia over the past decade indicates an increase in the overall level of financial literacy among its citizens. Existing assessments have predominantly relied on the internationally comparable OECD/INFE methodology, which evaluates financial literacy through three components: financial knowledge, financial behavior, and financial attitudes. While Croatian citizens have demonstrated more pronounced progress in financial knowledge, indicators of financial behavior have not shown a comparable rate of improvement. The aim of this paper is to analyze relevant available data sources in order to examine the dynamics of selected indicators of financial behavior and financial performance among Croatian citizens and to determine whether changes in these indicators point to improvements in the quality of personal financial management. The analysis encompasses available indicators related to savings and indebtedness, the use and composition of financial products, the structure of financial assets, and citizens' investment behavior. By linking the results of existing financial literacy assessments with objective indicators of financial behavior and outcomes, this paper seeks to provide a broader perspective on the financial capability of Croatian citizens. The contribution of the study lies in examining whether the documented increase in financial knowledge has been accompanied by corresponding changes in actual financial decisions and outcomes, as well as in considering the potential for complementing existing approaches to financial literacy measurement with indicators of observed financial behavior and realized financial outcomes.

Keywords: *financial literacy, financial behavior, financial outcomes*

1. INTRODUCTION

The increasing complexity of financial markets and the growing responsibility of individuals for managing their finances have made financial literacy an important determinant of household financial well-being. Financial literacy extends beyond financial knowledge and, within the widely applied OECD/INFE framework, encompasses financial knowledge, behavior and attitudes (Atkinson and Messy, 2012; OECD, 2023). These dimensions influence decisions concerning saving, borrowing, investing and long-term financial planning. Higher financial literacy has been associated with greater financial market participation, retirement planning and household wealth (Lusardi and Mitchell, 2011; van Rooij, Lusardi and Alessie, 2011; van Rooij, Lusardi and Alessie, 2012), while financial knowledge can be regarded as a form of human capital affecting financial decisions (Lusardi and Mitchell, 2014). However, greater financial knowledge does not automatically result in better financial behavior. Fernandes, Lynch and Netemeyer (2014) found relatively weak effects of financial education on subsequent behavior, although more recent evidence indicates that well-designed interventions can improve both knowledge and downstream financial behavior (Kaiser et al., 2022). This distinction is important because financial well-being ultimately depends on households' ability to meet obligations, absorb financial shocks and achieve long-term objectives (Brüggen et al., 2017).

Financial behavior can therefore be viewed as a mechanism linking knowledge to financial outcomes, while indicators such as savings, indebtedness, portfolio composition and financial asset accumulation can complement conventional measures of financial literacy. Croatia provides an interesting setting for examining this relationship. Vehovec, Rajh and Škreblin Kirbiš (2015) found that financial literacy among Croatian citizens was strongly associated with socioeconomic characteristics. Subsequent nationally representative assessments in 2015, 2019 and 2023 indicate a gradual improvement in financial literacy. The average score was 11.7 out of 21 points in 2015 and 12.3 in 2019 (Croatian National Bank, 2016; Croatian National Bank, 2024a). In 2023, the overall score was 12 out of 20 points, while financial knowledge increased from approximately 60% in 2015 and 65% in 2019 to 70% in 2023. However, financial behavior improved considerably less and remained below the averages of participating EU and OECD countries, despite financial knowledge exceeding the OECD average (Croatian National Bank, 2024a). This divergence raises the question of whether improvements in financial knowledge have been accompanied by observable changes in how Croatian citizens manage their financial resources. Knowledge of inflation, interest rates or diversification does not necessarily translate into greater saving, sustainable borrowing, portfolio diversification or financial asset accumulation. Survey-based measures may therefore provide an incomplete picture of household financial capability. Accordingly, this paper examines whether improvements in financial knowledge in Croatia have been accompanied by changes in objective indicators of savings, indebtedness, financial product use, financial assets and investment behavior. Although such changes cannot be attributed directly to financial literacy, they can indicate whether observed developments are consistent with improved financial management. The study thereby assesses the value of complementing conventional survey-based measures with indicators of observed financial behavior and realized financial outcomes.

2. FINANCIAL BEHAVIOR

Financial behavior is a key component of financial literacy because it reflects how financial knowledge and attitudes are translated into decisions and outcomes. Decisions concerning saving, borrowing, financial products, asset management and investment affect individuals' ability to achieve financial and broader life goals. Financial literacy should therefore be assessed not only through knowledge but also through its application in actual financial decision-making. Empirical research links financial literacy to stock market participation (van Rooij, Lusardi and Alessie, 2011), retirement planning and wealth accumulation (van Rooij, Lusardi and Alessie, 2012), debt-related behavior (Lusardi and Tufano, 2015), and credit card use (Allgood and Walstad, 2013). In Croatia, the relationship between financial literacy and consumer debt behavior has been examined by Bahovec, Barbić and Palić (2015). Studies based on actual financial decisions provide further insight into this relationship. Barber and Odean (2000) show that intensive trading may be associated with poorer net investment performance, while Calvet, Campbell and Sodini (2007) examine the welfare costs of household investment mistakes. Calvet, Campbell and Sodini (2009) link financial sophistication to underdiversification, portfolio inertia and the disposition effect, while von Gaudecker (2015) demonstrates that portfolio diversification and associated losses vary with financial literacy and financial advice. This evidence shifts attention from what individuals know to how they manage their finances and the outcomes they achieve. Although financial outcomes cannot be regarded as a direct measure of financial literacy, patterns of saving, borrowing, financial product use, asset composition and investment behavior can complement conventional knowledge-based measures. Financial behavior can thus be viewed as a link between financial knowledge and realized financial outcomes, providing an additional perspective on whether improvements in measured financial literacy are accompanied by better management of personal finances.

In order to identify the actual changes in the financial behavior of Croatian citizens, this chapter analyses the key indicators of household financial activity over the observed period. The analysis focuses on household indebtedness and credit activity, with particular attention paid to changes in the volume and structure of borrowing. In addition, the analysis examines household investment in different forms of financial assets and changes in their composition over time. Taken together, these indicators provide a comprehensive overview of the evolution of Croatian households' financial behavior.

2.1. Blocked Consumers, Outstanding Debt, and Consumer Bankruptcy Proceedings in Croatia

To provide a broader perspective on the development of household financial distress in Croatia, Table 1 presents the number of blocked consumers, the total outstanding principal, and the number of resolved consumer bankruptcy cases over the period 2016–2025. These indicators enable an assessment of changes in both the prevalence and financial magnitude of consumer indebtedness, while also illustrating the development of consumer bankruptcy proceedings during the observed period.

Year	Number of blocked consumers	Total outstanding principal (€ bn)	Resolved consumer bankruptcy cases
2016	327,176	5.46	53
2017	319,752	5.67	281
2018	264,751	2.34	249
2019	237,311	2.23	44,195
2020	231,602	2.25	56,036
2021	239,278	2.40	22,408
2022	228,722	2.39	18,933
2023	210,781	2.71	28,570
2024	199,165	2.93	34,001
2025	196,807	2.99	24,798

Table 1: Blocked consumers, outstanding debt and consumer bankruptcy proceedings in Croatia, 2016–2025
(Source: Authors' compilation based on Financial Agency (FINA) and Supreme Court of the Republic of Croatia data, 2016–2025)

Note: Total outstanding principal refers to the principal amount of unexecuted payment orders recorded in FINA's Register. For 2016–2022, amounts originally reported in Croatian kuna (HRK) were converted into euros using the official fixed conversion rate of EUR 1 = HRK 7.53450. The number of resolved consumer bankruptcy cases includes both regular and, from 2019 onwards, simplified consumer bankruptcy proceedings. A major methodological break occurs in 2019, when resolved consumer bankruptcy cases increased from 249 in 2018 to 44,195. This largely reflects the introduction of Croatia's simplified consumer bankruptcy procedure rather than a surge in conventional personal bankruptcies. In 2019, 43,969 of 44,195 resolved cases were simplified proceedings; similarly, they accounted for 18,811 of 18,933 cases in 2022 and 33,852 of 34,001 in 2024. Thus, these figures represent resolved court cases rather than necessarily individuals receiving debt discharge.

The number of blocked consumers declined substantially, from 327,176 in 2016 to 196,807 in 2025, a reduction of about 40%. However, the debt series contains a structural break between 2017 and 2018, when outstanding principal fell from approximately EUR 5.67 billion to EUR 2.34 billion, largely reflecting regulatory changes, debt write-offs, and changes in enforceability through FINA rather than debt repayment alone. More importantly, after this break, blocked consumers continued to decline while aggregate debt increased. Between 2019 and 2025, their number fell from 237,311 to 196,807 (-17%), while outstanding principal rose from EUR 2.23 billion to EUR 2.99 billion (+34%). Consequently, average debt per blocked consumer increased from approximately EUR 9,400 to EUR 15,200. This suggests a growing concentration of outstanding debt among fewer consumers: Croatia has substantially fewer blocked consumers than a decade ago, but those remaining carry considerably higher average debt.

2.2. Household Sector Lending in Croatia

To assess changes in the borrowing behavior of Croatian households, it is important to examine both the volume and structure of household lending over time. Table 2 presents the development of total household loans in Croatia between 2016 and 2025, distinguishing between housing loans, general-purpose cash loans, and other types of credit, while also showing their respective shares in total household borrowing.

Year	Total Household Loans (EUR bn)	Housing Loans	General-Purpose Cash Loans	Other Loans*
2016	16.8	7.9 (47.0%)	5.2 (31.0%)	3.7 (22.0%)
2017	16.7	7.6 (45.5%)	5.6 (33.5%)	3.5 (21.0%)
2018	17.1	7.5 (43.9%)	6.3 (36.8%)	3.3 (19.3%)
2019	17.8	7.7 (43.3%)	7.0 (39.3%)	3.1 (17.4%)
2020	18.2	8.3 (45.6%)	6.9 (37.9%)	3.0 (16.5%)
2021	18.9	9.0 (47.6%)	7.0 (37.0%)	2.9 (15.4%)
2022	19.9	9.9 (49.7%)	7.2 (36.2%)	2.8 (14.1%)
2023	21.7	10.9 (50.2%)	7.9 (36.4%)	2.9 (13.4%)
2024	24.3	11.9 (49.0%)	9.2 (37.9%)	3.2 (13.2%)
2025	27.4	13.7 (50.0%)	10.6 (38.7%)	3.1 (11.3%)

Table 2: Household Loans in Croatia by Type, 2016–2025
(Source: Author's calculations based on Croatian National Bank (CNB) statistical data, particularly Table D5c – Other Monetary Financial Institutions' Loans to Households by Purpose and Currency, and CNB statistical releases for 2023–2025.)

The data in Table 2 indicate a substantial increase in household borrowing in Croatia between 2016 and 2025. Total household loans rose from EUR 16.8 billion to EUR 27.4 billion (+63%), with particularly strong growth from 2022 onwards. Housing loans remained the largest component, increasing from EUR 7.9 billion to EUR 13.7 billion, while their share of total lending rose from 47.0% to 50.0%. General-purpose cash loans grew even faster, more than doubling from EUR 5.2 billion to EUR 10.6 billion and increasing their share from 31.0% to 38.7%. In contrast, other loans declined in relative importance, from 22.0% of total household lending in 2016 to 11.3% in 2025, despite remaining relatively stable at around EUR 3 billion in absolute terms.

Consequently, housing and general-purpose cash loans jointly increased their share from 78.0% to 88.7%, indicating a growing concentration of household indebtedness in these two categories. The acceleration since 2022 is particularly notable: total household loans increased from EUR 19.9 billion to EUR 27.4 billion by 2025 (+37.7%). This rapid growth deserves attention when assessing household indebtedness, credit risk, and vulnerability to changes in interest rates, disposable income, and broader macroeconomic conditions.

2.3. Financial Asset Allocation of Croatian Households

Table 3 presents the structure and development of Croatian households' financial assets over the period 2015–2024, based on the Financial Accounts statistics of the Croatian National Bank (CNB). In addition to the absolute value of each financial asset category, expressed in EUR billion, the table reports its percentage share in total household financial assets, thereby providing insight into both the growth and diversification of household financial wealth over the observed period.

Year	Currency and Deposits	Debt Securities	Loans Granted	Equity and Investment Fund Shares	Insurance and Pension Entitlements	Other Accounts Receivable	Total
2015	28.76 (51.7%)	0.23 (0.4%)	0.24 (0.4%)	12.94 (23.2%)	12.30 (22.1%)	1.22 (2.2%)	55.68 (100.0%)
2016	29.32 (51.1%)	0.24 (0.4%)	0.23 (0.4%)	12.70 (22.1%)	13.43 (23.4%)	1.42 (2.5%)	57.35 (100.0%)
2017	29.69 (50.1%)	0.23 (0.4%)	0.25 (0.4%)	12.91 (21.8%)	14.71 (24.8%)	1.44 (2.4%)	59.23 (100.0%)
2018	31.07 (50.0%)	0.23 (0.4%)	0.27 (0.4%)	13.38 (21.5%)	15.75 (25.3%)	1.50 (2.4%)	62.20 (100.0%)
2019	32.30 (47.8%)	0.24 (0.4%)	0.29 (0.4%)	15.05 (22.3%)	18.16 (26.8%)	1.60 (2.4%)	67.64 (100.0%)
2020	34.76 (47.7%)	0.25 (0.3%)	0.32 (0.4%)	16.41 (22.5%)	19.50 (26.8%)	1.62 (2.2%)	72.87 (100.0%)
2021	37.90 (47.1%)	0.25 (0.3%)	0.63 (0.8%)	18.44 (22.9%)	21.60 (26.8%)	1.74 (2.2%)	80.55 (100.0%)
2022	39.45 (47.3%)	0.38 (0.5%)	0.65 (0.8%)	19.38 (23.2%)	21.72 (26.0%)	1.91 (2.3%)	83.48 (100.0%)
2023	41.81 (43.8%)	2.94 (3.1%)	0.68 (0.7%)	22.36 (23.4%)	24.91 (26.1%)	2.77 (2.9%)	95.47 (100.0%)
2024	44.81 (41.6%)	4.86 (4.5%)	0.64 (0.6%)	26.37 (24.5%)	27.93 (26.0%)	3.01 (2.8%)	107.62 (100.0%)

Table 3: Composition of Croatian Households' Financial Assets, 2015–2024 – Year-end positions in EUR billion and percentage shares of total financial assets (Source: Croatian National Bank (CNB), Financial Accounts, Table T3 – Financial Assets and Liabilities by Institutional Sector and Financial Instrument, Sector S14 – Households, year-end (Q4) positions, ESA 2010 methodology. Authors' calculations of percentage shares based on CNB data)

Note: Absolute amounts are expressed in EUR billion, while figures in parentheses represent each category's percentage share of total household financial assets at the end of the respective year.

The share of currency and deposits declined from 51.7% in 2015 to 41.6% in 2024, despite substantial nominal growth, as other financial assets expanded more rapidly. Equity and investment fund shares remained relatively stable, increasing moderately from 23.2% to 24.5%. Insurance and pension entitlements increased from 22.1% to 26.0%, highlighting the growing importance of long-term savings. The most significant change occurred in debt securities, whose share rose from below 1% until 2022 to 4.5% in 2024, largely reflecting increased household investment in government retail bonds and Treasury bills.
Overall, the composition of Croatian households' financial assets became more diversified, with a declining relative importance of traditional bank savings and a growing role of pension savings and, particularly in recent years, debt securities.

3. ANALYSIS OF CHANGES IN THE FINANCIAL BEHAVIOR OF CROATIAN HOUSEHOLDS IN THE MACROECONOMIC CONTEXT

The analysis of Croatian households' financial behavior should consider the broader economic environment, as decisions on borrowing, saving and investment are influenced by income, inflation, asset prices, credit conditions and financial wealth. Examining these factors jointly provides a more comprehensive basis for assessing changes in household financial behavior and financial position. Accordingly, Table 4 presents annual changes in selected financial and macroeconomic indicators in Croatia from 2016 to 2025, including housing and general-purpose cash loans, household financial assets, average net wages, consumer price inflation and residential property prices. Together, these indicators reflect changes in household indebtedness, financial asset accumulation, disposable income and the economic conditions affecting purchasing power and investment decisions.

Year	Housing Loans (%)	Cash Loans (%)	Total Loans (%)	General-Purpose Financial Assets (%)	Average Net Wage (%)	CPI Inflation (%)	House Price Growth (%)
2016	—	—	—	—	—	−1.1	0.9
2017	0.6	5.4	2.7	2.3	5.2	1.1	3.8
2018	2.3	11.1	6.2	8.1	4.3	1.5	6.1
2019	6.3	11.1	8.5	5.1	3.5	0.8	9.0
2020	8.3	−1.4	3.6	8.0	4.8	0.1	7.7
2021	9.0	1.6	5.6	9.1	5.3	2.6	7.3
2022	10.3	2.4	6.9	4.1	7.4	10.8	14.8
2023	9.8	10.8	10.2	9.9	13.0	8.0	11.9
2024	9.1	15.0	11.6	19.1	14.8	3.0	10.4
2025	15.3	15.3	15.3	12.0	9.9	3.7	14.1

Table 4: Annual Changes in Selected Household Financial and Macroeconomic Indicators in Croatia, 2016–2025
(Source: Authors' calculations based on data from the Croatian National Bank (CNB) and Croatian Bureau of Statistics (CBS), various years.)

However, observing individual trends does not in itself reveal whether these developments are systematically related. Therefore, Table 5 complements the descriptive analysis by examining the relationships between household borrowing and selected financial and macroeconomic variables using Pearson's and Spearman's correlation coefficients.

The purpose of the correlation analysis is not to establish causal relationships, but rather to identify patterns of association that may provide additional evidence regarding changes in household financial behavior. Given the limited number of annual observations, the correlation results should be interpreted as descriptive evidence of association rather than as robust statistical evidence of underlying causal relationships.

Relationship	Pearson's r	p -value	Spearman's ρ	p -value	Interpretation
Housing Loans ↔ House Prices	0.857	0.003	0.917	<0.001	Very strong positive association
Housing Loans ↔ Net Wages	0.519	0.152	0.733	0.025	Moderate to strong positive association
Housing Loans ↔ Inflation	0.457	0.216	0.800	0.010	Positive monotonic association
Housing Loans ↔ Financial Assets	0.483	0.187	0.533	0.139	Moderate, but statistically uncertain
General-Purpose Cash Loans ↔ Net Wages	0.543	0.131	0.276	0.472	Weak to moderate association
General-Purpose Cash Loans ↔ Inflation	−0.005	0.989	0.251	0.515	Virtually no linear association
General-Purpose Cash Loans ↔ House Prices	0.283	0.461	0.276	0.472	Weak association
Total Loans ↔ House Prices	0.724	0.027	0.750	0.020	Strong positive association
Total Loans ↔ Net Wages	0.682	0.043	0.583	0.099	Relatively strong positive association
Total Loans ↔ Financial Assets	0.657	0.055	0.717	0.030	Strong positive association

Table 5: Correlation Analysis of Household Borrowing and Selected Financial and Macroeconomic Variables, 2017–2025

The correlation analysis indicates that the strongest relationship exists between housing loan growth and house price growth, suggesting that changes in household housing borrowing were closely associated with developments in the residential property market. At the same time, the positive relationships between total credit growth, wage growth and financial asset growth suggest that increasing household indebtedness occurred alongside improvements in households' income and financial wealth. Overall, the results point to a partial improvement in financial behavior rather than an unequivocal one, as stronger financial capacity was accompanied by continued growth in household borrowing.

4. CONCLUSION

The analysis indicates that the improvement in financial knowledge among Croatian citizens has been accompanied by positive, but not unequivocal, changes in financial behavior and outcomes. Household financial assets increased substantially and portfolios became more diversified, while the number of blocked consumers declined considerably. At the same time, household borrowing increased strongly, particularly in housing and general-purpose cash loans, and the remaining blocked consumers carried higher average levels of outstanding debt. These findings partly correspond with the results of the OECD/INFE financial literacy surveys. While Croatian citizens have demonstrated a clear improvement in financial knowledge, improvements in financial behavior have been considerably less pronounced. Similarly, the objective indicators examined in this study reveal progress in some dimensions of household financial behavior—such as financial asset accumulation and portfolio diversification—but also persistent vulnerabilities related to borrowing and debt. Overall, the results suggest that greater financial knowledge does not automatically translate into consistently better financial behavior. The findings therefore support complementing conventional survey-based measures of financial literacy with objective indicators of actual financial decisions and outcomes, providing a more comprehensive assessment of households' financial capability and financial well-being.

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ENTERPRISE SIZE AND ARTIFICIAL INTELLIGENCE ADOPTION: THE PORTUGUESE CASE IN THE EUROPEAN UNION CONTEXT

Catia Rosario
Intrepid Lab, ECEO, Lusófona University, Lisboa, Portugal
CETRAD – Centre for Transdisciplinary Development Studies, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
p5909@ulusofona.pt

Antonio Augusto Costa
Intrepid Lab, ECEO, Lusófona University, Lisboa, Portugal
CETRAD – Centre for Transdisciplinary Development Studies, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
p111@ulusofona.pt

ABSTRACT

Artificial intelligence adoption has become increasingly important for enterprise competitiveness, innovation and sustainable digital transformation. However, firms' capacity to adopt AI may differ substantially according to enterprise size. This study examines differences in AI adoption among small, medium-sized and large enterprises across the 27 European Union countries, with particular attention to Portugal. The analysis uses harmonised 2024 data from Eurostat, comprising 81 aggregated observations. Descriptive statistics, the Friedman test and pairwise Wilcoxon signed-rank tests with Holm correction are applied. The results reveal a consistent size-related adoption pattern: in every EU-27 country, large enterprises record the highest AI adoption rate, followed by medium-sized and small enterprises. The Friedman test confirms statistically significant differences between the three size categories, with perfect concordance across countries. All pairwise differences are statistically significant and display large effect sizes. Portugal follows the same hierarchy but presents below-average adoption among small and medium-sized enterprises, while its large enterprises perform slightly above the EU-27 country average. The findings indicate that Portugal's AI adoption disadvantage is concentrated primarily among smaller firms.

Keywords: *Artificial intelligence adoption; Enterprise size; Small and medium-sized enterprises; Digital transformation; Digital divide; Portugal; European Union.*

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Artificial Intelligence Adoption in Enterprises

Artificial intelligence (AI) has evolved into a strategic organisational capability with applications in automation, forecasting, decision support, customer management, supply-chain optimisation and innovation. Its adoption extends beyond software acquisition, requiring the integration of technology, data, human expertise and managerial practices with business activities and strategic objectives (Rangappan & Ueasangkomsate, 2026). AI can improve efficiency, productivity, decision quality and innovation, although its implementation depends on organisational and behavioural factors (Yance Carvajal et al., 2025). Furthermore, adequate digital infrastructure is essential for firms to exploit AI and enhance their performance (Vladimirov & Harizanova, 2026). AI adoption does not automatically create organisational value; its benefits depend on firms' ability to identify suitable applications, align them with operational needs and translate AI outputs into organisational change.

Evidence from Ecuadorian SMEs indicates that AI supports business-model innovation and sustainable value creation when enterprises possess the capabilities to reorganise their resources (Sánchez-Rodríguez et al., 2026). Therefore, AI adoption should be viewed as a multidimensional process shaped by technological readiness, organisational preparedness and environmental conditions. Key factors include IT infrastructure, existing digital tools, innovation levels, employee skills, financial resources and corporate regulation (Omrani et al., 2024). Management support is essential to AI adoption because it shapes resource allocation, digital strategy and employee skills. External conditions and government policies can influence managerial support, which strengthens organisational capabilities and digital infrastructure, ultimately enhancing AI use (Vladimirov & Harizanova, 2026). Although generative AI tools reduce technical and financial barriers, responsible adoption still requires an ethical climate, training, human oversight, transparency and privacy practices (Tran et al., 2026). Overall, AI adoption is a complex organisational transformation requiring infrastructure, data, human capital, financial resources, strategic alignment and governance. Because these capabilities vary across firms, enterprise size is likely to influence the capacity to adopt AI.

1.2. Enterprise Size and Disparities in AI Adoption

Enterprise size is an important source of heterogeneity in AI adoption because it is associated with differences in financial capacity, technological infrastructure, specialised human resources, data availability and managerial formalisation. Although AI technologies are potentially available to enterprises of all sizes, firms do not possess equal capabilities to evaluate, acquire, implement and govern them. Consequently, adoption patterns and implementation strategies tend to differ substantially between SMEs and large enterprises (Rangappan & Ueasangkomsate, 2026). Large enterprises are better positioned to adopt AI because they generally possess greater financial resources, advanced IT infrastructure, specialised personnel, formal data governance and greater capacity to manage implementation risks. These advantages support structured, strategically aligned adoption across multiple functions (Rangappan & Ueasangkomsate, 2026). In contrast, SMEs face stronger financial, technological and human-resource constraints, leading them to favour gradual, problem-driven applications with visible short-term benefits and to rely more heavily on training, external partnerships, commercial tools and public support. Evidence from manufacturing confirms that limited time, expertise and resources restrict SMEs' ability to evaluate and integrate evolving technologies, potentially reinforcing the cumulative competitive advantage of larger firms (Rangappan & Ueasangkomsate, 2026; Wiese et al., 2025). AI adoption depends heavily on digital infrastructure, including appropriate computing systems, compatible tools, reliable data and qualified employees. Smaller firms may face disadvantages not only in acquiring AI solutions but also in financing the complementary resources required for their implementation (Vladimirov & Harizanova, 2026). SMEs also frequently lack technical expertise, financial resources and implementation support, while education may not adequately address their practical needs (McCauley et al., 2025). Differences in AI adoption by enterprise size therefore reflect structural inequalities in organisational readiness: smaller firms may recognise AI's value but lack the necessary resources, whereas larger firms can develop broader and more formalised strategies. Differences in digital infrastructure and human capital significantly influence AI adoption across enterprise sizes. Effective implementation requires adequate computing systems, compatible tools, reliable data and skilled employees, making robust digital infrastructure a prerequisite for AI use (Vladimirov & Harizanova, 2026). SMEs also face shortages of technical expertise, financial resources and implementation support, alongside a gap between higher-education training and their practical needs (McCauley et al., 2025).

Thus, disparities in AI adoption largely reflect structural inequalities in organisational readiness: smaller firms often lack the complementary resources required for implementation, whereas larger firms are better equipped to pursue formal and comprehensive AI strategies. Despite the recognition of these differences, the literature remains fragmented. Many studies analyse AI adoption exclusively within SMEs or examine isolated industries and national contexts. Direct empirical comparisons of AI adoption rates across small, medium-sized and large enterprises remain comparatively limited (Rangappan & Ueasangkomsate, 2026). This limitation supports the need for systematic cross-country evidence on whether the same size-related hierarchy can be observed across different institutional and economic contexts. Examining AI adoption across the EU-27 by enterprise-size category can therefore contribute to the literature by determining whether adoption disparities constitute isolated national phenomena or a consistent structural pattern throughout the European Union.

1.3. Barriers and Enabling Factors in SMEs

The literature identifies a combination of technological, organisational, financial and environmental factors influencing AI adoption in SMEs. These factors are interdependent: limited financial resources can prevent investments in infrastructure and training, insufficient skills can make it difficult to formulate a viable AI strategy, and weak managerial understanding can reduce the willingness to allocate resources to experimental technologies. Accordingly, the barriers faced by SMEs should be interpreted as a connected system rather than as isolated implementation problems. Financial constraints are among the most frequently identified barriers. AI adoption can require expenditure on software, computing infrastructure, data preparation, cybersecurity, consultancy and employee training. These costs may be particularly burdensome for smaller firms, which typically possess less financial slack and a lower capacity to tolerate uncertain returns. This can lead SMEs to postpone adoption, select only low-cost applications or implement AI through incremental projects addressing narrowly defined problems (Rangappan & Ueasangkomsate, 2026). Limited resources also reduce SMEs' capacity for experimentation and make unsuccessful implementation more consequential than it would be for a large enterprise. AI adoption in SMEs depends on adequate digital infrastructure, reliable data and compatible technologies. Firms with limited prior digitalisation may therefore need foundational investments before adopting AI effectively (Omrani et al., 2024; Vladimirov & Harizanova, 2026). Adoption is also constrained by skills shortages, limited AI literacy, insufficient strategic capacity, lack of training, resistance to change and perceptions of complexity and resource demands (McCauley et al., 2025; Yance Carvajal et al., 2025; Wiese et al., 2025). Managerial support, strategic alignment, training and clear communication can reduce these barriers, while external partners—including technology providers, industry associations and Digital Innovation Hubs—can supplement SMEs' limited internal capabilities with specialised knowledge and implementation support (Gladysz et al., 2023; Vladimirov & Harizanova, 2026; Rangappan & Ueasangkomsate, 2026). Government policies and institutional support can facilitate AI adoption through financial incentives, advisory services, shared infrastructure and training. However, external support is most effective when it strengthens SMEs' internal managerial and organisational capabilities (Vladimirov & Harizanova, 2026; Omrani et al., 2024). Higher education institutions can also reduce skills and knowledge barriers by providing applied AI literacy, cybersecurity and ethical-governance training, as well as opportunities for practical collaboration and experimentation (McCauley et al., 2025). Furthermore, the routine use of generative AI requires governance procedures covering data, verification, accountability and employee conduct, supported by an ethical climate, training, human oversight, privacy and transparency (Tran et al., 2026).

1.4. Digital Infrastructure, Skills and Organisational Capabilities

The successful adoption of artificial intelligence depends on a combination of technological infrastructure, workforce skills and organisational capabilities. Access to an AI application is not sufficient if an enterprise lacks compatible information systems, reliable data, computing resources or employees capable of integrating the technology into existing processes. These complementary resources are particularly relevant for SMEs, where limited digital maturity may prevent firms from progressing from initial experimentation to systematic organisational use. Digital infrastructure including hardware, software, connectivity, cloud resources, storage systems and data-management mechanisms is the foundation of AI adoption. It directly supports AI use and reflects the influence of management support, digital strategy, employee skills and external conditions (Vladimirov & Harizanova, 2026). Existing digital tools, previous innovation, financial resources, skills and corporate regulation also facilitate adoption, suggesting that digital readiness develops cumulatively through earlier investments in technology and organisational knowledge (Omrani et al., 2024). Since AI requires accessible, accurate and relevant data, firms must also invest in data collection, integration, security and governance, particularly when information is fragmented or poorly structured (Vladimirov & Harizanova, 2026). Human capital is essential for identifying suitable AI applications, engaging with suppliers, evaluating outputs and incorporating them into organisational decisions. Alongside technical specialists, managers and employees need broader AI literacy to assess benefits, risks and organisational relevance. Skills shortages, limited financial resources and insufficient implementation support particularly constrain small businesses, while partnerships with higher education institutions can provide training, technical assistance and practical experimentation (McCauley et al., 2025). Workforce development should also include change management and clear communication, as perceived complexity, time demands and uncertainty can increase employee resistance. Organisational support and successful implementation examples can strengthen technology acceptance (Wiese et al., 2025). The Portuguese context reflects these concerns. AICEP Portugal Global (2024), reporting the results of an Experis survey, states that Portuguese employers regarded privacy and regulation, investment costs and employee resistance to change as important challenges to AI adoption. The same publication highlights workforce training, upskilling and reskilling as priorities associated with AI implementation. It also reports higher adoption among medium-sized and large enterprises than among microenterprises, supporting the broader argument that organisational resources and capabilities vary with enterprise size. Nevertheless, these figures should not be directly compared with Eurostat statistics because the Experis survey uses a different sample, enterprise classification and measurement of AI use. Organisational capabilities determine whether technological resources and employee skills produce effective AI implementation. Management support, digital strategy and innovation capabilities help allocate resources, align AI with organisational needs and promote experimentation. SMEs generally adopt AI incrementally and rely on external collaboration, while larger firms tend to use formal governance and systematic strategic alignment (Rangappan & Ueasangkomsate, 2026). AI creates competitive advantage only when firms can interpret its outputs, reorganise resources and transform processes, thereby supporting business-model innovation and sustainable value creation (Sánchez-Rodríguez et al., 2026). Digital infrastructure, workforce skills and organisational capabilities are therefore mutually reinforcing, and unequal access to these resources helps explain the adoption gap between smaller and larger enterprises.

1.5. Sustainability Implications of AI Adoption

Artificial intelligence can contribute to corporate sustainability by supporting more efficient resource allocation, process optimisation, waste reduction, energy management and environmentally informed decision-making.

AI can also help enterprises identify inefficiencies, monitor operational performance and develop products and business models that respond to environmental and social challenges. Nevertheless, the relationship between AI adoption and sustainability is not automatic. The effects depend on the objectives for which the technology is used and on the organisational capabilities that translate AI use into sustainable practices. In the context of manufacturing SMEs, advanced technologies may facilitate the optimisation of production, improve energy efficiency and reduce resource waste. Wiese et al. (2025) argue that the adoption of smart manufacturing technologies can support both organisational competitiveness and more sustainable production practices. However, their findings also indicate that limited resources, implementation complexity and insufficient expertise can prevent SMEs from accessing these benefits. The sustainability potential of AI may therefore remain concentrated among enterprises with the necessary financial, technological and human capabilities. AI can support sustainability and competitive advantage when combined with adequate financial resources and green innovation strategies. Evidence from Turkish construction SMEs indicates that AI strengthens the relationship between green innovation and sustainable competitive advantage (Farmanesh et al., 2025). However, sustainable value does not result from AI use alone; firms must develop reconfiguration capabilities that enable business-model innovation (Sánchez-Rodríguez et al., 2026). Specific applications also demonstrate AI's environmental potential, including systems that support sustainable urban water initiatives (Arslan et al., 2025) and renewable-energy marketplaces that improve supply-and-demand matching and energy efficiency (Holzinger et al., 2025). AI sustainability includes social and governance considerations such as transparency, privacy, accountability, human oversight and employee training. An ethical organisational climate, training and oversight are particularly important for responsible generative AI use (Tran et al., 2026). Employee inclusion through training, reskilling and change management can also reduce resistance and prevent AI from increasing workplace inequalities (AICEP Portugal Global, 2024). Moreover, unequal access to AI may widen productivity and competitiveness gaps between SMEs and larger firms. AI adoption should therefore form part of a broader sustainability strategy that considers environmental objectives, stakeholder impacts and responsible governance alongside efficiency gains. Its contribution to sustainable value depends on complementary innovation, organisational capabilities and deliberate strategic choices.

1.6. Research Gap and Study Contribution

Existing research identifies technological, organisational and environmental factors influencing AI adoption, including digital infrastructure, data, employee skills, financial resources, managerial support, strategic alignment and institutional assistance (Omrani et al., 2024; Vladimirov & Harizanova, 2026). SMEs nevertheless face persistent barriers such as high costs, limited expertise, perceived complexity and resistance to change (McCauley et al., 2025; Wiese et al., 2025; Yance Carvajal et al., 2025). However, the literature rarely compares SMEs directly with larger enterprises, leaving evidence across enterprise-size categories fragmented (Rangappan & Ueasangkomsate, 2026). Moreover, most studies focus on specific countries, sectors or applications including SMEs in Bulgaria, Turkey, Ecuador and Vietnam, as well as manufacturing SMEs making cross-country comparisons difficult because of differences in samples, measurements and research designs (Gladysz et al., 2023; Farmanesh et al., 2025; Wiese et al., 2025; Yance Carvajal et al., 2025; Sánchez-Rodríguez et al., 2026; Tran et al., 2026; Vladimirov & Harizanova, 2026). National estimates of AI use may differ because of variations in definitions and sampling methods. For instance, AICEP Portugal Global (2024) reported that 41% of surveyed Portuguese enterprises used AI, with higher adoption among medium-sized and large firms. However, these findings are not directly comparable with Eurostat data, highlighting the need for harmonised statistics.

This study addresses existing limitations by using Eurostat data to compare AI adoption among small, medium-sized and large enterprises across all 27 EU countries. It contributes by providing an EU-wide enterprise-size comparison, testing differences through the Friedman and pairwise Wilcoxon signed-rank tests, and positioning Portugal within the EU-27 distribution to assess whether its size-related adoption pattern reflects the broader European trend. The Portuguese comparison is particularly relevant because national evidence already suggests that AI adoption is more prevalent in larger organisations (AICEP Portugal Global, 2024). The present study complements this evidence through the use of an official harmonised indicator and consistent enterprise-size thresholds across all EU countries. It therefore provides a more comparable assessment of Portugal's relative position and identifies whether the national adoption disadvantage is concentrated among particular enterprise-size categories. This study is descriptive and comparative rather than causal. It does not claim that enterprise size alone causes AI adoption, as firm size may reflect differences in infrastructure, human capital, financial resources, innovation capacity and sectoral composition. Instead, it establishes whether a systematic size-related adoption gap exists across the EU-27. Demonstrating this pattern constitutes a necessary first step towards subsequent research examining the mechanisms that produce it. By combining a European comparative perspective with a detailed analysis of Portugal, the study contributes evidence concerning the organisational dimension of the digital divide. Its findings can inform policies designed to support AI adoption among SMEs and provide a foundation for future multivariate research incorporating digital infrastructure, cloud-computing use, ICT specialists and business research and development expenditure.

2. METHODOLOGY

2.1. Data Source

This study uses secondary data obtained from Eurostat, the statistical office of the European Union. The data were extracted from the dataset *Artificial intelligence by size class of enterprise*, which forms part of the European Union Survey on ICT Usage and E-commerce in Enterprises. The survey is conducted by national statistical authorities using harmonised methodological procedures, thereby supporting comparability across countries. The analysis covers the 27 Member States of the European Union in 2024. The variable examined is the percentage of enterprises reporting the use of at least one artificial intelligence technology in their business activities. According to Eurostat's classification, these technologies include systems used for written-language analysis, language or code generation, speech recognition, image recognition, machine learning for data analysis, process automation and decision support. The statistical population comprises enterprises with at least ten persons employed in the economic activities covered by the survey. Consequently, microenterprises with fewer than ten persons employed are excluded from the analysis.

2.2. Definition of Enterprise-Size Categories

Enterprises were classified according to the number of persons employed, following the categories used by Eurostat: small enterprises, with 10 to 49 persons employed; medium-sized enterprises, with 50 to 249 persons employed; and large enterprises, with 250 or more persons employed. Small enterprises were used as the reference category when interpreting differences in AI adoption across enterprise sizes. The unit of analysis is the country–enterprise-size combination. Each of the 27 Member States contributes one observation for each of the three size categories, resulting in a total of 81 aggregated observations. Each observation represents the percentage of enterprises within a particular country and size category that reported using at least one AI technology in 2024.

The dataset has a matched structure because AI adoption among small, medium-sized and large enterprises is observed within the same national context. This structure enables comparisons across enterprise-size categories and allows Portugal to be positioned relative to the overall pattern observed in the European Union.

2.3. Sample and Data Structure

The analysis examines differences in AI adoption across enterprise-size categories, both within countries and across the European Union. The harmonised nature of the Eurostat data provides a high degree of cross-country comparability. However, the dataset contains aggregated percentages rather than observations for individual enterprises. The results can therefore identify patterns and systematic differences in AI adoption by enterprise size, but they do not support firm-level causal inference. In addition, the exclusion of enterprises with fewer than ten persons employed means that the findings cannot be generalised to microenterprises. For the descriptive analysis, the data were retained in long format, with three observations per country and enterprise size represented by a categorical variable. For the Friedman test and the subsequent pairwise comparisons, the data were reorganised into wide format. In this format, each country represents one block and the three enterprise-size categories are represented by separate variables: AI adoption among small, medium-sized and large enterprises. This organisation produces a complete matched design, as all 27 countries have a valid AI-adoption value for each of the three enterprise-size categories. Consequently, no country was excluded from the statistical tests because of missing values in the dependent variable. The matched structure makes it possible to compare enterprise-size categories within the same national context, thereby reducing the influence of between-country differences on the comparison.

2.4. Statistical Techniques and Rationale

The empirical analysis combined descriptive and inferential methods. Descriptive statistics including the mean, median, standard deviation, minimum and maximum were calculated for each enterprise-size category across the EU-27. Portugal's adoption rates were compared with the corresponding EU mean and median using percentage-point differences and country rankings. The Friedman test was then applied to determine whether AI adoption differed significantly among small, medium-sized and large enterprises. The Friedman test was appropriate because each country provided three related observations, with countries treated as blocks and enterprise-size categories as treatments. When a significant overall difference was detected, Wilcoxon signed-rank tests compared small, medium-sized and large enterprises in pairs. The resulting p-values were adjusted using the Holm procedure to control the family-wise error rate while preserving greater statistical power than the conventional Bonferroni correction. All statistical tests were two-tailed and evaluated at the 5% significance level. Microsoft Excel was used to organise, validate and restructure the data from long to wide format for the matched analysis. Statistical tests were conducted in GRETL using version 1.2 of the Friedman function package and the Wilcoxon signed-rank. Holm-adjusted p-values and effect-size measures were subsequently calculated from the statistical output.

3. RESULTS

3.1. Descriptive Statistics for the EU-27

Table 1 presents the descriptive statistics for the percentage of enterprises using at least one artificial intelligence technology in the 27 Member States of the European Union, according to enterprise size. The statistics represent unweighted country-level measures, meaning that each Member State was assigned the same weight irrespective of its number of enterprises or population size. Therefore, the reported means should not be interpreted as the aggregate percentage of EU enterprises using AI, but rather as the average of the 27 national percentages.

Enterprise size	N	Mean (%)	Median (%)	Standard deviation	Minimum (%)	Maximum (%)
Small	27	12,03	8,78	6,40	2,57	23,52
Medium-sized	27	21,08	16,91	9,69	3,88	40,92
Large	27	41,15	40,48	14,75	11,26	70,40

Table 1: Descriptive statistics for AI adoption by enterprise size in the EU-27, 2024 (Source: Authors' calculations based on Eurostat data)

AI adoption increased clearly with enterprise size in 2024, averaging 12,03% among small enterprises, 21,08% among medium-sized enterprises and 41,15% among large enterprises. Large enterprises therefore recorded an average adoption rate approximately 3,4 times that of small enterprises. The respective median values 8,78%, 16,91% and 40,48% confirmed this pattern. In every category, the mean exceeded the median, indicating that countries with relatively high adoption rates raised the overall averages.The dispersion of AI adoption also increased with enterprise size. The standard deviation was 6,40 percentage points among small enterprises, 9,69 points among medium-sized enterprises and 14,75 points among large enterprises. In absolute terms, the differences between Member States were therefore more pronounced among large enterprises. The observed range increased from 20.95 percentage points among small enterprises to 37,04 points among medium-sized enterprises and 59,14 points among large enterprises. Romania recorded the lowest AI-adoption rate in all three enterprise-size categories: 2,57% among small enterprises, 3,88% among medium-sized enterprises and 11,26% among large enterprises. Denmark presented the highest adoption rate among both small enterprises, at 23,52%, and medium-sized enterprises, at 40,92%. Finland recorded the highest rate among large enterprises, at 70,40%. When country-level differences were calculated within each enterprise-size pair, the average adoption gap between medium-sized and small enterprises was 9,05 percentage points. The average gap between large and medium-sized enterprises was 20,07 percentage points, while the difference between large and small enterprises reached 29,12 percentage points. These descriptive results indicate that the most substantial increase in AI adoption occurs between the medium-sized and large-enterprise categories. However, inferential testing is required to determine whether the observed differences are statistically significant across the EU-27.

3.2. Portugal in the European Context

To assess Portugal's relative position, the national AI-adoption rate for each enterprise-size category was compared with the corresponding unweighted mean and median of the 27 EU Member States. Portugal's position in the descending country ranking was also calculated, with the first position corresponding to the country with the highest adoption rate.

Enterprise size	Portugal (%)	EU-27 mean (%)	EU-27 median (%)	Difference from EU mean (p.p.)	Portugal's rank
Small	6,66	12,03	8,78	−5,37	21st
Medium-sized	15,35	21,08	16,91	−5,73	18th
Large	41,89	41,15	40,48	+0,74	13th

Table 2: AI adoption in Portugal compared with the EU-27, 2024 (Source: Authors' calculations based on Eurostat data)

The results show that Portugal's relative position varies considerably according to enterprise size. Among small enterprises, 6,66% reported using at least one AI technology, 5,37 percentage points below the EU-27 country mean of 12,03%. The Portuguese value was also 2,12 percentage points below the European median of 8,78%.

Portugal ranked 21st among the 27 Member States in this category, indicating a comparatively low level of AI adoption among small enterprises. Among medium-sized enterprises, the Portuguese adoption rate reached 15,35%. This value remained 5,73 percentage points below the EU-27 mean of 21,08% and 1,56 points below the median of 16,91%. Portugal occupied the 18th position in the corresponding ranking. Although the adoption rate was higher than that observed among small Portuguese enterprises, the country continued to perform below the European reference values. A different pattern emerged among large enterprises. In Portugal, 41,89% of large enterprises used at least one AI technology, slightly exceeding both the EU-27 mean of 41,15% and the median of 40,48%. The differences were 0,74 and 1,41 percentage points, respectively. Portugal ranked 13th among the 27 Member States, placing it close to the centre of the European distribution. Taken together, these results indicate that Portugal does not exhibit a uniform disadvantage in AI adoption across all enterprise-size categories. The country's comparatively weaker position is concentrated among small and medium-sized enterprises, whereas large Portuguese enterprises perform at a level broadly consistent with, and marginally above, the European benchmark. The national gap in AI adoption therefore appears to be primarily associated with the limited uptake of AI among Portuguese small and medium-sized enterprises rather than with a generalised national shortfall. These comparisons are descriptive and should not be interpreted as evidence of a causal effect of enterprise size. Nevertheless, they reveal a pronounced size-related divide in Portugal and provide a basis for examining whether similar differences occur systematically across the EU-27.

3.3. Differences within Portugal

A comparison of the three enterprise-size categories reveals a substantial internal divide in AI adoption among Portuguese enterprises. As shown in Table 3, the percentage of enterprises using at least one AI technology increased from 6,66% among small enterprises to 15,35% among medium-sized enterprises and 41,89% among large enterprises.

Comparison	Difference (p.p.)	Adoption ratio
Medium-sized vs. Small	8,69	2,30
Large vs. medium-sized	26,54	2,73
Large vs. Small	35,23	6,29

Table 3: Differences in AI adoption between enterprise-size categories in Portugal, 2024 (Source: Authors' calculations based on Eurostat data)

Differences were calculated by subtracting the adoption rate of the smaller enterprise-size category from that of the larger category. The adoption ratio represents the adoption rate of the larger category divided by that of the smaller category. p.p. = percentage points. The difference between medium-sized and small enterprises was 8,69 percentage points. The adoption rate among medium-sized enterprises was therefore approximately 2,3 times that observed among small enterprises. This result suggests that the transition from the small to the medium-sized category is associated with a relevant increase in the uptake of AI technologies. The largest incremental difference was observed between medium-sized and large enterprises. AI adoption among large enterprises exceeded that of medium-sized enterprises by 26,54 percentage points and was approximately 2,7 times higher. This indicates that the adoption gap becomes particularly pronounced when comparing large enterprises with the remaining categories. In Portugal, AI adoption among large enterprises was approximately 6,3 times that of small enterprises, representing a gap of 35,23 percentage points. While large Portuguese enterprises achieved adoption levels comparable to the European benchmark, small and medium-sized firms remained considerably behind.

However, these descriptive results cannot establish statistical significance or causality because Portugal contributes only one aggregated observation per enterprise-size category. Inferential analysis therefore relies on the matched sample of all 27 EU Member States.

3 .4. Global Friedman Test

The Friedman test was applied to determine whether AI adoption differed significantly across small, medium-sized and large enterprises in the EU-27. Countries were treated as matched blocks, with each Member State contributing one observation for each of the three enterprise-size categories. The test produced a Friedman chi-square statistic of 54,00 with two degrees of freedom and a p-value below 0.001. The null hypothesis that AI adoption does not differ across enterprise-size categories was therefore rejected.

Number of countries	**Number of size categories**	**Friedman** χ^2	**Degrees of freedom**	**p-value**	**Kendall's** W
27	3	54,00	2	<0,001	1,00

Table 4: Friedman test for differences in AI adoption by enterprise size (Source: Authors' calculations based on Eurostat data)

The average rank was 1,00 for small enterprises, 2,00 for medium-sized enterprises and 3,00 for large enterprises. This ranking indicates that AI adoption increased consistently with enterprise size. In every Member State, small enterprises presented the lowest adoption rate, medium-sized enterprises occupied the intermediate position and large enterprises recorded the highest rate. The magnitude of the overall difference was assessed using Kendall's coefficient of concordance. The coefficient was calculated as follows:

$$W = \frac{\chi_F^2}{n(k-1)} = \frac{54}{27(3-1)} = 1.00,$$

where $n = 27$represents the number of countries and $k = 3$represents the number of enterprise-size categories. A value of $W = 1.00$ indicates perfect concordance in the ordering of the three categories across the countries analysed.

The consistent ordering across all EU-27 countries indicates that the relationship between enterprise size and AI adoption was not driven by a small number of Member States. The Friedman test therefore supports Hypothesis H1, confirming significant differences across enterprise-size categories. Wilcoxon signed-rank tests were subsequently used to identify which pairs of categories differed significantly.

4.5. Wilcoxon Pairwise Comparisons

Following the statistically significant Friedman test, pairwise comparisons were conducted using the Wilcoxon signed-rank test. Three comparisons were performed: small versus medium-sized enterprises, small versus large enterprises, and medium-sized versus large enterprises. The Holm procedure was applied to the original p-values to control the family-wise error rate arising from multiple comparisons.

Comparison	Median difference (p.p.)	W^+	W^-	z	Original p-value	Holm-adjusted p-value	Effect size r
Small − Medium-sized	−8,19	0	378	−4,529	0,00000593	0,00001780	0,872
Small − Large	−29,02	0	378	−4,529	0,00000593	0,00001780	0,872
Medium-sized − Large	−20,64	0	378	−4,529	0,00000593	0,00001780	0,872

Table 5: Wilcoxon signed-rank comparisons of AI adoption by enterprise size (Source: Authors' calculations based on Eurostat data)

The comparison between small and medium-sized enterprises revealed a statistically significant difference in AI adoption ($W^+ = 0, W^- = 378, z = -4{,}529$, Holm-adjusted $p < 0{,}001$). The median within-country difference was −8.19 percentage points, indicating that the adoption rate among medium-sized enterprises exceeded that of small enterprises by a median of 8,19 percentage points. The effect size was large ($r = 0{,}872$). A statistically significant difference was also found between small and large enterprises ($W^+ = 0, W^- = 378, z = -4{,}529$, Holm-adjusted $p < 0{,}001$). The median difference reached −29,02 percentage points, representing the largest disparity among the three comparisons. The corresponding effect size was also large ($r = 0{,}872$). Finally, the comparison between medium-sized and large enterprises produced a statistically significant result ($W^+ = 0$, $W^- = 378$, $z = -4{,}529$, Holm-adjusted $p < 0{,}001$). Large enterprises presented an adoption rate that exceeded that of medium-sized enterprises by a median of 20.64 percentage points. Once again, the estimated effect size was large ($r = 0{,}872$). All pairwise comparisons showed the same directional pattern across the 27 countries: medium-sized enterprises consistently recorded higher AI adoption than small enterprises, while large enterprises exceeded both groups. Consequently, each comparison produced a positive-rank sum of zero, a negative-rank sum of 378 and identical Wilcoxon statistics and effect sizes, despite differences in the magnitude of the percentage-point gaps. These results support Hypotheses H1a and H1b and, together with the Friedman test, confirm a systematic enterprise-size gradient in AI adoption across the EU.

4 . DISCUSSION

The results provide clear evidence that enterprise size is associated with substantial differences in artificial intelligence adoption across the European Union. In all 27 countries analysed, the percentage of enterprises using AI increases consistently from small to medium-sized and from medium-sized to large enterprises. This pattern suggests that enterprise size represents an important structural dimension of the digital divide within the European business sector.The descriptive results show that, on average, AI adoption reaches 12,03% among small enterprises, 21,08% among medium-sized enterprises and 41,15% among large enterprises. Therefore, the average difference between small and large enterprises is approximately 29 percentage points. Furthermore, the largest increase occurs between medium-sized and large enterprises, indicating that the capacity to adopt AI may accelerate once enterprises reach a certain scale. Large enterprises' higher AI adoption may reflect their greater financial resources, advanced digital infrastructure, specialised human capital, structured data and stronger capacity to invest in ICT, cloud services, and research and development. Conversely, small enterprises often face financial constraints, skills shortages, limited data availability and greater uncertainty about the costs and benefits of AI implementation. The Friedman test confirms that the observed differences between enterprise-size categories are statistically significant. The result, $\chi^2(2) = 54{,}00$, $p < 0.001$, leads to the rejection of the null hypothesis that AI adoption is identically distributed across small, medium-sized and large enterprises.

The associated Kendall's coefficient of concordance (W = 1,00) indicates a perfectly consistent ordering across the 27 countries: large enterprises report the highest adoption rate, medium-sized enterprises occupy an intermediate position and small enterprises exhibit the lowest rate. The pairwise Wilcoxon signed-rank tests reinforce this conclusion. Statistically significant differences were identified between all enterprise-size categories, even after applying the Holm correction for multiple comparisons. The effect sizes were also large (r = 0,87), demonstrating that these differences are not only statistically significant but also substantively relevant. Consequently, enterprise size appears to be associated with a systematic and pronounced adoption gap throughout the EU-27. Portugal follows the same general size-related pattern, but its position differs across enterprise categories. AI adoption among Portuguese small enterprises is 6,66%, which is 5,37 percentage points below the EU-27 country average. Among medium-sized enterprises, the Portuguese rate is 15,35%, corresponding to a gap of 5,73 percentage points relative to the European average. In contrast, AI adoption among Portuguese large enterprises reaches 41,89%, slightly exceeding the EU-27 country average of 41,15%. These results suggest that Portugal's relative disadvantage is concentrated primarily among small and medium-sized enterprises. Portuguese large enterprises appear to possess an AI adoption capacity comparable to that of their European counterparts, while smaller firms remain further behind. The difference between small and large Portuguese enterprises reaches 35,23 percentage points, exceeding the corresponding average gap observed across the EU-27. A large Portuguese enterprise is approximately 6,29 times more likely to report using AI than a small Portuguese enterprise. The concentration of AI adoption among large Portuguese enterprises may widen existing disparities in productivity, innovation and competitiveness. Policy measures should therefore address SMEs' specific constraints through financial incentives, shared infrastructure, specialised training, access to ICT expertise and collaboration with higher education institutions. Universities and polytechnics can support experimentation through applied research, technical assistance and technology-transfer initiatives. Reducing the adoption gap could also promote a more inclusive and sustainable digital transition. However, the findings are limited by the use of aggregated data from a single year, the absence of firm-level and sectoral controls, and an indicator that measures AI use without capturing its intensity, sophistication or impact. Future research could incorporate longitudinal and sectoral data, explanatory variables such as cloud use, ICT skills and R&D expenditure, and panel-data models to investigate the determinants of AI adoption more comprehensively.

5. CONCLUSION

The study seeks to answer the question of whether there is a systematic pattern of AI adoption associated with company size in the European space and to what extent Portugal follows this pattern. By placing the Portuguese results in the context of the EU-27, the aim is to identify in which size categories the main differences in adoption are concentrated and to contribute to a better understanding of the organizational dimension of the digital divide. The results could also provide relevant elements for the definition of policies and measures aimed at supporting digital transformation, particularly among smaller companies. Despite the growing interest in AI adoption, the existing literature remains relatively fragmented, often focusing on SMEs, specific sectors, or national contexts. Consequently, systematic comparisons between small, medium, and large enterprises in a harmonized European context are still limited. This gap is particularly relevant to understanding whether the differences associated with the business dimension constitute phenomena specific to certain countries or reflect a structural pattern common to the European Union. This study analyzed the differences in artificial intelligence adoption among small, medium, and large companies in the 27 Member States of the European Union, with particular attention to the Portuguese case. Based on harmonized Eurostat data for 2024, the results reveal a consistent adoption pattern associated with company size: large

companies have the highest levels of AI use, followed by medium-sized companies and, lastly, small companies. This hierarchy was observed in all countries analyzed, highlighting that company size constitutes an important structural dimension of inequalities in AI adoption. The descriptive results demonstrate the magnitude of this difference. The average AI adoption in the EU-27 was 12.03% among small companies, 21.08% among medium-sized companies, and 41.15% among large companies. The difference between small and large companies reached, on average, 29.12 percentage points. These results were reinforced by inferential analysis: the Friedman test identified statistically significant differences between the three size categories, while the Wilcoxon tests confirmed significant differences in all pairwise comparisons, even after Holm correction. The observed effects were high, reinforcing the substantive relevance of the identified differences. Portugal follows the general trend observed in the European Union, but presents a particularly distinct situation among the different business categories. AI adoption among small Portuguese companies was 6.66%, 5.37 percentage points lower than the average of the EU-27 countries, while among medium-sized companies it was 15.35%, 5.73 percentage points below the European average. In contrast, large Portuguese companies had an adoption rate of 41.89%, slightly higher than the EU-27 average of 41.15%. Thus, Portugal's main disadvantage does not appear to result from a generalized deficit in AI adoption, but is mainly concentrated in small and medium-sized enterprises. This difference is particularly relevant because it can contribute to deepening existing inequalities in productivity, innovation, and competitiveness. The concentration of AI adoption in large companies suggests the need for policies aimed at reducing the barriers faced by smaller companies. Measures related to financial incentives, worker training and retraining, access to specialized skills, shared digital infrastructure, technical support, and collaboration with higher education institutions can contribute to strengthening the capacity of SMEs to implement and integrate AI technologies.

It is important, however, to interpret these results in light of the study's limitations. The analysis uses aggregated data referring to a single year and does not allow for establishing causal relationships between company size and AI adoption. Furthermore, the indicator used measures the use of at least one AI technology, not allowing for an assessment of the intensity, sophistication, or impact of that use. The exclusion of companies with fewer than ten employees also constitutes a limitation to the generalization of the results to micro-enterprises. Future studies could overcome these limitations through the use of longitudinal and sectoral data and the incorporation of explanatory variables related to digital infrastructure, use of cloud services, ICT skills, investment in research and development, and other organizational capabilities. This will allow us to understand not only the existence of differences in AI adoption according to company size, but also the mechanisms that contribute to its formation and persistence.

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LEADERSHIP AND DECISION-MAKING STYLES IN FIRE CHIEFS IN PORTUGAL

Felipa Lopes dos Reis
School of Economic and Organizational Sciences (Portugal)
Lusófona University, Lisboa
p4338@ulusofona.pt

Helena Pimentel
School of Economic and Organizational Sciences (Portugal)
Lusófona University, Lisboa
p4323@ulusofona.pt

Marco Gomes
Lusófona University, Lisboa
cintra.gomes@gmail.com

ABSTRACT
The ability to lead is a basic premise for the long-term sustainability of any organization. Organizations are led and managed by people who have organizational and social skills in order to make decisions rationally and always in favor of the goals advocated at a strategic level. We all make decisions on a daily basis, but at a business and professional level, these decisions can have harmful consequences for the organization. To mitigate this situation, the leader or manager, in charge of decision-making, must have certain skills, cognitive or personal, social skills, as well as functional or organizational skills. This study aims to identify the decision-making styles and the respective leadership of fire commanders in Portugal, specifically in the command of corporations. It also has as a secondary objective to compare the results obtained for the commanders with their hierarchical inferiors. Leadership and decision-making in the context of firefighting is extremely important for effectiveness, safety, and survival of teams, for operational safety and also mental health of professionals. To achieve the proposed results, a quantitative methodology was used, with the application of 33 questionnaires. From the results obtained, it was found that Fire Commanders preferentially adopt a participatory leadership as well as make decisions analytically.
Keywords: *Fire commanders; Leadership styles; Decision making styles*

1. INTRODUCTION

In a globalized world in constant change, it is the role of the leader to influence his followers in order to adapt to new realities that emerge in the job market and within organizations. To lead people and teams in an organization, it is essential that a leader has the ability to accompany and lead all those who are led through the successive waves of change that flood and impact organizations in general. The relentless competitiveness of the world we live in, whether in social or business terms, makes leadership in organizations, the leadership of teams, has an increasingly important role in the sustainability of the organization in a medium/long term. Decision-making by leaders is fundamental to the solvency of the organization. Any leader must have the ability to influence his followers so that the recommended organizational goals are achieved voluntarily, always with a focus on his mission, team spirit and loyalty to the values practiced. The injections of influence given by leadership alter the intrinsic motivation of the individual and the group. Leaders perform their tasks better and take their duties and obligations seriously towards others, towards organization and towards themselves.

Adequate leadership and assertive decision-making, articulated with the organizational strategy aiming at the recommended objectives, are synonymous with greater efficiency, more productivity, more motivation and satisfaction in fulfilling the mission and all this is crucial for a continuous competitive advantage and long-term sustainability. In the context of firefighters is extremely relevant, given the high-risk, high-pressure and time-limited nature of their activity. It´s critical for operational effectiveness and professionals' well-being that the leader ensures the effectiveness and safety of all operational staff, guiding them and managing the risk inherent in the profession. The leadership style influences how decisions are made, more autocratically (necessary in imminent danger) or more participatively (useful in planning or lower-risk contexts). With this regard this investigation has the following starting question: What are the leadership and decision-making styles adopted by fire commanders? The work also has the following objectives: to characterize fire commanders leadership style; to characterize fire commanders' decision-making style; and comparing leadership and decision-making styles of fire chiefs with those of their hierarchical inferiors. Leadership styles and decision-making among firefighters are essential for developing more effective training programmes, ensuring that leaders can make the best possible decisions under extreme conditions, protecting lives and property while promoting health and resilience of their teams.

2. LITERATURE REVIEW

Since the dawn of humanity, we have lived in society, starting socialization in small groups so that it would be easier to resist many adversities. Thousands of years ago, we were already grouping together and aiming for common goals, for all these synergies to result, a leader was needed to command the group, to organize and guide those who were led, together they were stronger and only together could they achieve their goals. In today's organizations or companies, the process is similar, without proper or adequate leadership, organizational entropy reigns, bringing business failure and insolvency to the limit. Leadership has always been part of human history and human development for thousands of years. Biological and mental development is correlated with our leadership skills, we are the product of thousands of years of development, we learn to lead or simply let others lead. According to Rouco (2012), leadership is a ubiquitous theme in any organization or company, the correct implementation of some basic principles as well as certain methods intrinsic to the leadership process itself are crucial factors for the success of organizations. There are many concepts of what leadership means, for Reis (2020), there is no doubt that leadership is necessarily an agent of change, given that it has an inherent process of influencing the activities of an individual or a group, through competencies, that make it possible to transform knowledge into action, to reach a goal in a given situation, resulting in a high performance index, not least because an organization with leadership and strategic vision will have a bright future potential, but it will not achieve it if it neglects oriented leadership processes for change. More companies develop strategies necessary to reduce risk and strengthen competitiveness to be sustainable (Birnik, 2013). The sustainability orientation requires the integration of strategies in which all the company's resources are aligned towards the production of value, in the development of new products, leading to a change in learning and mentality (Hurley & Hult, 1998; Sharma & Vredenburg, 1998), and for this to happen some leadership skills are needed. Ulrich et al. (2000) defend the need to balance the results for the stakeholders, as the leader's primary role. Leaders should trust their intuition and expertise, but also to recognise signs that their initial pattern may be incorrect, training should be realistic and scenario-based to build a 'file' of patterns in leaders. The leader must have time to exercise and recognise patterns, which is the role of the leader, delegating tasks to focus on strategic decision-making, not only makes the decision, but ensures that the team understands and executes it (Klein, 1998).

For effective leadership, leader before his followers must have some leadership traits, like the ability to deal with people, he must have noble characteristics such as integrity, ability to deal with uncertainty and organizational and business knowledge as well as some qualities such as vision and the ability to create reliable and highly motivated teams, because difference between staff behavior "with a good leader" is physically noticeable. Leader may have all the necessary skills, but his efforts will not bear much fruit if the organization is not also subject to external and internal, technological, social, economic, political and cultural changes (Reis, 2020). There are several leadership styles, some are not better than others, they are different, a style can work well or less, well depending on certain situations, depending on other factors such as organizational culture, or for example with greater or lesser autonomy and self-regulation of the work that a given individual has to perform his task. There is no single 'best' style, the context requires hybrid and situational leadership, where different styles are applied according to challenges.

2.1. Directive Leadership Style

According to Rowe (1998), people who have a more autocratic style have a tendency towards authoritarianism and a great thirst for institutional power, where the organizational structure is usually very hierarchical and where procedures are rigid. There are no better or worse forms of leadership, all styles are better or worse due to the situational context, someone imagines an army platoon with a certain mission with a *laissez faire* leadership style, certainly not, there can be participatory leadership and delegation among the higher levels of the institution, but the leadership for base has to be directive when it lacks autonomy or self-regulation in its function. According to Rouco (2012) the leader conveys to his followers exactly what leader wants to be performed in a certain place and in a certain time space, still according to the author, he states that this style of leadership is appropriate for subordinates with little experience and competence to the execution of its task, where there is a direct order and the respective control of the same order.

2.2. Participatory Leadership Style

Participatory leadership is defined as influence and joint decision-making between a leader and his followers (Armenakis, Harris & Mossholder, 1993; Koopman & Wierdsma, 1998), the objective is to involve and give more attention to the followers in order to contribute to the problem solving and decision making (Nystrom, 1990). There are many leaders who recognize the importance of implementing this style of leadership due to the benefits of it in terms of more motivation of their subordinates due to participating in the management of the organization and being part of decision-making (Randolph, 2000), while others are more resistant to implementing it, participatory leadership requires a sharing of control over the decision and the loss of some power (Heller, 2003). This leadership style is favorable when subordinates have the experience and competence to perform their tasks, so the leader can involve them in the decision-making process, but always safeguarding the final responsibility, which is always the leader.

2.3. Leadership Style by Delegation

Delegation is assigning responsibility to other individuals for carrying out concrete activities as well as the formal authority to carry them out. This style of leadership is very useful in organizations, when there is a delegation of authority and responsibility to other people, we are empowering them, we are also contributing to their recognition and appreciation, but greater autonomy in decision-making implies greater responsibility.

The tendency of many companies, including successful companies like Google or Facebook, is to have a more relaxed management in which they have an organizational culture of task delegation, where subordinates are more involved in decision making and this increases employee retention (Garvin, 2013), as companies adopt flat or non-hierarchical organizational structures delegation will be an increasingly common and popular practice (Kastelle, 2013), it is absolutely necessary to give more freedom to all employees to work in a more autonomous way so that they can experience a series of positive results such as more job satisfaction, personal development in terms of innovation, creativity and commitment to the organization (Chen et al., 2007).

2.4. Leadership Competencies and Decision Making Styles

It is necessary to mention that, although styles are conceptually distinct, in reality the vast majority of managers present and use multiple styles. The style adopted in a given situation depends a lot on the context in which the decision is made, considering those styles describe ways of acting in general. Although it is not possible to determine exactly the decision style of each one, it can and should be important to have an idea of the dominant style, being sure that it reflects different needs. The directive style is associated with the need for power, the behavioral needs affiliation, association, the analytical needs realization, while the conceptual needs need recognition. The way in which the manager and/or leader relates to the subordinates is in accordance with their decision-making style. Therefore, while a manager with a directive style is direct in interacting with subordinates, the behavioral style tends to generate empathy.
Zaleznick, cited by Rowe (1998) studied the differences in decision styles between managers and leaders. This author considered tasks that require low cognitive complexity to be the maintenance functions of management, in which the objective is to obtain results and motivate employees. In the opposite direction, he considered as leadership functions tasks that relate to ideas and consequently require a higher level of cognitive complexity. The leader chooses to change as a way of leading, implementing a “vision” with the objective of guiding employees towards that same vision. In turn, the manager is dedicated to planning and problem solving. Managers and leaders are very different people in terms of motivation and the way they think and act. In this sense, the manager deals with efficiency, planning, procedures and control, being more rational, since they attribute greater value to reason and not so much to the sentimental component. On the contrary, the leader takes more risks, are more dynamic and creative and knows how to deal with change, so they will be more likely than managers to present the analytical or conceptual style as their dominant style. Studies linking leadership skills with decision-making styles are rare. Rowe (1992) materializes one of these rare exceptions in his study Managerial Decision Making. In this study, Rowe presents a table where he relates leadership skills with decision-making styles. As can be seen, skills such as “task orientation”, “vision”, “creativity”, “independence” and “innovation” tend to be related to the conceptual decision-making style. The analytical style relates to skills such as “problem solving”, “innovation”, “effectiveness” and “direction”. On the other hand, the behavioral style is linked to the competences “communication”, “empathy” and “interpersonal relationships”. The directive decision-making style does not show any leadership competence. As it is easy to understand, after the above, this style is more related to the managers themselves than to the leaders, hence it does not relate to any leadership skills.

3. METHODOLOGY

The purpose of this study is to identify and characterize leadership and decision-making styles adopted by fire commanders and the methodology used was quantitative in the form of a questionnaire, divided into three parts. The first part refers to the sociometric data collection from the respondent. The second part is the characterization of the respondents' leadership style.

In this part, the questions are closed-ended, on a 5-level Likert scale (level 1: Strongly disagree to level 5: Strongly agree). The third part concerns the characterization of the decision-making style. The questions in this part are also closed-ended, and the scale used comprises only 4 levels (8 points, 4 points, 2 points, 1 point). For the application of this questionnaire, a representative group of the study population (sample) was selected. Among the respondents are Fire Commanders, as well as hierarchical inferiors of different categories and classes. And then a Descriptive Statistical Analysis was done. To prepare a questionnaire, it is necessary to have the research problem very explicitly, and its construction depends on how it will be applied, the topic under study, the sample and the type of analysis. Also according to the author, the elaboration of questionnaire is carried out based on the definition of the problem and the theoretical framework of reference, taking into account some aspects such as the questions design, the accessible language, formulating questions in order to avoid dubious interpretation, contain only questions related to the research and objectives, have a certain order and type of information to collect (Reis, 2020).

3.1. Sample Sociodemographic Characterization

The research work sample comprises a total of 33 respondents belonging to the Fire Departments. Of the 33 respondents, 9 (27%) occupy the position of Commander, while the remaining (73%) are from different lower hierarchical classes. Regarding the ages of respondents, most respondents (25 respondents) are over 35 years old. The remaining (8 respondents) are adults under 36 years of age. With regard to the years of experience of the respondents, an important part of the respondents (14 respondents) has between 11 and 15 years of experience in their field and 16 respondents have more than 15 years of experience. It can therefore be said that most respondents have considerable career experience. Finally, it remains only to characterize the sample in terms of gender, of the 33 respondents, 28 (85%) are male and 5 (15%) are female.

4. RESULTS PRESENTATION AND ANALYSIS

4.1. Descriptive Statistical Analysis regarding Leadership Styles

As can be seen, both the Commanders and the other respondents show a tendency towards an approach more related to the Participatory Leadership Style, with values of 4.07 and 4.15 respectively. It is also possible to verify that the Directive Leadership Style is the one that presents a considerable difference between two groups. Commanders have an average value of 3.01 for this Style, while those in the hierarchy have an average value of 2.10. The Delegated Leadership Style appears as the second preference in both groups studied. Of the Styles studied, this is also the one with the highest Standard Deviation.

4.2. Descriptive Statistical Analysis regarding Decision Making Styles

It is possible to verify that, with regard to the Decision Making Styles studied, the values presented by the Commanders are very close to the lower hierarchical ones. The Analytical Decision Making Style is the one with the highest Average Value (4.3). The Conceptual Style is the one with the lowest value (V Mean=3.42).

4.3. Descriptive Statistical Analysis based on Years of Experience

It is verifiable that for all experience intervals, the most identifiable Leadership Style is Participatory, with the difference between lower and higher levels being much lower. Still in this field, it is also possible to observe that the Managerial Leadership Style presents a differential of more than one unit comparing the lower level of experience compared to the higher one.

With regard to the study of Decision Making Styles, with the exception of the lowest level of experience, the Analytical Style is the most identifiable among the different levels of experience studied. Of the four Styles studied, the comparative differential presented between the different levels is too low and not very linear to make effective conclusions related to this variable.

4.4. Descriptive Statistical Analysis compared to Academic Degree

It is verifiable that, for all academic degrees, the preferred Leadership Style and Decision-Making Style are Participatory and Analytical, respectively. As for Leadership Styles, it is possible to observe that there is a growing trend in the adoption of the Style by Delegation with the increase of the respondents' academic level. For the other two styles, the comparative differential presented between the different academic degrees is too low and not very linear to make effective conclusions related to this variable. Regarding the observation of Decision Styles, the Behavioral Style shows a decreasing trend of adoption with the increase in academic level. As for the other Decision-Making Styles, it is not possible to verify effective growth trends related to academic degrees.

5. CONCLUSIONS

From the sociodemographic data obtained, it is possible to verify that the respondents are well distributed in the different categories, making the results more significant and interesting for the study. To the starting question "What are the leadership and decision-making styles adopted by firefighter commanders?", it is possible to verify that Commanders prefer to adopt a Participatory Leadership and to engage in Analytical Decision-Making. It is then possible to fulfill the first objective, mentioned that Fire Commanders, in most situations, provide their subordinates with the ability to propose and decide together. It is also possible to conclude that, although this last approach is preferred, Commanders also show an interesting tendency to assign responsibility and formal authority to other individuals so that they can carry out concrete activities autonomously. As for the second objective, it can be concluded that Commanders are problem-solving oriented and strive to achieve the best in a given situation, they appreciate variety and challenge, but value control, they tend to be innovative and good at abstract reasoning and deductive logic. Even under stress, they follow established rules and standards. They react to stimuli with analytical insight and analyze them in a logical way. Regarding the third objective, it can be concluded that the lower hierarchical ranks of Fire Commanders, in general, have similar style tendencies. The main difference concerns the Directive Style, less marked in the case of the subordinates of the Commanders. This fact is easily explained by the superior hierarchical position of the Commanders, which in certain situations must prevail by directive command voice. Leadership effectiveness is influenced by the situation, leaders cannot have a single style, in situations of immediate risk, they switch to a directive style and in complex tasks, a participative style, where trust and communication is crucial. A situational leadership for firefighters while a more participatory or transformational style is crucial for motivation and well-being in daily routines. The results may have low generalizability and be biased by the specific group studied and can be interesting to analyze other countries or compare different regions. To mitigate limitations and improve leadership in the fire service, some suggestions can be made like analyse communication patterns (use of directive and supportive language) in radio recordings, for example, or simulations. Or also analyse behavioral leadership skills, such as situational awareness or assertive communication. Leadership is an important driver of team cohesion and performance, and functional leadership ensures that all resources are used in a coordinated manner to better results. Communication is a critical factor for effective leadership and operational safety in fire service, in an environment characterized by stress, life-threatening situations and limited time, the quality and clarity of communication can literally mean the difference between disaster or success.

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GENDER BALANCE IN UNIVERSITY GOVERNANCE: A COMPOSITE INDEX AND MACHINE LEARNING ANALYSIS OF ITALIAN HIGHER EDUCATION

Tahani Rashid
Department of Political and Social Science, University of Calabria, Italy
tahani.rashid@unical.it

Umair Yousaf
Department of Mathematics and Computer Science, University of Calabria, Italy
umair.yousaf@unical.it

Maria Nardo
Department of Political and Social Science, University of Calabria, Italy
maria.nardo@unical.it

ABSTRACT

Higher education institutions face growing pressure to demonstrate accountability for sustainability, extending beyond environmental reporting into questions of social inclusion and gender equality. Previous research has explored gender representation in Italian university governance; less attention has been given to the national-level configuration of gender representation across multiple governance bodies simultaneously. Certification frameworks tend to be based on single, easy-to-see signals rather than the entire distribution of decision-making power within an institution. This study addresses this gap by using open administrative data on the gender composition of eight governance bodies in about 100 Italian universities for the 2023 and 2024 academic years. A composite Governance Gender Balance Index was developed and examined through effect sizes, descriptive statistics, and unsupervised machine learning. Women held only 13.4% of Rector positions in 2023 (up to 18.2% in 2024). Even though the Equal Opportunity Committee was the only body with a female majority throughout. An initial comparison suggested that universities led by a female Rector had a significantly higher composite index than those led by a man. The comparison is partly circular by construction, because the index incorporates the Rector's own gender as one of its eight components. And the effect disappears altogether when the index is recalculated without including the Rector. This methodological finding has direct implications for how composite accountability indicators should be built. The 3-cluster K-means solution revealed that this association is not uniform across governance configurations. A pattern of high female representation in the Rector position coexists with weak representation in other strategically important governance roles. The practical implication is that university sustainability certification and accountability schemes should avoid indicators that double-count leadership gender, and should instead report governance balance across multiple independently constructed dimensions.

Keywords: *accountability; gender equality; higher education; university governance; unsupervised machine learning*

1. INTRODUCTION

Universities are no longer judged only by teaching and research output. In recent decades, they have been asked to demonstrate how their institutional practices align with sustainability goals of social inclusion and gender equality (Leal Filho et al., 2021). Sustainability reporting frameworks originally built for the corporate sector (including the Global Reporting Initiative) have been adapted for higher education.

Their application remains uneven and often more symbolic than substantive (Moggi, 2023). Governance is frequently discussed in this literature, but empirical assessments often focus on reporting practices, formal policies or individual governance positions rather than the distribution of gender representation across the wider governance architecture (Nardo et al., 2005). At the European level, gender equality has become an explicit eligibility condition for research funding. Since 2022, applicants to Horizon Europe from EU member states must have an adopted Gender Equality Plan in place (Karataş et al., 2025). Italian public administrations, including universities, have been required to establish an Equal Opportunity Committee known as the Comitato Unico di Garanzia since 2010 to monitor discrimination and promote organisational wellbeing (Legge 183/2010; Decreto Legislativo 165/2001, art. 57). These policy instruments assume that formal representation translates into substantive change. An assumption that organisational sociology has long treated with caution. The formal structures adopted to satisfy external expectations can become decoupled from an institution's actual day-to-day practice (Meyer and Rowan, 1977). That assumption has rarely been tested against the actual gender composition of the governing bodies that sit above and around these committees. Previous studies have examined women's access to Italian university governance, including the feminisation of individual governing bodies and the influence of institutional rules and university leaders. Existing studies have largely relied on case-based, longitudinal, or body-specific analyses. Less attention has been given to the national-level configuration of gender representation across multiple governance bodies simultaneously. This study addresses this gap by using open administrative data from Italy's Ministry of University and Research to construct a multidimensional Governance Gender Balance Index covering eight governance bodies across Italian universities in the 2023 and 2024 academic years. Rather than treating the presence of a woman in the Rector's position as sufficient evidence of institutional gender balance, the study examines whether female leadership is associated with broader representation across the governance structure (Cohen, 1988) and uses K-means clustering to identify distinct institutional configurations.

The study has three main contributions. First of all, it shifts the analysis from women in individual leadership positions to an evaluation of gender balance across the governance system of the university in a multidimensional way. Second, it broadens the scope of Italian research, which has thus far been limited to analyzes by institutions and bodies, to a national comparative perspective depending on administrative data. Third, it employs cluster analysis to identify governance configurations when assessed by a single leadership indicator that may appear similar but differ in the distribution of women in other decision-making and oversight bodies. Findings are relevant for the university sustainability accountability design and certification models. But if one leadership indicator can cover imbalances in the bodies that really assign resources and set policy, like the Board of Directors, then certification schemes that rely on that indicator risk paying symbolic presence rather than real structural change. This concern is relevant to a broader research programme that explores governance and accountability for sustainability models in universities, with particular regard to how such models may facilitate appropriateness and personalisation of care in university-affiliated health services, where gender sensitive governance has direct downstream effects for patient outcomes (Regitz-Zagrosek and Gebhard, 2023). The paper is structured as follows. Section 2 reviews the theoretical background on board diversity, critical mass, and accountability in higher education. Section 3 describes the data and methodology, including how the risk of a circular index was tested. Section 4 presents the results. Section 5 discusses the findings in light of the literature, and the last section, Section 6, concludes with implications for policy and directions for future research.

2. THEORETICAL BACKGROUND

2.1 Accountability and Governance in Higher Education

Accountability in higher education has traditionally been understood as accountability for academic quality and public spending. Recently, the concept has broadened to include accountability for an institution's social and environmental impact (Leal Filho et al., 2021). Universities that publish sustainability reports typically do so to respond to stakeholder pressure and to protect institutional legitimacy, rather than because a mature accountability system compels them to (Moggi, 2023). Moggi's review of Global Reporting Initiative adoption in universities finds that its guidelines were designed for corporations and fit poorly with the governance structures. The public mission of higher education institutions leaves a persistent gap between reported intentions and verifiable practice. This gap is consistent with what organisational behaviour describes as decoupling. Therefore, institutions tend to adopt formal structures that satisfy external legitimacy demands while leaving underlying operations mostly unchanged (Meyer and Rowan, 1977). Governance bodies are the mechanism through which accountability is exercised, when it exists. A Rector who is formally accountable for an institution's sustainability commitments still depends on a Senate and a Board of Directors to approve budgets, appoint staff, and ratify policy. An accountability model that examines only the top office, without examining the bodies that share and check that power, offers a blurred picture of institutional governance (Leal Filho et al., 2021). The symbol that measures the risk rather than the substance described by Meyer and Rowan (1977).

2.2 Gender Diversity, Tokenism, and Critical Mass

The idea comes from Kanter's (1977) foundational work on organisational demography that the number of women in a governing body matter, not only their presence. Kanter argued that when women make up a small minority group, typically less than 15%, they are treated as tokens rather than as individuals. Tokens face heightened visibility, pressure to conform to stereotypes, and limited influence over group decisions, regardless of their individual competence. Torchia et al. (2011) tested whether a specific threshold of representation of at least three women on a corporate board produced measurably different outcomes compared with one or two women. Using a sample of Norwegian firms, they found that boards with three or more women directors were associated with higher levels of firm innovation, while boards with only one or two women showed no such effect. They concluded that critical mass, not simply the presence of a woman in a senior seat, is what changes group dynamics and decision-making. More recent evidence extends this concern from board seats to board committees. Using data spanning firms subject to different national quota regimes, Duran, Turturea et al. (2026) reveal that mandated female board representation does not automatically extend to the major committees where much of a board's substantive work is done, particularly where ownership structures allow controlling shareholders to concentrate influence away from newly appointed women directors. This distinction is directly relevant to universities. A university can have a female Rector and still have a Board of Directors, a Senate, or a Director General's office where women remain a token minority or are absent. If critical mass theory holds in the university context as it does in the corporate one, the presence of a single female leader should not be treated as evidence of balanced governance overall, and the committee-level evidence reported by Duran et al. (2026) suggests this is a realistic possibility instead of a purely theoretical one.

2.3 Women in Academic Leadership

Empirical work on women in university leadership consistently finds persistent underrepresentation, though the scale and pattern vary country to country. Kohtamäki (2024) compares academic leadership in Bangladesh, China, and Finland and finds that structural and cultural barriers to women's advancement persist even in countries with strong formal gender equality policies, proposing that policy alone does not close the gap.

A systematic review by Meza-Mejia et al. (2023) similarly finds that women in academic leadership positions remain to face barriers from institutional culture, work-life balance expectations, and informal networks that favour men. The phenomenon is occasionally described using the metaphor of the leaky pipeline, the observation that women are lost from the academic career track at every successive stage, so that even when women make up half of doctoral graduates, they represent a much smaller share of full professors and an even smaller share of institutional leaders (Speer, 2023). In this context, one female Rector is a person who has pushed through a system that has continually barred women at every previous stage. The mere presence of her should not be taken as a sign that the pipeline issue has been solved for the institution. This also points to the need for caution in building composite indicators which take a single senior appointment as emblematic of the whole organisation.

2.4 Policy Context and the Link to Gender Medicine

The Italian Comitato Unico di Garanzia was established by Legge 183/2010, which merged the previously separate equal opportunity committees and anti-mobbing committees into a single body with a mandate to monitor discrimination and promote organisational wellbeing in every public institution. At the European level, making a Gender Equality Plan a mandatory eligibility requirement for Horizon Europe funding has pushed universities to formalise gender equality commitments in writing (Karataş et al., 2025). However, evidence on whether these formal plans change the underlying composition of governance bodies is still limited. This question has consequences that extend beyond governance itself. In clinical research and healthcare delivery, failing to account for sex and gender differences in disease presentation, treatment response, and outcomes has been shown to produce less effective and less personalised care (Regitz-Zagrosek and Gebhard, 2023). Universities that have medical schools and university hospitals are therefore not only accountable for their own internal gender balance, but also play a role in whether gender sensitive perspectives are embedded in the research and clinical training. A governance structure that is only nominally gender balanced, with a female Rector but persistent imbalance elsewhere, may be less likely to sustain the kind of institutional commitment that gender medicine requires. This connection motivates treating governance gender balance as a foundational, measurable accountability indicator, one that must be constructed carefully enough to be trusted, rather than a symbolic one.

3. DATA AND METHODOLOGY

3.1 Data Source

Open data is used from the portal of Italy's Ministry of University and Research, published by its Statistical Service under the Italian Open Data License v2.0 (MUR, Servizio Statistico, 2025). The dataset, part of a series titled Dati per bilancio di genere, reports the gender composition of the main governance bodies of Italian universities. The version used in this study covers the 2023 and 2024 academic years. It reports the number of women and men in each university. The data cover 8 governance bodies: Rector, Vice-Rector, Director General, Academic Senate, Board of Auditors, Board of Directors, Evaluation Unit, and Equal Opportunity Committee. The published files on the same portal were used to classify each university as state or non-state, and as a traditional or online institution.

3.2 Variable Construction

For each university, year, and governance body, the percentage of women among members was calculated as:

$$Women\%_{u,t,b} = \frac{Number\ of\ Women_{u,t,b}}{Total\ Number\ of\ Members_{u,t,b}} \times 100$$

where u denotes the university, t the year, and b the governance body. A separate binary indicator for bodies with a designated chair was recorded as:

$$Female\ Chair_{u,t,b} = \begin{cases} 1, if\ the\ chair\ is\ a\ woman \\ 0, if\ the\ chair\ is\ a\ man \end{cases}$$

For the single-occupant positions of Rector, Vice-Rector, and Director General were coded directly as:

$$Female\ Poisiton_{u,t,b} = \begin{cases} 100, if\ position\ is\ held\ by\ woman \\ 0, if\ position\ is\ held\ by\ man \end{cases}$$

This coding choice is revisited in Section 3.3 and tested explicitly in Section 4. A composite Governance Gender Balance Index was then calculated for each university and year as the simple average of the percentage of women across the eight governance bodies. This index treats each body as equally important, a simplifying assumption common in composite indicator design (Nardo et al., 2005). It is intended as a first transparent step toward a multidimensional accountability metric rather than a final weighting scheme. It includes the risk that a single-occupant office can dominate the summary measure.

3.3 Analytical Strategy

The analysis proceeds in four stages. First, descriptive statistics summarise the national trend in each governance body between 2023 and 2024. The composite index is compared across geographic macro areas and between state and non-state universities using one-way analysis of variance and independent samples t-tests. Second, the Rector's gender is itself one of the eight components of the composite index. So, to test whether the original comparison reflects a genuine association or an artefact of index construction, the comparison between female-led and male-led universities is repeated on a second index built from the remaining seven bodies only. Both comparisons are reported with mean differences, 95% confidence intervals, and Cohen's d (Cohen, 1988). Third, an unsupervised K-means clustering algorithm (MacQueen, 1967; Jain, 2010) is applied to the eight body-level percentages for the 2024 academic year. The number of clusters was selected using the elbow method applied to the within-cluster sum of squares, cross-checked against the silhouette coefficient (Rousseeuw, 1987). Fourth, because three of the eight variables are single-occupant offices that can only take the value 0 or 100, the clustering was repeated using only the five collegial, multi-member bodies. The two solutions were compared using the Adjusted Rand Index to assess how much the cluster structure depends on the single-occupant variables.

4. RESULTS

4.1 National Trends

Table 1 reports the national average percentage of women in each governance body for 2023 and 2024. The Rector's office showed the lowest female representation of anybody in both years, rising from 13.4% to 18.2%. The Equal Opportunity Committee was the only body with a female majority in either year, at 62.8% in 2023 and 62.4% in 2024. The remaining bodies clustered between roughly a quarter and two-fifths female representation.

Governance body	2023 (% women)	2024 (% women)
Rector	13.4	18.2
Vice-Rector	32.4	34.5
Director General	25.8	27.6
Academic Senate	37.4	36.4
Board of Directors	31.2	33.3
Board of Auditors	41.2	41.2
Evaluation Unit	40.5	40.9
Equal Opportunity Committee	62.8	62.4

Table 1. National average share of women per governance body 2023 & 2024

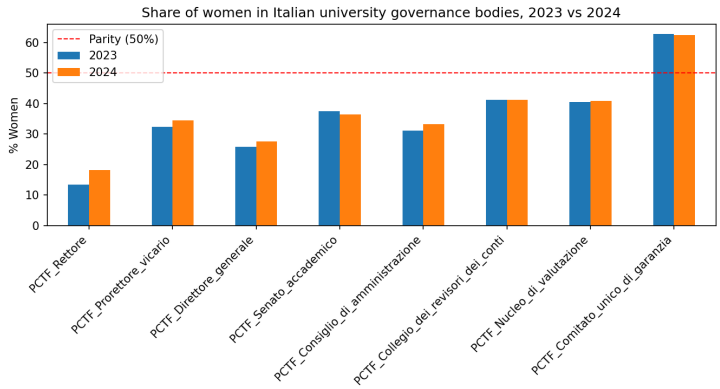

Figure 1. Share of women in Italian university governance bodies 2023 versus 2024

This pattern is consistent with the leadership-specific gap documented by Kohtamäki (2024) and with the leaky pipeline framing proposed by Speer (2023). Representation is comparatively strong in the body explicitly mandated to address gender and equal opportunity issues as compared to the office that concentrates the most institutional authority. This divergence fits the decoupling concern raised by Meyer and Rowan (1977) between formally mandated structures and substantive organisational change.

4.2 Regional and Institutional Type Variation

Table 2 shows the composite Governance Gender Balance Index by geographic macro area for 2024. Universities in the North-West of Italy show the highest average index at 41.2. While the universities in the Islands show the lowest at 30.4. A one-way analysis of variance across the five macro areas did not reach conventional statistical significance, F (4, 95) = 1.97, p = .106, so this regional pattern should be treated as descriptive rather than confirmed.

Macro-area	Mean index	Std. dev.	N
Centro	34.45	13.33	34
Isole	30.42	9.43	6
Nord-Est	38.95	9.57	13
Nord-Ovest	41.20	11.39	21
Sud	33.80	10.91	26

Table 2. Governance Gender Balance Index by macro-area 2024

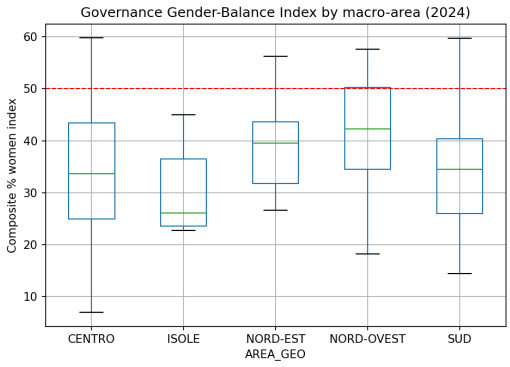

Figure 2. Governance Gender Balance Index by macro-area, 2024

Table 3 compares state and non-state universities. State universities show a higher average index, 37.69, than non-state universities, 32.36. An independent samples t-test approached but did not clear the conventional significance threshold, t (56.8) = 1.91, p = .062.

University type	Mean index	Std. dev.	N
Non statale (private)	32.36	13.83	31
Statale (public)	37.69	10.65	69

Table 3. Governance Gender Balance Index by university type 2024

4.3 The Rector Variable and the Risk of a Mechanical Association

An initial comparison of the composite index by Rector gender revealed a substantial difference. Universities led by a woman recorded a higher mean composite index (M = 44.5, SD = 9.67, n = 18) than those headed by men (M = 34.2, SD = 11.61, n = 82). This difference was statistically significant based on an independent-samples t-test, t (28.9) = 3.93, p < .001, with a mean difference of 10.26 percentage points (95% CI [4.91, 15.61]). The magnitude of difference was also considerable, with a large effect size (Cohen's d = 0.91; Cohen, 1988). This result would suggest that placing a woman in the Rector's office is associated with better gender balance across the institution. However, this interpretation requires caution because the composite index incorporates the Rector's own gender as one of its eight components, with the Rector variable coded as 100% for a female rector and 0% for a male rector. As the outcome variable already contains the predictor, the observed difference is guaranteed by construction rather than reflecting any relationship between rectorship and the other seven governance bodies. This kind of circularity is a recognised risk in composite indicator design (Nardo et al., 2005). It means the original comparison alone cannot be read as evidence that a female Rector predicts broader institutional balance. To address this, a second index was built using only the seven remaining governance bodies by excluding the Rector. Universities led by a woman showed a mean non-Rector index (M = 35.6, SD = 12.33) and the male leader's university showed a mean (M = 39.2, SD = 13.25). This difference was not statistically significant, t (26.4) = -1.11, p = .279, mean difference -3.6 percentage points, 95% CI [-10.28, 3.08]. The corresponding effect size was small (Cohen's d = -0.27), indicating a modest difference in the opposite direction to that observed in the original composite index.

Table 4. Composite index by Rector gender, original versus non-Rector index 2024

Comparison	Female-led mean	Male-led mean	Mean diff.	95% CI	t	p	Cohen's d
Original index (8 bodies)	44.5	34.2	10.26	[4.91, 15.61]	3.93	<.001	0.91
Non-Rector index (7 bodies)	35.6	39.2	-3.60	[-10.28, 3.08]	-1.11	.279	-0.27

This result is presented transparently because it is central to the methodological interpretation of the study. Once the Rector variable is excluded from the outcome measure, the analysis provides no statistically significant evidence of a relationship between Rector gender and the gender balance of the remaining governance structures. However, the difference is not statistically significant; its negative direction contrasts with the pattern observed in the original composite index. This is an important methodological point. When a leadership characteristic is included directly in the measure used to assess broader institutional outcomes, the observed relationship may partly reflect how the index is constructed rather than a substantive connection. This finding therefore underscores the need for caution when designing accountability and certification measures, especially when leadership indicators are combined with the organisational structures that they are intended to represent (Nardo et al., 2005).

4.4 Institutional Governance Profiles

The corrected comparison in Section 4.3 shows no significant, non-circular relationship between Rector gender and the balance of the remaining governance structure on average. This does not mean Rector gender is unrelated to institutional patterns altogether, only that a simple two-group mean comparison on a circular index cannot detect such a relationship.

To explore this pattern further, an unsupervised k-means analysis was conducted using the complete profiles of the universities without defining the groups according to the rector gender in advance. Solutions with k = 2 to k = 6 were evaluated using the within-cluster sum of squares and the silhouette coefficient (Rousseeuw, 1987). The resulting silhouette scores were relatively low and closely clustered, ranging from 0.123 to 0.142. This suggests that, although some structure is present in the data, the clusters are not sharply separated. Such a pattern is not unexpected in social and administrative data, where institutional characteristics often vary continuously, and groups may overlap substantially. The elbow criterion, together with the marginal advantage in silhouette score and the interpretability of the resulting groups, supported retaining a three-cluster solution, though this should be read as a useful description of the data rather than a definitive typology, a caveat examined further in Section 4.5.

Governance body	Cluster 0	Cluster 1	Cluster 2
Rector	30.0	13.6	12.0
Vice-Rector	18.2	37.5	44.6
Director General	6.9	0.0	100.0
Academic Senate	35.4	37.0	36.4
Board of Directors	21.3	39.7	36.4
Board of Auditors	12.9	53.4	53.1
Evaluation Unit	50.7	35.3	39.4
Equal Opportunity Committee	72.5	59.0	58.9
Composite index	29.6	34.1	47.4
Number of universities	30	45	25

Table 5. Mean share of women per governance body by cluster 2024 (K-means, k = 3, silhouette = 0.142)

Cluster 0, with 30 universities, combines an above-average female rectorship (30.0%) with the lowest female representation on the Board of Directors (21.3%) and one of the lowest shares of female Directors General (6.9%). Cluster 2, with 25 universities, shows the reverse pattern. The lowest average female rectorship (12.0%) alongside the highest composite index of any cluster (47.4), driven by near-universal female representation in the Director General role and comparatively strong representation on the Board of Directors and Board of Auditors. This divergence is compatible with the token representation mechanism described in the organisational literature (Kanter, 1977; Torchia et al., 2011), and with recent evidence that mandated female board representation does not automatically extend to the committees that hold operational power (Duran et al., 2026). The data used here could not measure decision-making influence, participation, or informal power directly. Thus, this interpretation should be understood as a descriptive pattern, offered through the lens of the token representation literature, rather than a confirmed causal mechanism.

4.5 Sensitivity of the Cluster Solution to Single-Occupant Offices

Three of the eight governance bodies, Rector, Vice-Rector, and Director General, are single-occupant positions, recorded as either 0% or 100% female. Because the clustering variables were standardised before analysis, a single individual's gender in these positions can exert a disproportionate influence on the distances that determine cluster membership. To test the robustness of the three-cluster solution to this feature of the data, the K-means analysis was repeated using only the five collegial, multi-member bodies: Academic Senate, Board of Directors, Board of Auditors, Evaluation Unit, and Equal Opportunity Committee.

Specification	Best silhouette (k)	Agreement with full model (ARI)
Model A: all 8 bodies (k = 3)	0.142 (k = 3)	reference
Model B: 5 collegial bodies only (k = 3)	0.204 (k = 2); 0.175 (k = 3)	0.38

Table 6. Cluster sensitivity analysis of full model versus collegial-bodies-only model 2024

When the analysis was restricted to the collegial governance bodies, the highest silhouette score was obtained with k = 2 rather than k = 3. Moreover, the three-cluster solution showed only moderate agreement with the original eight-variable clustering, with an Adjusted Rand Index (ARI) of 0.38, where a value of 1 indicates identical cluster assignments and a value close to 0 indicates agreement no better than expected by chance. This suggests that the single-occupant positions, particularly the Rector position, contribute meaningfully to the structure identified in the full model. According to the typology presented in Section 4.4 should be understood as one useful lens on the 2024 data, rather than a definite or stable classification of Italian universities. Additional years of data, once available, would allow a more definitive test of how stable these institutional profiles are over time.

4.6 Top and Bottom Performing Institutions

Table 7 lists the universities with the highest and lowest composite index values in 2024. The highest performing institutions include large public universities, while the lowest performing institutions include several private and online universities. As noted in Section 4.2, the state versus non-state difference was not statistically significant at the conventional threshold in this sample.

Top universities	Index	Bottom universities	Index
Roma La Sapienza	59.85	Vita-Salute San Raffaele	18.25
Reggio Calabria per Stranieri	59.66	Chieti-Pescara D'Annunzio	18.16
Aosta	57.58	Napoli telematica Pegaso	17.34
Milano IULM	57.14	Benevento Giustino Fortunato	14.40
Bologna	56.22	Roma Link Campus	13.20
Pisa Scuola Sant'Anna	55.95	Roma CASD	7.05
Siena	55.70	Firenze Italian University Line	6.94

Table 7. Highest and lowest ranked universities by Governance Gender Balance Index 2024

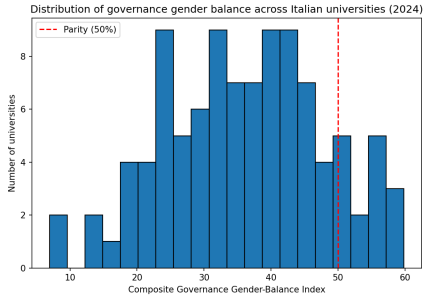

Figure 3. Distribution of the Governance Gender Balance Index across Italian universities 2024

5. DISCUSSION

The results reveal two interrelated but distinct issues in how university accountability for sustainability and inclusion is currently assessed. The first is methodological. As demonstrated in section 4.3, a composite index which includes a leadership variable can produce an apparent association when that same leadership variable is subsequently used to explain the index. This is precisely the circularity risk flagged in the composite indicator literature (Nardo et al., 2005). It means that accountability frameworks built on similarly constructed indices, for example a Gender Equality Plan score that treats the presence of a female leader as one of its own success criteria. It should be read with the same caution applied here. The second issue is substantive. It survives the methodological correction. The cluster analysis in Section 4.4 explained that Italian universities do not vary along a single dimension of gender balance. Some combine visible female leadership with weak representation in the bodies, while others show the reverse pattern. A reporting framework that focuses only on whether a university has a female leader would classify these two groups as similarly successful or unsuccessful on gender grounds.

Yet, the underlying patterns of representation may be substantially different. This supports Moggi's (2023) argument that sustainability reporting frameworks designed for the corporate sector fit poorly with the distributed governance architecture of universities. It also reflects the broader decoupling concern raised by Meyer and Rowan (1977) about formal structures that satisfy external legitimacy demands without changing underlying practice. The token representation literature (Kanter, 1977; Torchia et al., 2011) and the recent committee-level evidence from Duran et al. (2026) offer one plausible interpretation of the pattern observed in Cluster 0, where a female Rector alongside weak representation in the Board of Directors and Director General roles. This should be declaimed as a compatible interpretation instead of a demonstrated mechanism. The administrative data used here cannot observe influence, participation, or informal power directly. The sensitivity analysis in Section 4.5 provides a further qualification. Since the three-cluster typology is only moderately stable once single-occupant offices are set excluded (ARI = 0.38), the typology should be treated as a description of the 2024 data as opposed to a settled classification of Italian universities. The weak and statistically non-significant relationship reported for the non-Rector index in Section 4.3. It is also consistent with the leaky pipeline literature (Speer, 2023). This literature points to cumulative and institution-specific career barriers as a source of gender inequality in place of a single leader's identity. If governance balance were mainly a function of who sits in the Rector's office, a strong non-Rector effect would be expected. The absence of such associations suggests that the composition of the remaining seven bodies is shaped by separate institutional procedures, including internal statute design, appointment procedures, and faculty pipelines that a single leadership indicator cannot capture. Finally, the connection to gender medicine introduced in Section 2.4 deserves a brief return here. Regitz-Zagrosek and Gebhard (2023) show that failing to systematically account for sex and gender differences in clinical research and treatment can lead to poorer and less personalised health outcomes. Universities with medical schools and affiliated hospitals convene at the institutional root of this problem. It is their faculty, curricula, and research priorities that shape whether gender sensitive medicine is taught and practised downstream. A governance structure that achieves gender balance primarily at the level of symbolic representation, as Cluster 0 may suggest, is less likely to sustain the institutional commitment that embedding gender medicine into curricula and research programmes requires. This is one of the reasons for a carefully constructed, multidimensional accountability index, built to avoid the circularity identified in Section 4.3. It may be more useful to policymakers and certification bodies than a single leadership indicator.

6. CONCLUSION AND IMPLICATIONS

This study examined whether the gender of a university's Rector, as the most visible governance position, can serve as a reliable indicator of gender balance across the university's broader governance structure. Using open administrative data on Italian universities for 2023 and 2024, an initial analysis suggested a strong and significant association. But this association was found to be partly an artefact of a composite index that included the Rector's own gender as one of its components. After excluding the rector from the index, the association was not statistically significant. Moreover, the estimated difference shifted slightly in the opposite direction. The cluster analysis of the full governance structure nonetheless identified a group of universities combining a female Rector with continued imbalance in the Board of Directors and the Director General's office. This pattern is compatible with the token representation mechanism described in the literature. However, this typology proved only moderately stable once single-occupant offices were excluded from the clustering variables. These findings have direct implications for the design of accountability and certification models for university sustainability. A multidimensional composite index that avoids double counting leadership variables of the kind tested here offers a more complete and more methodologically defensible alternative.

At the same time, the moderate stability of the cluster typology suggests such indices should be presented with appropriate caution about their precision. This study also highlights several directions for future research. The data used cover only two academic years, which limits the ability to assess longer-term trends that a full historical series would allow. It also permits the cluster stability question raised in Section 4.5 to be tested directly despite a single cross-sectional sensitivity check. More detailed institution-level data would also help explain the sources of the variation observed across universities. Information on the gender composition of academic staff could provide greater insight into the processes underlying institutional differences. Future research will extend this analysis to academic staff data disaggregated by scientific field, with particular attention to medical and health science disciplines. This would allow the governance findings to be linked more directly to the broader gender-medicine and personalised-care agenda underlying the research programme.

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MAPPING THE STAKEHOLDER ECOSYSTEM OF EUROPEAN OUTDOOR HOSPITALITY: A DESK RESEARCH ANALYSIS

Josipa Cvelic Bonifacic
Faculty of Tourism and Hospitality Management, University of Rijeka
Primorska 42, p.p. 97, 51410 Opatija, Croatia
josipa.bonifacic@gmail.com

ABSTRACT

The European outdoor hospitality sector — encompassing campsites, glamping sites, holiday parks and related mobile accommodation formats — has developed into an increasingly diversified and professionalised segment of the hospitality industry. Despite its growing commercial and structural importance, the stakeholder landscape underpinning the sector remains insufficiently systematised in academic research. This paper aims to identify, categorise and analyse the principal stakeholder groups shaping the European outdoor hospitality ecosystem and to examine the structural relationships and patterns emerging across them. The study adopts an exploratory desk research approach based on qualitative analysis of a broad corpus of publicly accessible secondary sources, including institutional publications, organisational documentation, industry reports, trade press and market analyses. Drawing on stakeholder theory and the business ecosystem perspective, the analysis identifies seven interrelated stakeholder groups: business associations; consumer organisations and clubs; automobile and touring clubs; manufacturers and suppliers; tour operators and online platforms; publishing and media organisations; and camping brands and chains. The findings reveal a sector characterised by persistent fragmentation at the level of national representation alongside increasing forms of structural integration. Three forms of integration are particularly visible: institutional integration among previously separate organisations, ownership consolidation through mergers and acquisitions, and network or brand integration through shared standards, positioning and market visibility. The analysis also highlights the growing importance of digital platforms, classification systems, and quality and sustainability signalling mechanisms. The proposed stakeholder mapping provides destination managers, campsite operators, policymakers and researchers with a structured framework for understanding the relationships and sources of influence shaping the European outdoor hospitality ecosystem.

Keywords*: camping; ecosystem; Europe; outdoor hospitality; stakeholder*

1. INTRODUCTION

The European outdoor hospitality sector — encompassing campsites, glamping sites, holiday parks and related mobile accommodation formats — has developed from a traditionally seasonal and predominantly campsite-based form of tourism into an increasingly diversified and professionalised segment of the hospitality industry. Recent market analyses indicate substantial economic activity and continued development across several segments associated with outdoor hospitality, including recreational vehicles and glamping (Mordor Intelligence, 2026; Fortune Business Insights, 2026). Yet the economic and operational development of the sector has not been accompanied by an equally systematic understanding of the institutional and organisational architecture surrounding it. A dense network of business associations, consumer organisations, automobile clubs, manufacturers, suppliers, distribution intermediaries, publishers, classification bodies and branded chains contributes to how outdoor hospitality is produced, marketed, classified, distributed and consumed across Europe.

Existing knowledge about this landscape remains fragmented across organisational websites, industry publications and individual market reports rather than being systematised within a coherent analytical framework. This represents a relevant research gap. Understanding who the principal stakeholders are, what functions they perform, and how they interact is a necessary precondition for analysing sector governance, market development, destination competitiveness, sustainability transitions and quality assurance in outdoor hospitality. Contemporary tourism research increasingly conceptualises tourism organisations as embedded in complex ecosystems consisting of heterogeneous and interdependent actors rather than operating in isolation (Hillebrand, 2022). Accordingly, the study addresses the following research question:

Which stakeholder groups constitute the European outdoor hospitality ecosystem, what functions do they perform, and what structural relationships and patterns of integration and consolidation can be identified across these groups?

The purpose of this paper is therefore to identify, categorise and analyse the principal stakeholder groups constituting the European outdoor hospitality ecosystem and to examine the structural relationships and dynamics emerging across them, with particular attention to institutional integration, digitalisation, quality signalling and consolidation. The remainder of the paper is structured as follows. Section 2 introduces the theoretical framework, situating the study within stakeholder theory and the business ecosystem perspective. Section 3 describes the desk research methodology. Section 4 presents the findings, organised into seven stakeholder groups. Section 5 discusses the cross-cutting patterns identified through the mapping, while Section 6 concludes with practical implications, limitations and directions for future research.

2. THEORETICAL FRAMEWORK

2.1 Stakeholder Theory in Tourism and Hospitality

Stakeholder theory, as originally formulated by Freeman (1984), defines a stakeholder as any group or individual that can affect, or is affected by, the achievement of an organisation's objectives. Although developed within strategic management, the framework has been widely applied to tourism and hospitality, where the fragmented and multi-actor nature of destination and sector governance makes stakeholder identification particularly important (Sautter & Leisen, 1999). Mitchell, Agle and Wood (1997) subsequently refined stakeholder analysis by proposing that stakeholder salience — the degree of priority given to competing stakeholder claims — depends on three attributes: power, legitimacy and urgency. This framework is useful for interpreting outdoor hospitality because stakeholder groups differ substantially in the resources and mechanisms through which they can influence sector outcomes. Automobile clubs, digital platforms and large ownership groups may exercise substantial market influence, while national associations may derive their influence primarily from representation and legitimacy. Rowley (1997) extended the organisation-centred perspective of stakeholder influence into a network perspective, arguing that stakeholder influence is shaped not only by the attributes of individual actors but also by their structural position and the pattern of relationships surrounding them. This perspective is particularly relevant to outdoor hospitality, where influence extends beyond individual campsite–stakeholder relationships and operates through interconnected networks of associations, classification bodies, manufacturers, intermediaries, platforms and commercial operators. Tourism-specific research has further demonstrated the importance of identifying and coordinating heterogeneous stakeholder groups in sustainable tourism development (Byrd, 2007; Waligo, Clarke & Hawkins, 2013). More recent work has also highlighted the value of network perspectives for understanding tourism development and stakeholder interaction (Nguyen et al., 2019).

2.2 The Business Ecosystem Perspective

A complementary perspective is provided by Moore's (1993) concept of the business ecosystem, which conceptualises industries as communities of co-evolving organisations whose capabilities and fortunes are interdependent. Rather than viewing competition as occurring exclusively between firms within a defined industry boundary, the ecosystem perspective draws attention to suppliers, distributors, competitors, intermediaries and other actors whose activities collectively shape market outcomes. Applied to outdoor hospitality, this perspective highlights that campsites and holiday parks operate within a considerably wider ecosystem of manufacturers, consumer organisations, classification bodies, publishers, digital platforms, tour operators and multi-site ownership groups. These actors influence quality signalling, market visibility, consumer access, distribution and trust. Recent tourism research similarly argues that tourism organisations should be understood as embedded within complex and dynamic ecosystems of interdependent actors and that ecosystem mapping can represent an important analytical and managerial capability (Hillebrand, 2022). Combining the stakeholder and business ecosystem perspectives, the present study conceptualises European outdoor hospitality as a stakeholder ecosystem: a functionally differentiated but interdependent set of organisations whose individual and collective actions shape sector outcomes. The study does not attempt to measure the complete social network of European outdoor hospitality. Rather, stakeholder mapping is used as an exploratory analytical instrument that can provide a basis for future empirical network analysis.

3. METHODOLOGY

This study adopts an exploratory desk research design based on the qualitative analysis of secondary sources. The approach was selected because the European outdoor hospitality sector is characterised by a highly fragmented organisational structure and the absence of a single comprehensive directory of sector stakeholders. The study therefore focuses on identifying and systematising organisations that perform relevant commercial, representative, informational, intermediary or standard-setting functions within the sector. Data collection was conducted during 2025 and 2026 and drew on a broad corpus of publicly accessible sources, including institutional and organisational websites, corporate and organisational reports, industry publications, trade-press articles, press releases and market reports. Where available, primary organisational sources were prioritised for factual information concerning organisational membership, ownership, geographical scope, acquisitions, partnerships and service portfolios. Secondary industry sources were used primarily to complement or contextualise information not readily available from primary sources. Source identification proceeded iteratively. The initial search was structured around seven functional stakeholder categories identified in the preliminary conceptual framework. Additional organisations and relationships were subsequently identified through a snowballing procedure, whereby information published by one organisation was used to identify affiliated, competing, partnering or otherwise relevant organisations. An organisation was included when its activities demonstrated a direct and identifiable role in the production, representation, distribution, classification, communication or consumption of outdoor hospitality services. The collected material was subjected to qualitative thematic categorisation. Organisations were assigned to the stakeholder group corresponding to their primary function: representing business interests; representing consumer interests; providing mobility-related services; manufacturing or supplying products; intermediating accommodation or travel sales; producing sector information and media content; or operating, branding or coordinating multiple accommodation properties. Where an organisation performed several functions, classification was based on the function most directly associated with its role in the outdoor hospitality ecosystem.

The analysis subsequently examined relationships and recurring patterns across the seven stakeholder groups, with particular attention to cross-border integration, mergers and acquisitions, digital platforms, classification systems, and quality and sustainability signalling mechanisms. The study is exploratory and interpretive rather than statistically representative. The research corpus constitutes the basis for analytical mapping rather than a statistically defined sample. Consequently, the resulting stakeholder map should be understood as a structured analytical representation of the sector rather than an exhaustive census of all European outdoor hospitality organisations. The geographical scope is deliberately limited to Europe. Within Europe, the mapping inevitably privileges organisations with an accessible digital presence; smaller organisations and actors operating primarily through domestic-language channels may therefore be under-represented. In addition, given the pace of structural change in the sector, organisational configurations should be understood as reflecting the 2025–2026 research period rather than as permanently stable arrangements.

4. FINDINGS: THE STAKEHOLDER ECOSYSTEM OF EUROPEAN OUTDOOR HOSPITALITY

The desk research identified seven principal, functionally distinct but interdependent stakeholder groups operating within the European outdoor hospitality ecosystem:

1. Camping business associations
2. Consumer organisations and clubs
3. Automobile and touring clubs
4. Manufacturers and suppliers
5. Tour operators and online platforms
6. Publishing and media organisations
7. Camping brands, quality networks and chains

4.1 Camping Business Associations

Camping business associations represent the commercial interests of campsite and holiday-park operators at national and European levels. Their activities typically include policy advocacy, representation before public authorities, information and advice to members, professional networking, and support in legal, technical and marketing matters. At European level, the European Federation of Campsite Organisations & Holiday Park Associations (EFCO&HPA) acts as an umbrella organisation representing the interests of the campsite, holiday and caravan-park industry. Its membership comprises national trade associations from 23 European countries (EFCO&HPA, n.d.). At national level, independent associations represent campsite operators within their respective markets, creating a multi-level structure in which national representation is complemented by European-level coordination. The Croatian Camping Union represents Croatian camping interests nationally and internationally and provides an example of how national associations remain important institutional actors even as parts of the commercial ecosystem become increasingly internationalised.

4.2 Consumer Organisations and Clubs

Consumer organisations and clubs represent the interests of campers, caravanners and motor-caravanners and provide services including advocacy, information, membership benefits and international networking. The Fédération Internationale de Camping, Caravanning et Autocaravanning (F.I.C.C.), founded in 1933 by 16 clubs from seven countries, currently brings together 69 federations and clubs from 35 countries (FICC, n.d.). The Camping Card International (CCI), associated with the FICC system, provides a consumer-facing mechanism combining camper identification, campsite discounts and liability insurance.

A related but distinct organisation, the International Naturist Federation (INF-FNI), represents the interests of naturist recreation. Its inclusion demonstrates that consumer representation within outdoor hospitality is not homogeneous but includes specialised recreational communities with distinct needs.

4.3 Automobile and Touring Clubs

Automobile and touring clubs constitute a distinctive stakeholder group whose traditional focus on mobility has expanded into camping-related information, classification, booking and digital services. The Allgemeiner Deutscher Automobil-Club (ADAC), with 22.7 million members in 2025, is Germany's largest automobile club and one of Europe's most influential mobility organisations (ADAC, 2025). Through PiNCAMP, ADAC is active in campsite classification, digital information and booking services. A particularly significant development occurred in January 2024, when ADAC, ANWB and TCS consolidated their existing camping activities within PiNCAMP GmbH. The three organisations became shareholders of the joint company, with ADAC holding 52.5%, ANWB 42% and TCS 5.5% (PiNCAMP, n.d.). This represents an important example of cross-border institutional integration, connecting traditionally national mobility and consumer organisations through shared digital and classification infrastructure. ADAC's camping information system also illustrates the scale of information infrastructure in this stakeholder group. The ADAC Campingführer 2026 covers more than 5,500 campsites in 35 countries, while the wider PiNCAMP platform covers a substantially broader international inventory (PiNCAMP, n.d.).

4.4 Manufacturers and Suppliers

Manufacturers and suppliers provide the physical products and infrastructure underpinning substantial parts of the outdoor hospitality ecosystem, including touring caravans, motorhomes, mobile homes, glamping accommodation and camping equipment. The European Caravan Federation (ECF) acts as an umbrella organisation for 17 national caravanning federations and represents organisations involved in the production, sale and use of leisure vehicles and mobile homes, as well as specialist components and services (European Caravan Federation, n.d.). The Caravaning Industrie Verband (CIVD) provides further industry-level representation within the European recreational vehicle market. Beyond leisure vehicles and mobile homes, the supplier ecosystem encompasses manufacturers of tents, awnings, glamping structures, sanitary equipment, energy systems, outdoor furniture and other specialised products. This broad supplier base demonstrates that outdoor hospitality is embedded in a wider industrial ecosystem extending beyond accommodation providers themselves.

4.5 Tour Operators and Online Platforms

Tour operators and online platforms represent the distribution layer of the outdoor hospitality ecosystem. Their roles, however, differ substantially. Traditional camping tour operators may contract accommodation capacity and place mobile-home units on partner campsites, thereby participating directly in the design and distribution of the holiday product. Specialised digital platforms primarily provide search, information and booking intermediation. A further development is the increasing presence of generalist online travel agencies and accommodation platforms, including Booking.com and Airbnb, within outdoor accommodation markets. Their inclusion connects campsites, glamping accommodation and mobile homes with broader accommodation inventories and illustrates the increasing interaction between outdoor hospitality and the wider platform economy. From an ecosystem perspective, the importance of these platforms lies not only in their role as distribution channels but also in their potential influence over information flows, consumer access, visibility and market relationships.

4.6 Publishing and Media Organisations

Publishing and media organisations have historically played an important role in reducing uncertainty for consumers in camping markets. Before the emergence of digital platforms, printed campsite guides represented one of the principal mechanisms through which campers discovered destinations, compared facilities and assessed quality. Today, this function is increasingly combined with digital content, websites, apps and other consumer-facing information services. Automobile clubs developed particularly influential guidebooks. ADAC publishes the ADAC Campingführer, while ANWB publishes its own Erkende Campings guide, which presents information on more than 4,200 European campsites assessed by ANWB inspectors (ADAC, 2025; ANWB, n.d.). The inclusion of both organisations illustrates how major mobility and consumer organisations have historically combined classification, publishing and information functions within the camping ecosystem. Alongside these club-based publishers, independent specialist publishers have also shaped the European camping information market. Alan Rogers has traditionally positioned its campsite guides around independent inspection and editorial assessment. A particularly important independent camping specialist is ACSI, which has published camping guides since 1965. ACSI describes itself as a European camping specialist and publishes printed campsite guides based on annual inspections; its current European guide covers 7,505 campsites in 31 countries (ACSI, n.d.). Although ACSI has subsequently expanded into websites, apps and other camping services, its publishing and inspection activities remain an important information and signalling mechanism within the ecosystem.

4.7 Camping Brands, Quality Networks and Chains

The final and currently most dynamic stakeholder category comprises camping brands, quality networks and multi-site ownership groups. These organisations differ in governance and ownership structures but share the function of creating common standards, market visibility, positioning or consumer recognition across multiple properties. Quality and concept networks include LeadingCampings of Europe, which currently brings together approximately 48 campsites in 10 European countries (LeadingCampings, n.d.). Sustainability-oriented networks such as ECOCAMPING perform a related signalling function by promoting environmental management and sustainability among participating campsites. Such networks do not necessarily imply common ownership; rather, they create shared quality, sustainability or positioning frameworks across independently operated properties. Ownership-based and branded chains represent a different form of integration. Yelloh! Village illustrates a branded network model that combines a common identity and standards with independently operated participating properties. The network currently comprises around 100 campsites across several European markets (Yelloh! Village, n.d.). In Scandinavia, First Camp's acquisition of Svenska Campingpärlor in 2021 brought together two major camping portfolios and represented an important step in the consolidation of the regional camping market (First Camp Group, 2021).
A further dimension is visible in pan-European ownership groups. European Camping Group acquired VacanceSelect in 2023 and Alannia in 2025, illustrating a strategy of sequential cross-border expansion through acquisitions (European Camping Group, n.d.; PAI Partners, 2023). Roompot's acquisition of Landal GreenParks in 2023 represents another major example of ownership consolidation within European holiday accommodation. The transaction created a combined organisation operating hundreds of holiday destinations across Europe (Roompot, 2023). In Croatia, Valamar and Maistra illustrate the integration of camping within diversified hospitality groups. Both companies operate dedicated camping portfolios as components of broader tourism and hospitality businesses. Their development demonstrates how camping can become an integrated component of destination and hospitality portfolios rather than a stand-alone accommodation business.

Stakeholder group	Primary function	Representative organisations	Geographic scope
Camping business associations	Representation of campsite and holiday-park operators; advocacy and member services	EFCO&HPA; Croatian Camping Union	European and national
Consumer organisations and clubs	Camper representation, information, membership and consumer services	FICC; Camping Card International; INF-FNI	International and national
Automobile and touring clubs	Mobility services, campsite classification, information and booking	ADAC/PiNCAMP; ANWB; TCS	National and increasingly integrated
Manufacturers and suppliers	Leisure vehicles, mobile homes, glamping structures and camping equipment	ECF; CIVD	European and national
Tour operators and online platforms	Distribution, booking and packaging of camping holidays	Specialised camping operators; Booking.com; Airbnb	European and global
Publishing and media organisations	Guides, information, inspection and destination discovery	ADAC; ANWB; Alan Rogers; ACSI	National and European
Camping brands, quality networks and chains	Shared branding, quality, sustainability or multi-site ownership	LeadingCampings; ECOCAMPING; Yelloh! Village; First Camp; ECG	National to pan-European

Table 1. Stakeholder Groups

5. DISCUSSION

5.1 Consolidation and Integration

Read across the seven stakeholder groups mapped in Section 4, a recurring pattern of consolidation becomes visible across several parts of the European outdoor hospitality ecosystem. This consolidation takes different forms, including institutional integration, mergers and acquisitions, cross-border expansion and the development of shared digital and classification infrastructures. The evidence suggests that consolidation should not be understood exclusively as ownership concentration. Three partially overlapping forms can be distinguished. First, institutional integration occurs when previously independent organisations consolidate activities within shared infrastructures. The establishment of PiNCAMP GmbH by ADAC, ANWB and TCS provides a particularly clear example. Second, ownership consolidation occurs through mergers and acquisitions. Examples include Roompot's acquisition of Landal GreenParks, First Camp's acquisition of Svenska Campingpärlor, and European Camping Group's successive acquisitions of VacanceSelect and Alannia. Third, network and brand integration occurs without necessarily involving common ownership. LeadingCampings, ECOCAMPING and branded networks such as Yelloh! Village illustrate how common standards, sustainability frameworks, identity and positioning can create integration among independently or differently owned properties. This distinction is analytically important because it demonstrates that structural integration in outdoor hospitality operates through both capital and coordination mechanisms. Some organisations increase their influence by acquiring or integrating physical assets, while others do so by controlling information, classification, distribution, branding or sustainability standards.

5.2 National Representation versus International Infrastructure

At the same time, the mapping reveals persistent fragmentation at the level of national business and consumer representation. National associations remain largely independent and domestically governed, while international integration is more visible in digital platforms, classification systems, ownership structures and commercial distribution.

The ecosystem therefore exhibits a dual structure: representation remains predominantly national, whereas several market-facing and infrastructure-related functions are becoming increasingly internationalised. This distinction is important for understanding stakeholder influence. National associations may possess strong legitimacy because they directly represent domestic members, even where their financial or market power is limited. By contrast, large platforms, international ownership groups and integrated classification systems can exercise substantial market influence because they connect large numbers of consumers, properties and commercial actors.

5.3 Stakeholder Power, Legitimacy and Salience

Mitchell, Agle and Wood's (1997) stakeholder salience framework provides a useful interpretive lens for this differentiation. However, because the present study does not measure stakeholder perceptions empirically, the classification presented below should not be interpreted as a validated ranking. The classification represents an analytical proposition derived from the functions, resources and market positions documented through the desk research. Its purpose is to structure future empirical investigation.

** The term "Dangerous" follows Mitchell et al.'s (1997) stakeholder typology and is not a normative judgement about the organisations concerned.*

Stakeholder group	Power	Legitimacy	Urgency	Indicative salience
Camping business associations	Moderate	High	Moderate	Dominant
Consumer organisations & clubs	Low–Moderate	High	Low	Discretionary
Automobile & touring clubs	High	High	Moderate–High	Definitive
Manufacturers & suppliers	Moderate–High	Moderate	Low	Dominant
Specialised tour operators & booking platforms	High	Moderate–High	Moderate	Dominant
Generalist OTAs/platforms	High	Moderate–Low	Moderate	Dangerous*
Publishing & media organisations	Low–Moderate	High	Low	Discretionary
Camping brands & chains	High	Moderate	High	Definitive

Table 2 presents an interpretive stakeholder salience mapping based on the functions, resources and market positions identified through the desk research. It is an analytical proposition rather than a validated measurement or definitive ranking.

6. CONCLUSION

This study has mapped the principal stakeholder groups constituting the European outdoor hospitality ecosystem and examined the structural patterns emerging across them through an exploratory desk research approach grounded in stakeholder theory and the business ecosystem perspective. Seven functionally distinct but interdependent stakeholder groups were identified: business associations; consumer organisations and clubs; automobile and touring clubs; manufacturers and suppliers; tour operators and online platforms; publishing and media organisations; and camping brands, quality networks and chains. The analysis indicates that the European outdoor hospitality ecosystem combines persistent fragmentation with increasing forms of structural integration. Three forms of integration are particularly visible: institutional integration among previously separate organisations, ownership consolidation through mergers and acquisitions, and network or brand integration through shared standards and positioning. At the same time, national representation remains largely fragmented, producing a distinctive structural tension between nationally organised stakeholder representation and increasingly internationalised commercial, digital and classification infrastructures.

The analysis further suggests that stakeholder influence is increasingly shaped not only by ownership or organisational size but also by control over information, classification, distribution, consumer access and quality or sustainability signalling. This highlights the value of viewing outdoor hospitality as an ecosystem rather than solely as a collection of accommodation providers. For destination managers, campsite operators and policymakers, the stakeholder map provides a structured framework for identifying relevant partners, intermediaries and sources of market influence. For researchers, it provides a basis for further investigation of stakeholder governance, cross-border integration, digitalisation and sustainability in European outdoor hospitality. The study is exploratory and subject to the limitations of desk research. The analysis relies primarily on publicly available secondary sources and therefore cannot establish stakeholders' own perceptions of power, legitimacy or urgency. Nor does the mapping constitute a complete census of all European organisations. Future research should therefore combine the present mapping with stakeholder interviews, surveys and quantitative social network analysis. Longitudinal research would also be valuable for examining whether the consolidation patterns identified here represent a persistent structural transformation or a temporary phase of market development.

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THE IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ON THE DESTINATION MANAGEMENT ORGANIZATION (DMO)

Lidija Galic
University of Mostar, Mostar, Bosnia and Herzegovina
lidija.galic@ef.sum.ba

ABSTRACT

We live in a new modern world where neither work nor private life is possible without Information and communication technology (ICT). Bosnia and Herzegovina is just one of the countries that are trying to turn this to its advantage when it comes to the tourism sector. Critics will agree that Bosnia and Herzegovina has something to offer as a destination, but does not know how to take advantage of it. The biggest blame for this is shifted to the insufficient development of destination management. This paper deals precisely with what is the impact of Information and communication technology (ICT) on the destination management organization (DMO) and whether there is one. This finding can be useful to destination management organizations and their managers when attempting to understand the influence of Information and communication technology on destination management but also all stakeholders of destination management organizations or the tourism industry. Primary data has been collected through a questionnaire with a sample of 200 respondents. In this research, the time span can be limitation. Data that is used in this research is obtained from various employees of tourist boards as representatives of destination management organizations (DMOs). The survey was conducted via Google forms and the obtained data were processed in Excel and SPSS. Although a certain number of studies have been conducted on this topic of Information and communication technology (ICT) and destination management organization (DMO), this specific conceptual model has not yet been developed. Based on the results, we can see that respondents have a positive view of the future regarding this issue and that they think there will be improvements, but they also think that there is a place for progress in the present.

Keywords: *Bosnia and Herzegovina, destination management, DMO (destination management organization), ICT (Information and communication technology), tourism*

1. INTRODUCTION

To make Bosnia and Herzegovina a more desirable destination, concrete actions have been taken. According to the United States Agency for International Development (USAID), they launched the USAID Developing Sustainable Tourism in Bosnia and Herzegovina Activity in 2020 with five years of implementation, intending to support the economic growth of the tourism sector in Bosnia and Herzegovina. Other goals of Activity are to accelerate economic growth in the tourism sector, increase job opportunities, provide sustainable income for individuals and tourism-related companies, help to reshape the “BiH brand,” and make a positive impact on adjacent sectors including agriculture, transportation, and environmental protection while also advancing cross-cutting issues such as gender equality and social inclusion. Also, according to IPA II funds of the European Union, in 2022 workshops were held as part of the project "Protection of underwater heritage through digitalization and valorization as a new form of tourist offer - Wrecks4all" on the topic of destination management of diving destinations. Strengthening and diversifying the tourist offer is the main goal of this Project. Representatives of tourist agencies, hoteliers, and diving clubs from the Herzegovina-Neretva Canton attended.

The Wrecks4all project was approved under the Interreg IPA Cross-border Cooperation Programme Croatia - Bosnia and Herzegovina - Montenegro 2014-2020 and is co-financed by the ERDF and IPA II funds of the European Union. All this means that a more serious approach to tourism in Bosnia and Herzegovina is in full force, which leads us to destination management and Information and communication technology (ICT). According to the World Tourism Organization (UNWTO), destination management is the coordinated and thoughtful planning of all elements that make up a tourism destination. This can involve anything from attracting visitors to providing amenities for them to enjoy during their stay in town – whether it's free Wi-Fi or a stocked convenience store. Although there are no exact solutions in the literature for the best way to manage destination development, there is still growing awareness of the need for local communities to give more power to destination management to manage the development of tourism (Magaš, 2008).

Destination management is an intrinsically cooperative activity. Attractions, tourism enterprises, local businesses, service businesses, and residents are called to work together to provide tourists with the best experience. Despite possible benefits, sometimes this kind of cooperation is hindered by the competitive behavior of various players and by the lack of coordination capabilities. Hence, often an ad-hoc organization (Destination Management Organization - DMO) is established to promote cooperation and to manage cooperative relationships among stakeholders. The DMO should then identify governance strategies, promote cooperative behavior and coordinate the activities of the various subjects involved in the delivery of the tourist experience (Barbini and Presutti, 2015).

As a consequence, the management of destinations, Destination Management Organization (DMO), and the ways to improve their performances have become vital subjects, especially for many mature European destinations (Negrusa, Lupu, Coro, and Moca, 2017). More concerning for the emergent subject has been the lack of debate and analysis over key concepts and terms associated with the destination as a phenomenon (Fyall, Garrod, Wang, 2012). Especially in Bosnia and Herzegovina.

2. LITERATURE REVIEW AND HYPOTHESES' DEVELOPMENT

2.1. Information and communication technology (ICT)

According to UNESCO, Information and communication technology (ICT) is a scientific, technological, and engineering discipline and management technique used in handling information, its application, and association with social, and economic, and cultural matters. ICT includes skills, software, applications, and systems. ICT education consists of four components: ICT/Digital Literacy; ICT Infrastructure and Support Applied Technologists; Specialized Business and Industry uses of ICT; and ICT Research and Development Scientists (Mid-Pacific ICT Center, 2014).

Beekman (2003) points out that ICT is a term that is applied to describe computers and communications equipment that are able to create software, transmit information, and manipulate it in various formats in order to manage tourism businesses effectively. In this paper, one of the focuses will be on factors and domains of Information and communication technology (ICT), seen in Table 1., which part of it will be used for the research model.

Factors	Domains
Basic ICT Skills	• Knowledge of Computer Systems • Search Internet • Communication and Networking • Word Processing • Use of Spreadsheets
Advanced ICT Skills	• Image Processing • Use of Database • Technological Platforms • Web 2.0 tools
Multi-Media and Attitudes Toward ICT	• Entertainment and Learning with ICT • Online Procedures • General Attitudes towards ICT

Table 1. Factors and domains of Information and communication technology (ICT)
Source: Cano (2005); Chen, Castillo, and Ligon (2015).

Cooper, Fletcher, Fyall, Gilbert, and Wanhill (2005) caution that, perhaps, the greatest challenge that organizations face today is to identify and train managers who will be effective and innovative users of ICTs, thus leading to technology-based decision-making that is more efficient in many ways. Unlimited access to information forces the use of digital technologies necessary for building relationships with customers and shaping a positive corporate image (Zawadzki, 2021).

2.2. Destination management organizations (DMOs)

Destination management focused on tourists and tourism is realized by towns and regions that have the preconditions and internal sources for developing a certain sort of tourism. According to the profile of the town or the region and their offer, the strategy of a tourism destination is created. Towns with a compact attractive offer of tourism products and services concentrate on the external communication policy, while towns with good preconditions for tourism development but without a developed or sufficient offer support running a business in the tourism or create specific products or product packages (Ryglová, 2008). A destination management organization (DMO) is defined as the leading organizational unit, which integrates various destination management tasks and coordinates the stakeholders in a targeted way. It can be a public or private institution or a public-private partnership (Partale and Partale, 2019). Pike (2004) similarly defines DMOs as sellers of a specific place, and interconnecting different sectors of the tourism industry. Destination management organizations (DMOs) can be considered as a mirror of the organizational aspects of tourism destinations which should constantly re-engineer and adapt their tourist offer to changing market conditions (Beritelli and Reinhold, 2009). However, there is no universal definition of DMOs. Their missions, objectives, structures, and names can be different, depending on the location (Pike, 2016). But DMOs can develop their tourism destinations to strategically position themselves in a highly competitive tourism market. Keeping in mind that achieving a high level of tourist satisfaction and intensifying the intention to revisit are among the goals of tourism destinations, periodic research and the constant adjustment of the provided tourism activities should occur since tourists are becoming more demanding because of the elevated number of tourism competitors and want to experience novel, high-quality activities and services (Dias, González-Rodríguez and Patuleia, 2021).

Bosnia and Herzegovina often take over practices from Croatia as one of the countries in the neighborhood and applies them in its complex system. Destination management in the Republic of Croatia in the public sector is the system of the tourist board, municipalities, governments, and associations, while in the private sector of enterprises, agencies, centers, and carriers (Institute of Tourism, 2011). An increasing number of DMOs have nowadays become more complex structures, re-joining numerous public and private sector stakeholders national/regional/local governmental/public authorities; agencies established for economic development; town center management organizations; national park management; providers of transport services; tourist attractions, events, and cultural organizations; providers of hospitality services (accommodation, restoration, leisure, and retail operations); intermediaries (tour operators, travel agencies, organizers of events, cultural organizations, etc.); agencies representing the destination; media; local/regional tourism consortia and partnerships; agencies encouraging and supporting business development; organizations focusing on developing skills (UNWTO, 2007, Negrusa, Lupu, Coro and Moca, 2017).

Finding the right balance between the interests of stakeholders with the environmental vision of a destination, and at the same time fulfill the demands and expectations, require long-term marketing and management planning and dialogue among different groups of interest (Byrd 2007; Middleton and Hawkins, 1998). Wray, Dredge, Cox, Buultjens, Hollick, Lee, Pearlman, and Lacroix (2010) enumerated the most important features of successful and sustainable destination management. Effective DMOs should have a long-term vision of destination development, clear designation of responsibilities and appropriate operational structures, and transparent and responsible decision-making engaging local groups of interests. As stated by Notarstefano (2008) finding the right balance between the economic development of tourism destinations, the conservation of their resources and the well-being of the local population has become a challenging task for many DMOs.

The large number of stakeholders involved, the potential conflicts of interest, and the different types of perceptions as well as knowledge coexisting within local communities can constitute obstacles to the efficiency of a DMO (Morrison, 2019). In this paper, one of the focuses will be on the role and activities of DMOs, as seen in Table 2., and which part of it will be used for the research model.

Table ends on the next page

Role	Specific Activities
External Destination Marketing (EDM)	● web-marketing; ● advertising, both classic and based on new media; ● familiarisation tours; ● sales blitzes; ● direct sales; ● direct mail; ● cooperative programs; ● events, festivals, conferences, fairs, etc

Internal Development Role (IDD)	• visitor services, including visitor management; • measuring and evaluating visitor satisfaction; • information and market research, with the purpose of helping stakeholders better • understand: market demands, industry supply, and the existing gaps between the two parts; • ensure high-quality development of human resources; • resource stewardship for sustainable destination management and development; • contribute to the attraction and raising of financial resources, including venture capital;
Overall Destination Management (ODM	• coordination of stakeholders; • management of crises.

Table 2. The roles and specific activities of Destination management organizations (DMOs) Source: Presenza, Sheehan, and Ritchie (2005); Negrusa, Lupu, Coro, and Moca (2017)

Today, information that is relevant for the customer is distributed through rating portals, blogs, and social media. Those who want to be found online will need to have a presence here. The DMO's former role as an advertising medium is no longer as important. Nowadays, influencers and travelers provide information about the destination themselves. Given this background, the DMO must become a source of authentic information and must proactively stimulate, distribute and influence online content (Partale and Partale, 2019). DMOs can also develop products, thematic packages of products, and marketing strategies to promote a given destination in its entirety. DMOs can do much to build and promote regional 'brands.' To be effective, a DMO should thus cover an area large enough to be attractive as a destination (The World Bank, 2019).

2.3. Effects of Information and communication technology (ICT) on Destination management organizations (DMOs)

Many transformations have occurred within the tourism sector since the destination marketing literature commenced in the early 1970s, which have had wide-ranging implications for DMOs. Among these changes were the introduction of jet aircraft, privatization and the outsourcing of government services, the demise of communism, global recognition of sustainability issues, explosion in media channels, globalization, disintermediation, and online distribution, information communications technologies (ICTs) and social media networking, the decline of the traditional passive all-inclusive coach tour and the rise of independent travelers and travel packages, the rise of short breaks and the emergence of low-cost carriers and last minute discount pricing, and resurgence of cruising, backpackers, adventure travelers and ecotourism, dark tourism, and medical tourism; and the rise of terrorism and ensuring security measures, all of which have stimulated research on the implications for destinations (Pike and Page, 2014). Information and communication technology (ICT) access and use have been recognized worldwide (Chinn and Fairlie 2007, 2010). However, there is still little international evidence from related literature. While some recent papers have begun to give attention to the potential for ICT developments to produce disruptive and transformative change (Gretzel, Sigala, Xiang and Koo, 2015; Gretzel, Werthner, Koo and Lamsfus, 2015; Werthner, Alzua-Sorzabal, Cantoni, Dickinger, Gretzel, Jannach and Zanker, 2015), to date there appears to be no systematic attempt to analyze tourism futures with regard to ICT (Hughes and Moscardo, 2019).

The existing discussion of ICT and tourism has mostly focused on ways in which new technologies can automate or make existing tasks more efficient (doing old things better) or ways that expand and alter existing tasks (doing old things in new ways). For many organizations, the real challenge lies in trying to think ahead to what happens beyond these options, what new things are going to emerge, and what fundamental changes might ensue (Contractor and Bishop, 2000; Rainie and Wellman, 2012). ICT tools have facilitated business transactions in the industry by networking with trading partners, distributing product services, and providing information to consumers across the globe. On the other hand, consumers are also using online to obtain information and plan their trips and travel. Information is the key element in the tourism industry (Shanker, 2008). The main effect that ICTs have is that they keep afloat businesses that use them (Law & Jogaratnam, 2005). Although ICTs appear to offer new opportunities for business mainly relevant in four different aspects: gaining a competitive advantage, improving productivity, developing new businesses, and facilitating new ways of management (Buhalis, 1998, 2003; Gruesc et al., 2009; Ion and Andreea, 2008; Irvine and Anderson, 2008; Shanker, 2008), it seems that firms do not experience an increase in their outcome because of the use of ICTs (López and Muneta, 2015). The impact of information and communication technologies (ICTs) on tourism and their foreseeable future evolution seem to be shaping a new scenario for destination management. This new context has given rise to the need for new management models. One of these models is the emerging smart tourism destination (STD), although it requires greater conceptual precision in order to become a new paradigm for destination management (Ivars-Baidal, Celdrán-Bernabeu, Mazón and Perles-Ivars, 2017). But as stated by Boes, Buhalis, and Inversini (2016) a smart destination does not rely only on the technological aspects of digitalization, but mostly on its utilization for the implementation of participatory processes of destination management. The rapid emergence and evolution of technological innovations can be seen as a double-edged sword. Some organizations and destinations will embrace new technologies and the potential they offer; others may not be ready for this change and may find it difficult to operate in a system that no longer follows traditional rules and practices (Pedrana, 2014). The research assumes that:

H1 - there are differences in basic and advanced Information and communication technology (ICT) skills that affect External Destination Marketing (EDM) and Internal Development Role (IDD) in destination management organization (DMO)

H2- there are differences in the impact of Information and communication technology (ICT) on destination management organization (DMO)

3. RESEARCH OBJECTIVES AND RESEARCH MODEL

Research objectives

1. *To explore Information and communication technology (ICT) and destination management organization (DMO)*
2. *To analyze the impact of Information and communication technology (ICT) on destination management organization(DMO)*
3. *To understand the importance of Information and communication technology (ICT) and destination management organization (DMO)*

Research model

Although a certain number of studies have been conducted on the topic of Information and communication technology (ICT) and destination management organization (DMO), by examining a certain scientific and professional literature in this field, it has been shown that such a conceptual model with these variables as seen on figure 2., applied research methodology and selected sample such as employees of tourist boards as representatives of destination management organization (DMO) have not yet been developed.

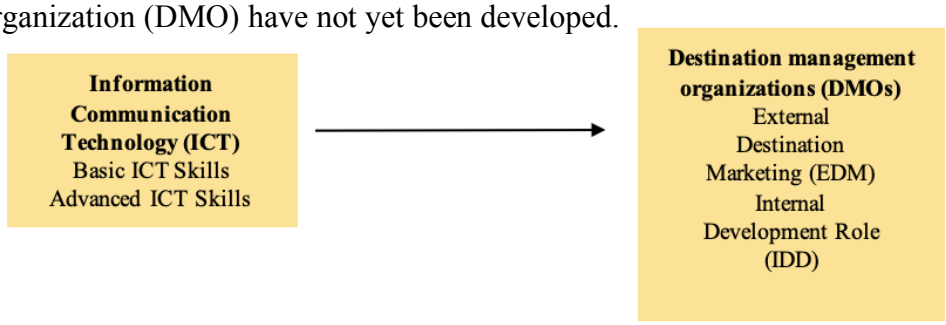

Figure 1: Research model / Source: author

4. RESEARCH METHODOLOGY, DATA COLLECTION, AND FINDINGS

Some claims in the questionnaire design rely on the books and research thesis on the subject of related research, such as Cano (2005); Chen, Castillo, and Ligon (2015); Presenza, Sheehan, and Ritchie (2005); Negrusa, Lupu, Coro, and Moca (2017); but mostly the claims in the questionnaire are independently defined on the basis of the study of the theoretical oeuvre. In this paper, the research was conducted in Bosnia and Herzegovina in a time period of four months. Data that is used in this research is obtained from various employees of tourist boards as representatives of DMO. In order to collect relevant data, a questionnaire was used in the paper. Questions in the questionnaire were asked with five intensity responses (Likert's scale type). The questionnaire has been distributed randomly and 250 questionnaires were distributed, while 200 returned with complete answers. The survey was conducted via Google forms and the obtained data were processed in Excel and SPSS. *Table 2***.** exhibits the demographic profile of the respondents. Out of 200 respondents, 64 respondents lie in the age group of 36-45, 48 respondents are related to the age group of 25-35, 35 respondents lie in the 46-55 age group, and 32 respondents belong to the below-25 age group. The least number of respondents belong to the above 55 age group. Among respondents, 48 percent are females and 52 percent are males from whom data is collected.

Age group	**R**	**%**
Below 25	32	16
25-35	48	24
36-45	64	32
46-55	35	17.5
Above 55	21	10.5
Gender		
Female	96	48
Male	104	52

Table 2. Demographic profile of respondents
Source: author

Relationships between the demographic profile of respondents, age and gender, and two indicators of ICT, basic ICT and advanced ICT scores, were examined also. And there was a relation, between age, and gender with basic ICT and also advanced ICT scores. Higher competency levels in both basic and advanced ICT scores have likely employees who are female and younger. In this research, a set of questions were asked to determine the state of employees regarding the objectives of the research:
Q1: To what extent has the level of knowledge of basic and advanced ICT skills in your organization changed in the last five years?
Q2: To what extent will the level of knowledge of basic and advanced ICT skills in your organization change in the next five years (Your expectation)?
Q3: How successful is your organization in External Destination Marketing (EDM)?
Q4: How successful is your organization in its Internal Development Role (IDD)?
Q5: How successful is your organization in basic ICT skills?
Q6 How successful is your organization in advanced ICT skills?
Q7: How much does your organization encourage the development of ICT skills in terms of destination management?

The results of the survey show answers to *question Q1* that 13.5% of respondents answered that it was reduced, 41.3% of respondents answered that it remained the same as before, that the number increased by **42.7%** (slightly increased by 33.2%, and significantly increased 9.5%, while they do not know 2.5%. The results of the survey show answers to *question Q2* that 2.6% of respondents answered that it will be reduced, 31.3% of respondents answered that it will remain the same as before, that the number will increase **62.7%** (slightly increase 59.3% and significantly increase 5.4%, while they do not know 3.4%

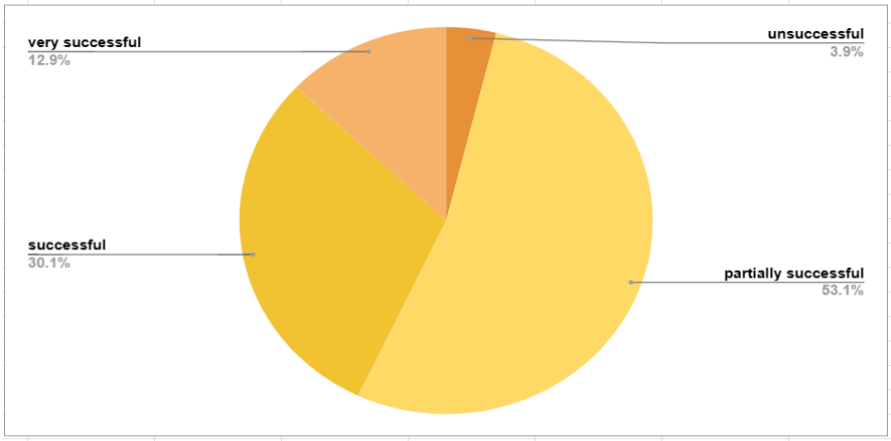

Chart 1: Q3- How successful is your organization in External Destination Marketing (EDM)?
Source: author

The results of the survey show answers to *question Q4* 2.8% of respondents said it was unsuccessful, partially successful **43.2%**, it is successful 31.9%, and it is very successful 22.1%. The results of the survey show answers to *question Q5* 13.7% of respondents said it was unsuccessful, partially successful 33.3%, it is successful **40.2%**, and that it is very successful 12.8%.

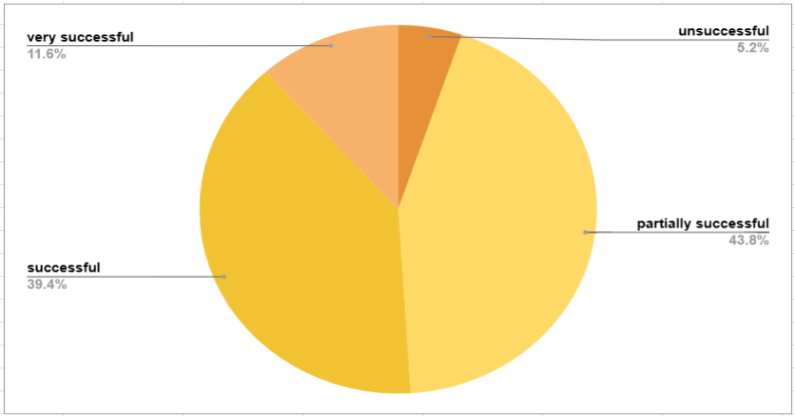

Chart 2: Q6 - How successful is your organization in advanced ICT skills?
Source: author

The results of the survey show answers to *question Q7* 6.4% of the survey that they do not encourage at all, 12.3% are of the opinion that it is very small, not much not little 28.1%, to significantly encourage thoughts 30.6% and to strongly encourage thoughts 22.6% surveyed. Based on the results, we can see that respondents have a positive view of the future and that they think there will be improvements, but they also think that there is a place for progress in the present.

	Average score	**Standard deviation**	**Median**
Increased reach on social media platforms and the Internet	**1.77**	1.10	1.00
Personalization based on the interests and preferences of travelers	**2.33**	1.40	2.00
Enhanced visitor experience based on easy access to destination information	2.30	1.36	2.00
Improved communication with every stakeholder	2.26	1.37	2.00
More effective operations	1.88	1.22	1.00

Table 3: The impact of Information and communication technology (ICT) on the destination management organization (DMO)
Source: author

The results of research related to the impact of Information and communication technology (ICT) on the destination management organization (DMO) are shown in table 3. above and show that the opinion of the surveyed is that biggest impact is personalization based on the interests and preferences of travelers with an average score of 2.33, while the lowest average score of 1.77 has an impact of increased reach on social media platforms and the Internet.

5. CONCLUSION, LIMITATIONS, AND RECOMMENDATION

Based on the results of this research that is conducted in Bosnia and Herzegovina, we can see that respondents who are employees of tourist boards as representatives of destination management organization (DMO) have a positive view of the future regarding this issue and that they think there will be improvements, but they also think that there is a place for progress in the present. Given the results obtained, it can be noted that in fully confirmed hypothesis H1 - there are differences in basic and advanced Information and communication technology (ICT) skills that affect External Destination Marketing (EDM) and Internal Development Role (IDD) in destination management organization (DMO). Results show that there is an impact of Information and communication technology (ICT) on the destination management organization (DMO). The impact of Information and communication technology (ICT) on the destination management organization (DMO) was increased reach on social media platforms and the Internet with an average score of 1.77, personalization based on the interests and preferences of travelers with an average score of 2.33, enhanced visitor experience based on easy access to destination information with an average score of 2.30, improved communication with every stakeholder with an average score of 2.26, more effective operations with an average score of 1.88. Higher competency levels in both basic and advanced ICT scores have likely employees who are female and younger. Given the results obtained, it can be noted that in fully confirmed hypothesis H2- there are differences in the impact of Information and communication technology (ICT) on destination management organization (DMO). There can be found limitations in this study. For example, time span. Especially because ICT skills are not easy to learn for some people and time and repetition are very much needed during the learning process. The recommendation would also be to involve other destination management organizations (DMOs) representatives in the research in order to see an even clearer picture of not only destination management organizations (DMOs), but also destination management. Regardless of the visible developments in recent times, it is necessary to constantly work on creating better conditions for employees for new learning advanced ICT skills but also practice basic ICT skills. This is possible through continuous education, whether they are done independently or within organizations. What the research has also shown as the possibility of steps forward is certainly a better infrastructure of destination management. And that means all stakeholders have to get involved.

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ADS THAT FOLLOW YOU: DOES AI-DRIVEN PERSONALIZATION ENHANCE CONVENIENCE OR FEEL CREEPY?

Bence Toth
Budapest University of Economics and Business, Marketing Master's Programme
Toth.Bence.31@unibge.hu

Kyra Gloria Takacs
Budapest University of Economics and Business, Marketing Master's Programme
Takacs.Kyra.Gloria.70@unibge.hu

Nguyen Ngoc Anh
Budapest University of Economics and Business, Marketing Master's Programme
Nguyen.NgocAnh.74@unibge.hu

Yassine Mouloudi
Budapest University of Economics and Business, Marketing Master's Programme
Mouloudi.Yassine.87@unibge.hu

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business, Marketing Master's Programme
papp-vary.arpad@uni-bge.hu

ABSTRACT

Artificial Intelligence (AI) has become a fundamental component of contemporary digital marketing, enabling a transition towards AI-driven customer engagement through advanced personalization technologies. By collecting, aggregating, and analysing vast amounts of behavioural data, AI-powered platforms can predict user preferences and deliver highly personalized content and advertising in real time. This paper examines how AI-driven personalization is applied in social media marketing and explores its main benefits and challenges. Using a narrative literature review supported by illustrative case studies, the paper analyses how leading digital platforms, including Meta (Facebook and Instagram), Spotify, Netflix, and TikTok, employ recommendation engines, predictive analytics, and machine learning algorithms to improve user engagement, customer experience, and marketing effectiveness. At the same time, the study discusses the ethical implications of AI-driven personalization, including concerns related to algorithmic transparency, excessive personalization, manipulation, and data privacy. Overall, the paper argues that AI-powered personalization has become a strategic capability in modern marketing, while emphasizing that its long-term success depends on responsible AI practices and maintaining users' trust.

Keywords: *AI, AI-driven advertising, personalization, recommendation engines, social media, user experience, user privacy*

1. INTRODUCTION

Artificial Intelligence (AI) has developed rapidly in recent years and has become one of the key technologies driving the Fourth Industrial Revolution. Its integration with technologies such as the Internet of Things (IoT), Big Data, and Cloud Computing has fundamentally transformed business processes across industries. Marketing has also undergone a profound transformation, with artificial intelligence becoming a key driver of customer engagement, personalization, and real-time decision-making.

AI extends the capabilities of traditional digital marketing through machine learning algorithms that can predict consumer preferences and behaviours and enable large-scale personalization (Hastie et al., 2009; Provost & Fawcett, 2013; Rafieian & Yoganarasimhan, 2023). Furthermore, advances in machine learning and deep learning have expanded the application of AI on digital platforms by enabling the delivery of highly personalized content based on individual preferences. These technologies provide marketers with deeper insights into users' emotions and behaviours, making communication increasingly resemble one-to-one interactions, one of the defining characteristics of modern digital marketing (Goodfellow et al., 2016; Lecun et al., 2015; Cambria et al., 2013). The rapid growth of social media has further accelerated the adoption of AI-driven marketing. Today, AI is widely recognized as a core component of digital marketing because of its ability to process large volumes of data, support real-time decision-making, and deliver highly personalized user experiences. Recommendation engines, for example, improve customer experience by providing personalized suggestions based on individual preferences and behavioural patterns (Huang & Rust, 2018; Joulin, 2017). Similarly, content optimization algorithms automatically prioritize messages to maximize their relevance and effectiveness (Saurwein & Spencer-Smith, 2021). Beyari and Hashem (2025) emphasize the role of AI in personalizing social media marketing strategies and enhancing customer experiences, while Dhavaleshwar (2024) demonstrates that AI-driven personalization increases user engagement by delivering content tailored to individual preferences. Through applications such as influencer marketing, content optimization, and personalized messaging, AI enables businesses to interact with consumers in real time, strengthening brand awareness, improving user experience, and increasing purchase intentions. Despite these advantages, the growing use of AI in social media marketing also raises important ethical challenges related to privacy, security, transparency, and algorithmic accountability. Organizations must therefore ensure legal compliance and protect user privacy if AI-driven marketing is to remain sustainable and trustworthy (Bryson, 2018; Mittelstadt et al., 2016, 2016b). The aim of this paper is to examine the role of AI-driven personalization in social media marketing through three case studies: Meta (Facebook and Instagram), Spotify and Netflix, and TikTok. The paper explores both the opportunities and the challenges associated with AI-powered personalization, focusing on its impact on customer experience, marketing effectiveness, and user privacy.

2. THE MASTERS OF PERSONALIZATION: HOW AI SHAPES USER EXPERIENCES

2.1. The Meta (Facebook/Instagram) Ad Machine

Meta (Facebook and Instagram) operates one of the world's largest digital advertising ecosystems, serving more than three billion users. According to recent statistics, approximately 85% of successful Facebook advertisers rely on AI-driven automation (Lee, 2024). To deliver highly targeted advertising, Meta has developed an integrated ecosystem combining artificial intelligence, machine learning, big data, deep learning, and recommendation engines to predict users' interests, preferences, future behaviours, and conversion probabilities in real time. Meta collects data from two primary sources. The first consists of on-platform data, including behavioural information, social graph data, content interactions, interest signals, and demographic characteristics. The second comprises off-platform data, gathered through Meta Pixel, Software Development Kits (SDKs), first-party advertiser data, third-party data brokers, and device-level signals (Meta, 2024). These diverse data sources are processed through Meta's advertising infrastructure to support behavioural prediction and real-time advertising optimization. To personalize advertising, Meta creates Ad Profiles, which integrate thousands of direct and inferred behavioural signals into comprehensive user profiles. These profiles include inferred interests, purchasing behaviour, potential needs, advertising priorities, conversion probabilities, and predictions of future behaviour.

In addition, Meta reportedly utilizes Shadow Profiles, which are constructed from inferred information to estimate the characteristics and potential behaviours of individuals who are not active users of Meta platforms, thereby extending the reach of its advertising ecosystem (Aguiar et al., 2022). A recent technological advancement is the Generative Ads Recommendation Model (GEM), a next-generation recommendation system designed to improve advertising relevance (Li et al., 2025). By combining Ad Profiles, Shadow Profiles, and advanced recommendation algorithms, the system continuously updates customer segments, predicts behavioural changes, and delivers highly personalized advertisements in real time. The integration of these technologies has significantly improved advertising performance, particularly click-through rates (CTR), while also enhancing the relevance of advertisements presented to users. For example, if a user frequently follows Apple and Samsung, visits official brand pages, and adds a MacBook Air to a wishlist, the system may classify the individual as a high-income consumer interested in premium electronics. Consequently, the user is more likely to receive advertisements for flagship devices and high-end accessories rather than unrelated products such as baby-care or fashion items. A practical example is provided by a fashion retailer that implemented Meta's Lookalike Audiences feature. By applying machine learning algorithms to existing customer data, the platform identified users with similar behavioural characteristics and interests. According to Koast.ai (2023), this approach resulted in a 35% increase in conversion rates while substantially improving the cost-effectiveness of customer acquisition.

2.2. The Spotify & Netflix Recommendation Engines

A central element of everyday digital media use is that platforms appear to "know" us. With remarkable accuracy, users receive content, advertisements, and recommendations that match their tastes and current mood. The technological basis for this phenomenon is predictive behavioural analysis, which uses patterns of user interactions to predict what types of content users are most likely to consume. Among streaming providers, this paper examines Spotify and Netflix as two representative examples. Both platforms operate complex learning architectures that shape consumer behaviour, as discussed in The Influence of Digital Changes on Media and Entertainment Business Models: A Case Study of Netflix and Spotify (Pratama, Narimawati, & Mulyadi, 2023).

2.2.1. Spotify and Netflix as Two Different but Related Systems

Although the two services operate in different media environments, their algorithms are based on the same fundamental principles: a combination of collaborative filtering, content-based features, deep learning models, and real-time behavioural tracking. Spotify's primary goal is to support continuous music discovery. Therefore, its system simultaneously interprets listener behaviour (especially skip behaviour as a strong negative signal), the acoustic "sound DNA" of songs, and clusters based on users' taste similarities. These analyses are complemented by context-sensitive recommendations and natural language processing (NLP) of online music discourse.

Netflix, on the other hand, primarily aims to minimize churn by helping users find something to watch within 60–90 seconds. To achieve this, in addition to collaborative and content-based filtering, it uses deep learning models to analyse short-term viewing trends and increases the likelihood of clicks through personalized thumbnail images. While Spotify's objective is to maintain continuous music discovery, Netflix focuses on immediate decision-making and platform retention. Nevertheless, both systems rely on the same technological logic based on predictive behavioural analysis.

2.2.2. Spotify Wrapped as an Emotional Data Narrative

Spotify Wrapped is an excellent marketing tool because it transforms user data into an emotional experience. This service organizes a person's listening habits throughout the year into a story format, in which the user becomes the protagonist of their own musical journey. As a result, it increases both customer loyalty and users' willingness to share their results on social media (Annabell & Rasmussen, 2025).

Wrapped stands out because it transforms data aggregation into self-expression through positive interpretation, thereby reducing resistance to data collection while creating a cultural event that has become a widespread annual ritual. By turning musical taste into easily shareable content, Spotify effectively transforms its users into ambassadors for the brand. Furthermore, Wrapped not only provides personalized recommendations but also builds emotional attachment and community identity, representing one of the most effective forms of contemporary marketing, as highlighted in Unveiling the Magic: How Spotify Wrapped Casts a Spell on Its User (Azzahrah, 2024).

2.2.3. Netflix's Personalized Thumbnails

One of Netflix's most powerful yet largely invisible AI-based marketing tools is its system of personalized thumbnails. The platform maintains hundreds of possible preview images for each title and individually selects the one most likely to generate clicks for each user. Studies have shown that the appearance of a thumbnail can strongly influence whether a user chooses to watch particular content. For example, users who prefer romantic movies may see artwork emphasizing romance, while those who frequently watch films featuring a particular actor may see that actor prominently displayed on the thumbnail.

Furthermore, personalized thumbnails are not merely a visual feature but represent a form of micro-level predictive marketing that directly influences viewing decisions and increases engagement without users necessarily being aware of its persuasive effect. As described in Custom Thumbnails: The Changing Face of Personalisation Strategies on Netflix (Eklund, 2022), this approach has become a key element of Netflix's personalization strategy.

Spotify and Netflix recommendation systems are excellent examples of how predictive behavioural analysis functions in digital media. Although they operate in different media sectors, they rely on similar AI-driven principles. Predictive modelling is therefore not only about improving user experience but also about creating direct marketing value by shaping preferences, increasing customer loyalty, and subtly influencing consumer behaviour. Whether through the emotional storytelling of Spotify Wrapped or the personalized visuals of Netflix thumbnails, these technologies demonstrate how AI-driven personalization has become a powerful strategic marketing tool in the modern digital ecosystem.

2.3. The TikTok "For You" Page

When people think about TikTok, the first feature that usually comes to mind is the For You Page (FYP). It is the part of the platform that determines which videos each user sees, regardless of whether they follow the content creators. What makes the FYP particularly interesting as a case study is that it not only responds to users' preferences but also actively shapes their interests over time. TikTok explains that its recommendation system is based on signals such as watch time, replays, comments, likes, and even subtle interactions, including pausing videos or adjusting the volume (TikTok, 2020). From the first few minutes a new user spends on the platform, the system begins building a profile of the content most likely to capture that user's attention.

According to Cotter (2021), TikTok's algorithm continuously tests users by combining familiar content with new topics in order to observe their reactions. Over time, it constructs what researchers describe as an algorithmic identity, reflecting how the platform interprets users based on their behavioural patterns (Bishop, 2019). The influence of the FYP extends far beyond simple content recommendation and can be summarized in four main effects:

1) Shaping users' interests. One of the clearest effects of the FYP is its impact on user engagement. Klug et al. (2023) found that when TikTok's personalization features were reduced, users spent significantly less time on the platform. This suggests that the recommendation system does not simply reflect existing interests but actively directs users' attention. Because the FYP learns rapidly and continuously adapts to behavioural signals, users frequently discover new hobbies, music, or creators that they had not previously considered interesting.

2) Creating recommendation loops. TikTok functions as more than a neutral content distribution platform. The more users interact with a particular type of content, the more similar content the FYP recommends. Bishop (2019) describes this process as a recommendation loop, in which certain topics become increasingly visible simply because the algorithm continues to promote them. Similarly, interview participants in Cotter's (2021) study reported that their FYP had "changed their interests," illustrating how recommendation algorithms can gradually influence users' content consumption.

3) Contributing to filter bubbles. Because the recommendation system is optimized to maximize viewing time and engagement, users may gradually be exposed to increasingly homogeneous content. Terren and Borge (2021) argue that algorithms such as TikTok's can unintentionally reinforce specific interests and create small-scale echo chambers. Although this may benefit niche creators by connecting them with highly relevant audiences, it may also reduce users' exposure to diverse perspectives and content.

4) Influencing culture and society. The FYP also plays a major role in determining which content becomes viral. Unlike earlier social media platforms, TikTok can turn a video created by an unknown user into a global trend within a matter of hours. Abidin (2021) argues that this redistribution of visibility gives the platform considerable cultural influence. Songs, slang, memes, consumer trends, and even political opinions can spread rapidly because TikTok's recommendation algorithm distributes selected content to millions of users.

This case study demonstrates how TikTok represents a new generation of AI-driven personalization. Rather than waiting for users to explicitly express their interests, the platform continuously experiments, predicts, and reinforces behavioural patterns to maximize engagement. Consequently, the For You Page has become one of the most influential recommendation systems in the digital environment, shaping not only individual user behaviour but also broader cultural trends.

3. THE TWO SIDES OF THE COIN: CONVENIENCE VS. CREEPINESS

Throughout its history, marketing has continuously adapted to technological change, and the emergence of Artificial Intelligence (AI) has accelerated this transformation. Today, AI-driven marketing represents one of the most dynamic developments in the evolution of digital marketing. Most users have experienced the feeling that their smartphones or digital platforms seem to "know" what they want, sometimes even before they consciously recognize their own interests.

As demonstrated by the case studies presented in this paper, including Meta (Facebook and Instagram), TikTok, Spotify, and Netflix, this phenomenon is the result of sophisticated AI systems designed to optimize user experience while improving marketing effectiveness. To better understand this development, it is necessary to examine both the opportunities and the challenges associated with AI-driven personalization.

3.1. The Bright Side: Convenience Through Personalization

Modern digital marketing has evolved from broad audience segmentation towards hyper-personalization. While traditional marketing approaches classified consumers into relatively large segments, AI-driven personalization increasingly treats each user as an individual with unique preferences, behaviours, and needs that can be addressed in real time. To achieve this level of personalization, two core AI mechanisms are employed: real-time tracking and predictive modelling. As highlighted by Gao and Liu (2023, as cited in González Mendoza et al., 2025), "AI facilitates more precise, real-time personalization, thereby considerably enhancing customer relationships." AI algorithms analyse a wide range of behavioural data, including browsing history, user interactions, and engagement signals, allowing platforms to continuously adapt the content presented to each individual. González Mendoza et al. (2025) further emphasize that real-time tracking enables the analysis of virtually every user interaction across digital platforms. These capabilities are complemented by predictive analytics. Rather than simply reacting to users' current behaviour, AI systems continuously update their models using previously collected data to anticipate future interests and behaviours. Streaming platforms such as Netflix and Spotify provide excellent examples of this approach. Instead of waiting for users to search for content, these platforms analyse previous consumption patterns and recommend movies, series, or music that users are statistically most likely to enjoy, effectively anticipating preferences before they are explicitly expressed. Hyper-personalized advertisements and marketing messages often contribute to stronger emotional connections between consumers and brands. Alghaswyneh (2025) argues that personalized marketing "captures consumer attention and fosters emotional connections with brands, improving loyalty and advocacy."

To further strengthen these relationships, companies increasingly rely on Generative AI. This technology enables the creation of dynamic advertisements and marketing content tailored to the visual and textual preferences of individual users. As noted by González Mendoza et al. (2025), "generative AI is essential for campaign creation, data management, and personalization." Consequently, highly personalized advertising can strengthen emotional attachment to brands and encourage users to become active members of brand communities. A practical example of this trend is the emergence of conversational agents such as Snapchat's My AI, which transforms passive advertising into interactive dialogue by providing recommendations in a helpful, human-like manner rather than through traditional banner advertisements. Ultimately, these developments create measurable value for both businesses and consumers. For companies, the primary benefit is improved return on investment (ROI), as AI enables advertisers to focus their resources on users with the highest predicted conversion probability instead of addressing uninterested audiences. At the same time, consumers benefit from receiving more relevant products, services, and content that better match their individual preferences. According to Alghaswyneh (2025), AI-driven personalization enhances "customer interaction, satisfaction, and loyalty by delivering tailored experiences that address consumer preferences." Consequently, hyper-personalized marketing has the potential to create value for both businesses and consumers by simultaneously improving marketing efficiency and customer satisfaction.

3.2. The Dark Side: When Personalization Becomes Creepy

The benefits of AI-driven personalization are accompanied by significant challenges that should be considered by both businesses and consumers. Although users enjoy highly personalized content and recommendations, the underlying technology often operates as a so-called "black box." In practice, this means that users only see the final outcome in the form of advertisements or recommendations, while the logic behind data collection, processing, storage, and decision-making remains largely invisible. Taeihagh (2021) identifies this phenomenon as a major challenge, stating that "the opacity of complex ML algorithms remains a major barrier to AI governance as it limits the extent of transparency, explainability and accountability."

Moreover, "algorithms are often kept intentionally opaque by their developers to prevent cyber-attacks and to safeguard trade secrets" (Taeihagh, 2021). At the same time, AI systems rely on the continuous collection of vast amounts of personal data, creating additional security and privacy risks. As noted by Karami et al. (2025), "privacy concerns arise due to the collection and use of personal data to power AI algorithms... The potential for data breaches and unauthorized access necessitates robust data protection measures." These risks have already been demonstrated by incidents such as the Cambridge Analytica scandal, in which personal data from millions of Facebook users were harvested without informed consent and used to create psychological profiles, exposing the vulnerabilities associated with large-scale data collection.

The lack of transparency also creates opportunities for consumer manipulation. Hyper-personalized advertisements may exploit psychological vulnerabilities or temporary emotional states to maximize engagement. As highlighted by Karami et al. (2025), "personalized marketing messages are geared to exploit the weaknesses of people and modify their behaviours, which makes it possible for there to be a danger of manipulation and undue influence." Platforms such as TikTok illustrate this potential risk. Engagement-optimized recommendation algorithms may unintentionally trap users in feedback loops, often referred to as "rabbit holes," by continuously promoting similar content in order to maximize watch time. In such cases, the primary objective is no longer to satisfy users' needs but to maximize platform engagement.

Another important challenge is algorithmic bias. Since AI systems are trained on historical data, they may inherit and even amplify existing human biases. As Karami et al. (2025) point out, "if the training data corresponds to prejudices that exist in the actual world, then these biases may be maintained or magnified by the algorithms." Real-world examples illustrate these risks. Amazon's now-discontinued AI recruitment tool systematically disadvantaged female applicants, while racial disparities have been identified in risk assessment systems such as COMPAS. These cases demonstrate how historical biases can be reproduced and amplified through AI, potentially affecting individuals throughout their interactions with digital platforms.

Ultimately, when transparency is lacking, the feeling of being "followed" gradually shifts from convenience to discomfort, reducing users' trust in AI-driven systems. Alghaswyneh (2025) notes that "ethical considerations, particularly data privacy and transparency... played a significant role in shaping consumer perceptions." Consequently, organizations increasingly need to adopt Responsible AI frameworks that emphasize transparency, accountability, and responsible data governance. As Díaz-Rodríguez et al. (2023) conclude, "trustworthy AI is... a sine qua non condition for the realization of the potentially vast social and economic benefits AI can bring."

Therefore, the sustainable development of AI-driven marketing depends on ensuring auditability, transparency, and accountability throughout the entire lifecycle of AI systems. Regulatory initiatives, such as the European Union's AI Act, represent an important step towards strengthening this accountability. By establishing legal safeguards for the development and deployment of AI, these frameworks seek to ensure that technological innovation enhances consumer experiences without undermining fundamental rights.

4. CONCLUSION

The foundations of contemporary digital marketing have fundamentally changed. Rather than relying primarily on broad demographic segments, marketing increasingly depends on real-time, AI-driven behavioural prediction. Artificial intelligence has fundamentally transformed digital marketing by enabling real-time behavioural prediction, hyper-personalization, and data-driven customer engagement. The findings of this study demonstrate that platforms such as Meta, Spotify, Netflix, and TikTok employ sophisticated algorithms and recommendation systems to collect, aggregate, and analyse user behaviour. Based on these data, they develop advertising profiles and algorithmic identities that enable the delivery of highly personalized content and advertisements. At the same time, AI-driven personalization presents two contrasting dimensions: convenience and creepiness. On the one hand, real-time tracking and predictive modelling enhance user experience by providing more relevant content while improving marketing effectiveness and increasing return on investment (ROI) for businesses. On the other hand, these technologies raise important ethical and privacy concerns. The "black box" nature of complex AI algorithms limits transparency and accountability, while large-scale data collection creates security risks and increases the potential for consumer manipulation. Furthermore, algorithmic optimization may contribute to filter bubbles, narrow content exposure, and the reinforcement of existing biases embedded in training data. For marketing professionals, the ability to understand and effectively utilize real-time behavioural data has become an essential competence. At the same time, adopting Responsible AI principles is equally important. The long-term success of AI-driven marketing depends on ensuring legal compliance, protecting user privacy, and maintaining consumer trust. From an academic perspective, further research is needed to address the "black box" problem by improving the explainability, transparency, and auditability of AI systems. In addition, future studies should further examine how algorithmic recommendation systems shape user behaviour, consumer preferences, and broader cultural trends. Finally, AI will continue to play a central role in the evolution of digital marketing, particularly through the development of increasingly immersive and personalized customer experiences. The key challenge will be to ensure that technological innovation remains aligned with ethical principles and fundamental rights, allowing businesses to benefit from AI while preserving users' trust and autonomy.

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QUALITY MANAGEMENT AT WORTEN: WORTEN RIOSUL COMPARED TO WORTEN COLOMBO (PORTUGAL)

Felipa Lopes dos Reis
p4338@ulusofona.pt
Lusofona University, Lisbon, Portugal

Bernardo Maria Louro Pedro
bernardolouropedro@gmail.com
Lusofona University, Lisbon, Portugal

Afonso Antunes Saramago Monteiro
aantunesmonteiro@gmail.com
Lusofona University, Lisbon, Portugal

Rui Simao dos Santos Castanheira
ruicastanheira0708@gmail.com
Lusofona University, Lisbon, Portugal

ABSTRACT

This research sets out to explore and compare how quality management is perceived and implemented in two Worten retail locations — specifically, the store in Rio Sul and the store in Colombo. The main goal is to analyze the sales sector through the eyes of the customer, particularly focusing on how feedback provided by consumers can influence the adaptation or improvement of a particular quality dimension within these environments. To carry out this comparative analysis effectively, the research adopts a methodology based on the SERVQUAL model — a widely recognized tool in the domain of quality management. This model facilitates the evaluation of service quality by examining the gap between customers' expectations and their actual perceptions of the service received. By working through this gap, researchers can understand not only how well a service is being delivered but also how closely it aligns with what customers value. The SERVQUAL framework comprises five main dimensions that provide a comprehensive view of service quality: tangibility (which relates to the physical appearance of facilities, equipment, and staff), reliability (referring to the ability to perform the promised service accurately and dependably), responsiveness (which captures how willing and prompt employees are in providing service), assurance (the knowledge and courtesy of staff, as well as their ability to instill trust), and empathy (the extent to which personalized attention and care are offered to customers). A structured questionnaire, grounded in these five dimensions, was designed and distributed to customers at both Worten stores. The responses gathered from this questionnaire form the empirical base of the study and are analyzed to identify strengths and weaknesses in service quality at both locations. By interpreting these data, the research aims to offer a detailed and data-informed comparison, shedding light on how service quality is experienced differently in two branches of the same retail chain. Ultimately, this study seeks not only to assess the current state of service quality management at the Rio Sul and Colombo Worten stores but also to identify actionable recommendations that could enhance customer satisfaction. The research contributes valuable insights for management teams looking to refine their approach and tailor their services more effectively to customer expectations, particularly in a highly competitive and dynamic retail sector.

Keywords*: Quality Management, Customer Satisfaction, Service Perception, Worten, Comparative Study, Consumer Experience*

1. INTRODUCTION

In today's market, where consumers are constantly bombarded with choices and digital access to alternatives is instantaneous, maintaining a competitive edge in the retail sector requires more than just offering the latest products or competitive pricing. Customer service has evolved into a central pillar of brand identity and business sustainability, especially in specialized retail areas such as electronics and home appliances. As consumer behavior becomes increasingly sophisticated, so do the expectations surrounding the shopping experience. No longer is the transaction solely about acquiring a product — it is about the journey that leads to that purchase, and everything that follows it. The ambiance of the store, the demeanor and helpfulness of employees, the clarity and accessibility of information, and the reliability of after-sales support all play vital roles in shaping the consumer's overall perception of a brand. Against this backdrop, the present study seeks to investigate the quality management practices of Worten, a leading Portuguese electronics and appliance retailer, by comparing two of its physical locations: the store located at Rio Sul Shopping Center and the store at Colombo Shopping Center. While both stores operate under the same corporate framework, they are situated in different geographic and socioeconomic settings. This distinction opens the door to exploring whether — and how — customer perceptions of quality differ between the two locations, despite the shared brand identity. To facilitate this comparison, the SERVQUAL model will be employed as the primary evaluative tool. This model, which has been extensively validated in the field of service quality research, allows for an in-depth analysis of service delivery from the customer's point of view. By collecting data through targeted questionnaires and analyzing responses across the model's five service quality dimensions, this study aims to pinpoint specific areas where each store excels or falls short in meeting customer expectations. The broader objective is to contribute to a more refined understanding of quality management within retail environments that operate across diverse contexts. The findings of this research may offer practical guidance not only to Worten's managerial teams but also to other retailers seeking to enhance their service strategies based on actual consumer insights. Additionally, the study illustrates how models like SERVQUAL can be effectively adapted to modern retail challenges, serving as a bridge between theoretical frameworks and actionable business decisions.

2. LITERATURE REVIEW

2.1. Importance of quality management

In recent decades, quality management has transitioned from being an operational consideration to a strategic imperative. Particularly in competitive, customer-facing industries such as retail, a company's approach to managing quality can significantly impact its reputation, customer base, and long-term viability. Academic literature consistently highlights the importance of well-structured quality management systems (QMS). These systems enable businesses to standardize processes, reduce inefficiencies, and improve overall organizational performance. But more importantly, they play a crucial role in shaping how customers perceive the reliability and value of a company's services. Pinto and Pinto (2011) conducted an in-depth study on the adoption of quality management certification in Portugal, examining data from 364 companies over a 12-year period. The research found that organizations were primarily motivated to pursue certification due to benefits such as cost reduction, improved internal efficiency, and increased competitiveness in their respective markets. These motivations underscore the fact that quality management is not just about meeting minimum standards — it's about gaining a competitive advantage through continuous improvement. Cima and Opazo (2010) contributed further to this discourse by analyzing the role of advanced quality tools such as Failure Mode and Effects Analysis (FMEA) and Six Sigma.

These methodologies allow companies to identify potential points of failure before they manifest, thereby enhancing the reliability and predictability of service delivery. Their research confirms that in a globalized economy, where competition is both fierce and fast-moving, structured approaches to quality management are not optional — they are essential. Moreover, a 2014 study published in the Brazilian Journal of Business Management explored the intersection of quality management and innovation. The study found that organizations that engaged in ongoing evaluation and refinement of their processes were also more likely to engage in innovative practices. This finding reinforces the idea that quality management not only improves current performance but also lays the foundation for future growth and innovation. Together, these studies illustrate the multifaceted value of quality management — it enhances operational efficiency, promotes innovation, and most importantly, aligns organizational performance with customer expectations. This last point is especially crucial in the retail sector, where consumer loyalty is often hard-won and easily lost.

2.2. Analysis of quality management from the consumer perspective

While the internal mechanisms of quality management are undoubtedly important, their real-world effectiveness is ultimately judged by the consumer. A well-designed quality system that fails to resonate with customers — or worse, goes unnoticed — can hardly be deemed successful. Therefore, understanding and measuring quality from the consumer's perspective has become a central focus in modern management literature. One relevant study by Guerlixa (2022) examined how perceived service quality influences consumer satisfaction and loyalty in the food retail sector. Interestingly, while the study found a strong relationship between perceived quality and repeat purchases, it noted a weaker correlation with other loyalty indicators such as brand advocacy or price insensitivity. This finding suggests that while service quality is vital, it must be part of a broader value proposition to fully engage customers. Silva and Saraiva (2015) took a slightly different approach by looking at the influence of leadership within Total Quality Management (TQM) frameworks. Their research revealed that leadership is not just a background variable — it is central to the successful implementation of quality practices. Where leadership was strong and visibly committed to quality, customer satisfaction and loyalty tended to be higher. Meanwhile, Dala (2023) focused on the telecommunications market in Angola, specifically the Zap/Fibra service. The study revealed that service quality had a direct impact on both customer satisfaction and loyalty. Notably, the dimensions of reliability, assurance, and empathy emerged as the most influential, providing valuable insights for companies operating in service-heavy industries. What these studies have in common is a clear emphasis on the customer's voice. Whether in food retail, telecommunications, or electronics, service quality is no longer measured only by internal audits or ISO checklists. It is measured by how customers feel — and how those feelings influence their decisions to stay, return, or leave.

2.2.1. Contextualization and characterization of service quality in the sales sector

In the retail environment, especially in the sales sector, service quality is more than a business necessity — it's a defining element of the consumer experience. Companies that recognize this and invest in the consistent delivery of exceptional service are more likely to thrive in an increasingly crowded and demanding marketplace. A range of studies supports this understanding, demonstrating how service quality plays a pivotal role in attracting, converting, and retaining customers. For instance, research by Fabio dos Santos (2017) underscores the fundamental importance of attentive and well-structured service interactions. His work highlights that service quality is directly linked to consumer decision-making — a customer who feels well-treated and well-informed is significantly more likely to return and recommend the business to others.

Similarly, Larissa Muniz Santos (2021) studied retail practices in Itaperuna, RJ, where she observed a tangible correlation between service quality and the purchasing decision process. Her findings pointed to service excellence as a unique differentiator — a strategic asset that impacts the bottom line. The importance of specific quality dimensions is further emphasized in Joana Faria's (2017) research, which notes that reliability — delivering on promises consistently — is particularly influential in determining how customers evaluate their shopping experience. Meanwhile, in a more recent investigation by Ema Rodrigues and Marlene Fainde (2023), service quality was explored in the context of Fersol-Beira. Their results reveal that customers prioritize not only the immediacy of service but also the availability of post-sale support and personalized care. Competitive pricing and technical support also emerged as critical contributors to satisfaction and repeat business. From these analyses, it becomes evident that service quality in sales environments cannot be seen as a secondary element. It is, instead, at the forefront of the customer journey. Whether a consumer is browsing casually or purchasing high-investment electronics, the perceived quality of service directly shapes their level of trust and engagement. For retail organizations like Worten, understanding these expectations and consistently meeting or exceeding them is key to sustainable success.

2.3. Contextualization and promotion of the sales sector in Portugal

The sales sector in Portugal has undergone significant development in recent years, both in terms of growth and strategic innovation. Companies are adapting rapidly to evolving consumer expectations, investing in modern promotional techniques, and reshaping their service models to stay competitive in a digitally accelerated market.

Commerce Expansion and Promotional Trends

In 2023, commercial turnover in Portugal climbed by 4.6%, reaching nearly €195 billion. This upward trajectory reflects the impact of robust marketing strategies, seasonal promotions, loyalty programs, and dynamic in-store campaigns. Businesses across the country have placed greater emphasis on offering value-driven incentives that go beyond pricing, focusing instead on enhancing the overall shopping experience. Specialized service providers, such as SIG Portugal, have played a key role in supporting these efforts by offering brand activation services and point-of-sale promotions that attract attention and engage customers more effectively. These marketing techniques have proven successful in boosting visibility and generating higher foot traffic.

The Rise of E-commerce

E-commerce continues to be a major force shaping the retail sector. According to recent data, the share of online purchases in overall retail activity increased by approximately 9% in 2023. Surveys indicate that 75% of companies operating in various sectors expect digital sales to expand even further in the coming years. This shift toward digital reflects broader changes in consumer behavior. Convenience, price transparency, and the ability to compare options easily have become dominant factors. Retailers are responding by enhancing their digital platforms, investing in user-friendly interfaces, offering faster delivery options, and integrating online and in-store experiences more seamlessly.

New Players and Growing Competition

The competitive landscape in Portugal has intensified with the entry of international players. For instance, the Spanish retailer Primaprix — known for selling well-known brands at discounted prices — is making inroads with store openings in cities like Porto, Lisbon, and Guimarães. This move signals a growing appetite for value-driven alternatives.

Likewise, Mercadona, another major Spanish supermarket chain, has aggressively expanded in Portugal. After five years in the country, the company plans to open 10 new stores in 2025, bringing its total to 70. These developments have intensified pressure on domestic retailers to refine their offerings, improve service quality, and innovate more rapidly to stay competitive.

Changing Consumer Behavior
Portuguese consumers are increasingly focused on savings and strategic buying. A recent study revealed that promotional items were involved in over 51% of purchase decisions. Additionally, 77% of respondents indicated that they regularly compare prices and lean toward budget-friendly brands. This behavior underscores the need for retailers to adopt agile, responsive sales strategies that meet the expectations of a price-conscious, digitally informed consumer base.

2.4. Characterization of the sales sector in Portugal

A Digital Surge
Portugal's retail sector, especially in e-commerce, has seen exponential growth over the past decade. In 2012, online commerce accounted for approximately €39 billion, representing 27% of all commercial transactions in the country. By 2013, this figure had risen to €49 billion — roughly 31% of the national GDP. Projections from that time estimated that e-commerce revenue could reach as much as €73 billion by 2017. Driving this growth was a significant rise in internet usage. In 2013, 64% of the Portuguese population (6.7 million people) were online, with 2.5 million actively engaging in e-commerce. This figure was expected to climb to 3.5 million by 2017, marking a clear transition toward digital retailing.

Product Diversity and Consumer Preferences
The most frequently purchased items online included consumer electronics, sports goods, home furnishings, and mobile phones. This trend aligns closely with Worten's product catalog, highlighting the importance of maintaining a strong digital presence in these categories. As for payment methods, consumers leaned heavily on digital wallets such as PayPal, followed by credit card payments and cash-on-delivery options.
Adapting to the Times
Faced with a digitally empowered consumer base, Portuguese retailers have had to modernize. Many have focused on digital transformation, investing in scalable e-commerce platforms, responsive customer service systems, and advanced analytics tools to personalize marketing and improve the customer journey. This continuous evolution is key to sustaining momentum and adapting to future disruptions.

2.4.1. Evolution of the sales sector in Portugal
Recent years have brought profound changes to how retail operates in Portugal. E-commerce, once a novelty, is now an integral part of the national economy, changing how consumers shop, what they expect, and how companies deliver.

Digital Commerce and Consumer Shifts
In 2022, online retail recorded another 9% growth, with food, fashion, and electronics emerging as dominant categories. The convenience of shopping online, the variety of choices, and flexible payment options have made digital platforms the preferred mode for many. This trend is expected to persist, if not accelerate, with the rise of mobile shopping and personalized marketing.

International Competition and Local Strategy
The arrival of retailers like Mercadona and Primaprix has intensified the need for innovation among Portuguese businesses. Worten, for example, faces pressure not just from local rivals but also from global competitors, requiring constant investment in customer service, product diversity, and omnichannel infrastructure.

Industry-Specific Examples
Portugal's footwear sector provides a strong case study in adaptation. Facing tough competition from countries with lower production costs, Portuguese firms have embraced automation and technological innovation. By 2030, the industry is projected to invest €600 million in modernizing operations, demonstrating how quality, innovation, and efficiency can coexist in a competitive strategy.

Conclusions on Sector Evolution
The transformation of the Portuguese retail landscape is far from over. Companies that succeed will be those that can merge digital agility with customer intimacy, creating retail experiences that are seamless, memorable, and value-rich.

2.4.2. Economic impact of sales at Worten in Portugal
As a flagship brand of the Sonae Group, Worten has a prominent role in the Portuguese economy, particularly within the electronics and home appliances sector. The company continues to show strong financial health and strategic growth. In 2023, Worten reported revenues of €1.3 billion, marking a 4.9% increase over the previous year. This growth reflects the brand's ability to adapt to both digital and physical retail trends. Online sales, for instance, grew by 6%, making up 16% of total revenue — a strong indicator of Worten's effective digital transformation strategy. In terms of physical expansion, Worten opened 18 new stores in 2023, 14 of which were part of the iServices brand. These new locations generated new employment opportunities and contributed to regional economic development.

Worten's dual investment in brick-and-mortar and digital platforms strengthens its role as one of Portugal's most influential retail employers and technology providers.

2.5. Worten

2.5.1. Contextualization of the Worten group
Founded in 1996 and integrated into the Sonae Group, Worten has grown into one of Portugal's most recognized names in the technology and electronics retail market. From its inception, the company has focused on offering a diverse catalog of cutting-edge products — from appliances to entertainment systems — and building a strong national presence through dozens of stores. Worten's online store has become a vital component of its strategy, especially in recent years. Beyond offering products, the brand provides comprehensive services, including home delivery, installations, repairs, and extended warranties. Initiatives like "Worten Resolve" aim to guarantee ongoing support and customer satisfaction after the sale. The company also prioritizes sustainability. Worten has implemented programs to recycle old equipment and reduce its environmental impact while continuing to invest in digital solutions and omnichannel integration. Although it once had physical operations in Spain, Worten has since restructured to focus more effectively on online commerce in international markets. Through its slogan "technology for everyone," Worten reiterates its mission to make innovation accessible and integrated into daily life for Portuguese consumers.

3. RESEARCH METHODOLOGY

This research follows a quantitative methodology designed to capture customer perceptions of service quality at two Worten stores: Rio Sul and Colombo. A questionnaire comprising 28 questions was created and distributed via Google Forms. Of these, 12 questions were dedicated to each store, allowing for balanced comparative insights. The remaining questions collected demographic data and general information about the respondents' familiarity and experiences with the Worten brand. Distribution was done mainly through Instagram, leveraging its high engagement and broad user base. A total of 54 responses were collected — a sufficient sample for a focused comparative analysis. The sample was selected using a non-probabilistic, convenience-based approach. Although it was not randomized, care was taken to ensure diversity in responses, covering various age groups and usage behaviors. Collected data focused on service quality dimensions such as store layout, staff professionalism, product availability, speed of service, and overall satisfaction. Descriptive and comparative statistical analysis methods were used to uncover meaningful trends.

4. PRESENTATION AND DATA PROCESSING

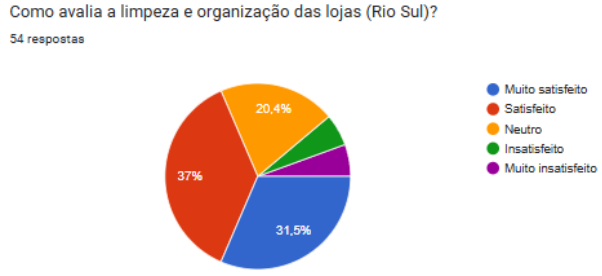
Following the data collection phase, responses were organized using Excel and prepared for statistical analysis. For each store, responses were reviewed and categorized, with averages, frequency distributions, and percentages calculated for key variables. Each set of 14 store-specific questions was evaluated separately and then compared to reveal differences in customer satisfaction, service perception, and operational efficiency. Graphical representations — including bar charts and pie charts — were created to visually convey the results. These visual tools made it easier to identify patterns and highlight where one store outperformed the other or where both shared similar strengths or weaknesses. By comparing responses from the same participants regarding two different locations of the same brand, the study uncovered contextual nuances in customer perception. These findings contribute directly to the development of data-driven recommendations aimed at improving service quality and overall customer experience at Worten.

4.1. Google forms

4.1.1 How do you evaluate the cleanliness and organization of the stores?

Distribution of evaluations regarding the cleanliness and organization of the stores at Rio Sul Shopping. The majority of customers are satisfied (37%), while 31.5% are very satisfied. Only 20.4% were neutral, and 11.2% remained dissatisfied or very dissatisfied. This indicates the need for improvements in the store environment.

Distribution of evaluations regarding the cleanliness and organization of the stores at Colombo Shopping. The majority of respondents are satisfied (40.7%), while 29.6% are very satisfied and 22.2% are neutral. Only 7.5% maintain an opinion of dissatisfaction or strong dissatisfaction. The data indicates a predominantly positive perception.





4.1.2. Does the store have modern and well-maintained equipment?

Customer perception of the modernity and maintenance of equipment in the stores at Rio Sul Shopping. The majority of respondents (66.6%) are either satisfied or neutral, with 20.4% being very satisfied. However, 13% express dissatisfaction, suggesting opportunities for modernization and maintenance to improve satisfaction.

Evaluation of the equipment in the stores at Colombo Shopping. The majority of customers are satisfied, with 37% very satisfied and 31.5% satisfied. Only 9.3% express dissatisfaction. The overall perception is positive, suggesting that the equipment meets consumer expectations well.





4.1.3. Are the employees well-presented and uniformed?

Evaluation of the presentation and uniformity of employees in the stores at Rio Sul Shopping. The majority are satisfied (62.9%), with 25.9% being very satisfied. However, 14.9% express dissatisfaction, indicating room for standardization and improvements in the employees' image.

Customer perception of the presentation and uniformity of employees at Colombo Shopping. The vast majority (77.7%) are satisfied or very satisfied, reflecting a positive image of the staff. Only 7.5% express some level of dissatisfaction, and 14.8% remain neutral.

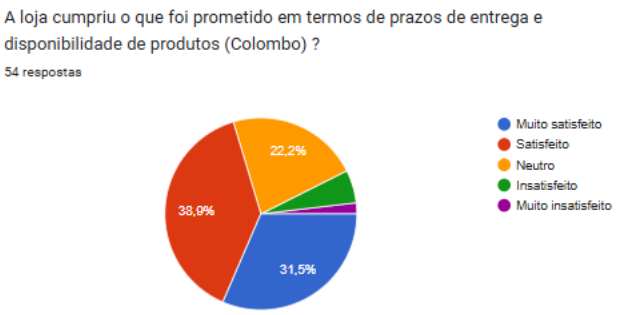




4.1.4. Did the store fulfill what was promised in terms of delivery times and product availability?

Evaluation of the fulfillment of delivery times and product availability in the stores at Rio Sul Shopping. The majority of customers are satisfied (59.3%), with 24.1% very satisfied. However, 28.6% are neutral, and 13% are dissatisfied, suggesting the need for improvements in inventory control and delivery times. Satisfaction regarding the fulfillment of delivery times and product availability in the stores at Colombo Shopping. The majority of customers (70.4%) are satisfied or very satisfied, with a low dissatisfaction rate (7.5%). The data suggests good logistical performance and stocking in the stores at the location (*Graphs following on the next page*).

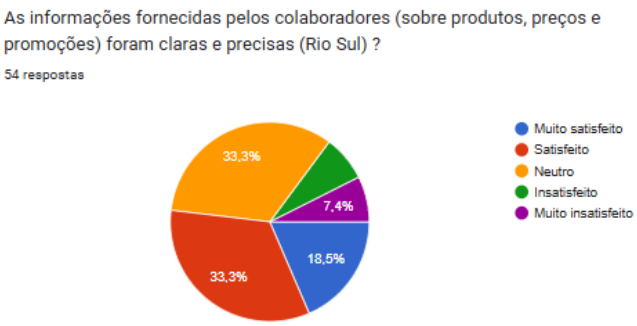


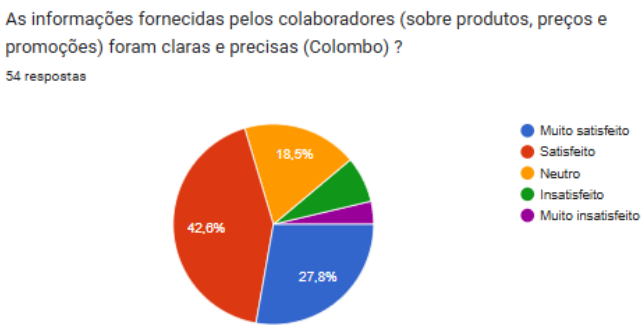


4.1.5. Were the information provided by the employees (about products, prices, and promotions) clear and accurate?

Clarity and accuracy of the information provided by employees in the stores at Rio Sul Shopping. Only 18.5% are very satisfied, while 33.3% are satisfied, and the same percentage remains neutral. With 14.8% expressing dissatisfaction, the data suggests the need to reinforce employee training regarding communication with customers.

Evaluation of the clarity of information provided by employees at Colombo Shopping. The majority of customers (70.4%) are satisfied or very satisfied, demonstrating good performance in communication. Only 11.2% express dissatisfaction, while 18.5% remain neutral.



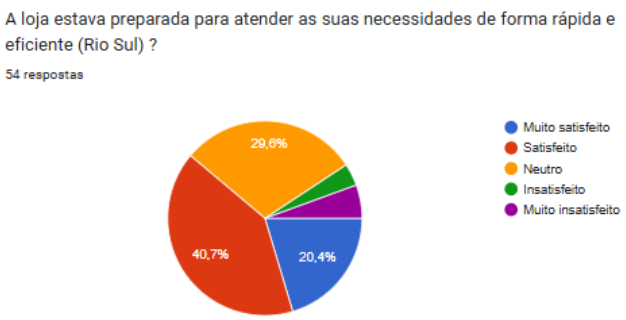


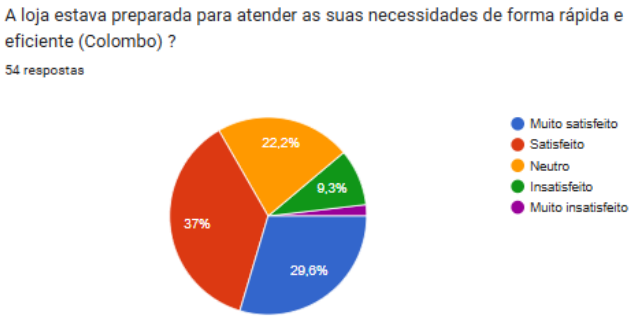
4.1.6. Was the store prepared to meet your needs quickly and efficiently?

Evaluation of the readiness and efficiency of service in the stores at Rio Sul Shopping. The majority of customers (61.1%) are satisfied or very satisfied, although 28.6% have a neutral opinion and 11.1% report dissatisfaction. This indicates overall good performance, with opportunities for improvement in service time and quality.

Customer perception of the ability of the stores at Colombo Shopping to provide quick and efficient service. The majority (66.6%) are satisfied or very satisfied, with only 11.2% dissatisfied. The performance is positive, with potential to reduce neutrality (22.2%) and enhance the perceived excellence.

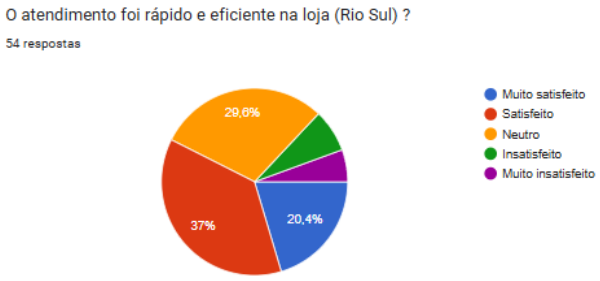
Graphs following on the next page





4.1.7. Was the service quick and efficient in the store?
Evaluation of service in the stores at Rio Sul Shopping regarding speed and efficiency. The majority (57.4%) are satisfied or very satisfied, but 29.6% are neutral, and 13% report dissatisfaction. There is room for improvement in response time and the quality of customer interaction.

Evaluation of the agility and efficiency of service at Colombo Shopping. The majority of customers (66.7%) are satisfied or very satisfied, with a low dissatisfaction rate (5.6%) and 27.8% neutral. The data indicates good performance in customer service.





4.1.8. When you requested assistance, were you attended to efficiently and without delay?
Evaluation of the assistance provided when requesting support at Rio Sul Shopping. Only 16.7% are very satisfied, while 38.9% are satisfied and 27.8% are neutral. With 16.7% expressing dissatisfaction, this is one of the more sensitive areas, indicating the need for improvements in support and agility for specific requests.

Customer perception of the assistance provided when requesting support at Colombo Shopping. With 68.5% satisfaction and only 9.3% dissatisfaction, the data indicates strong performance, surpassing Rio Sul in this aspect, highlighting the preparedness of the teams for customer support.

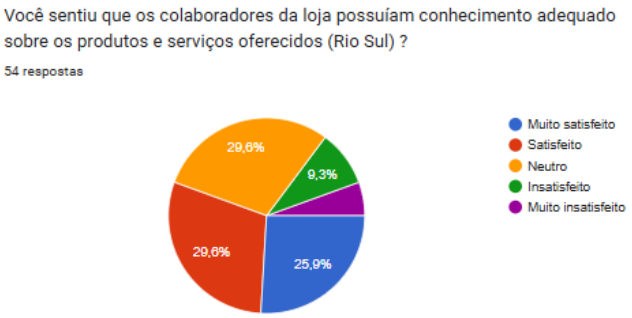


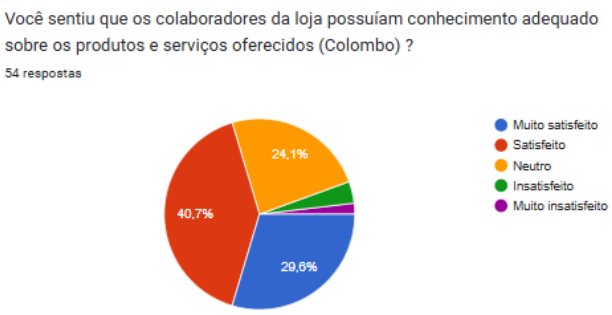


4.1.9. Did you feel that the employees at the store had adequate knowledge of the products and services offered?

Evaluation of employees' knowledge about products and services in the stores at Rio Sul Shopping. With 55.5% satisfaction, the result is moderately positive, but the high rate of neutrality (29.6%) and 14.9% dissatisfaction indicate room for improvement in training and team development.

Perception of employees' knowledge in the stores at Colombo Shopping. With 70.3% of customers satisfied or very satisfied, and only 5.6% dissatisfied, this is one of the best results in the survey, indicating strong team preparation to guide and inform customers.

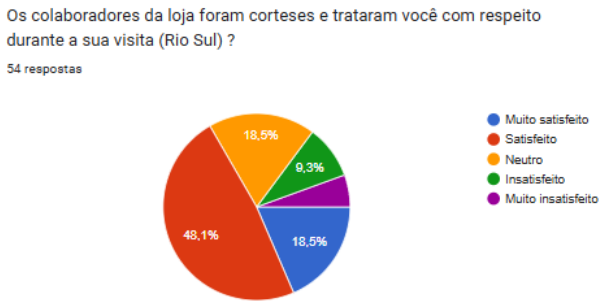


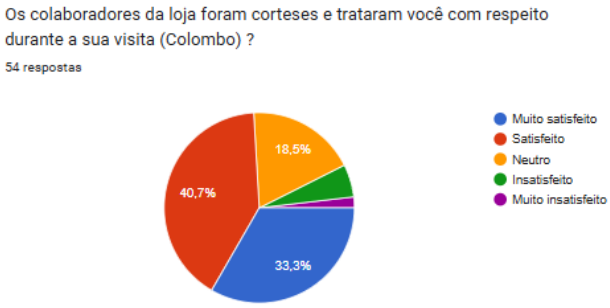


4.1.10. Were the employees at the store courteous and treated you with respect during your visit?

Evaluation of the courtesy and respect of employees during the visit to Rio Sul Shopping. The majority (66.6%) of customers expressed satisfaction, but 14.8% indicated dissatisfaction, suggesting the need for standardization in service and reinforcement of a culture of respect and customer care.

Evaluation of the courtesy and respect of employees at Colombo Shopping. With 74% satisfaction and only 7.5% dissatisfaction, the result reflects a high standard of personalized service, making it one of the strongest points of the unit's performance.

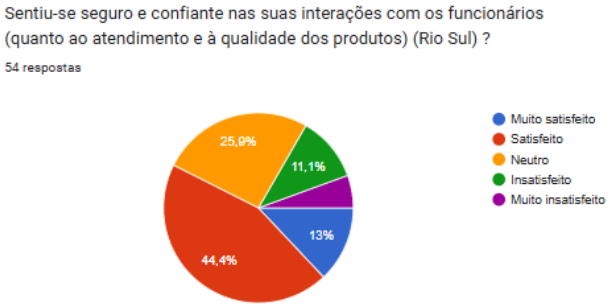


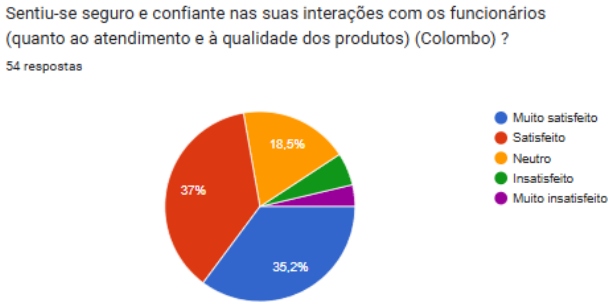


4.1.11. Did you feel safe and confident in your interactions with the employees (regarding service and product quality)?

Evaluation of safety and confidence in interactions with employees at Rio Sul Shopping. While 57.4% of customers are satisfied, the low rate of complete satisfaction (13%) and 16.7% dissatisfaction highlight weaknesses in the experience, suggesting the need to strengthen trust and consistency in service and the products offered.

Evaluation of safety and confidence in interactions with employees at Colombo Shopping. With 72.2% satisfaction and only 9.3% dissatisfaction, the data indicates a positive experience, with a notable high rate of complete satisfaction (35.2%), reinforcing trust in the teams and the products offered.

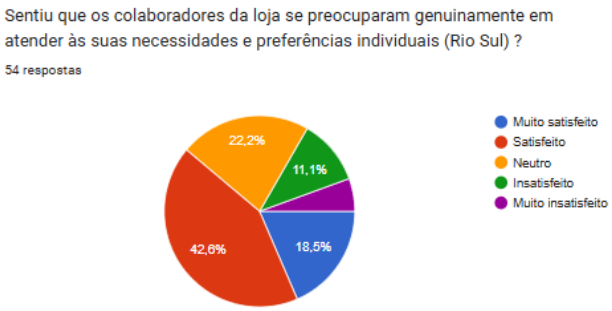


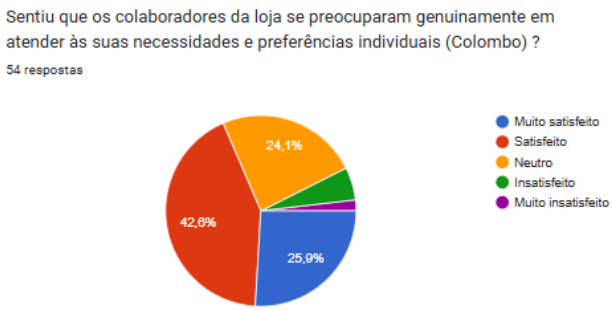


4.1.12. Did you feel that the employees at the store genuinely cared about meeting your individual needs and preferences?

Evaluation of the perception of individual care by employees at Rio Sul Shopping. Although the majority of customers are satisfied (61.1%), the dissatisfaction rate (16.7%) and neutrality (22.2%) suggest opportunities for humanizing and personalizing service, especially in terms of active listening and attention to customer preferences.

Perception of individual care in customer service at Colombo Shopping. With 68.5% of customers satisfied and only 7.5% dissatisfied, the data reflects a more humanized and personalized service compared to Rio Sul, highlighting the advantage of a close relationship with customers.

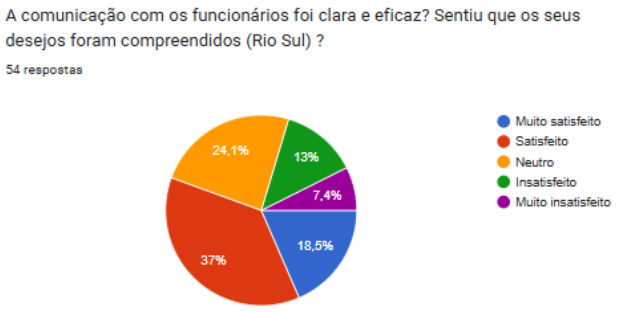


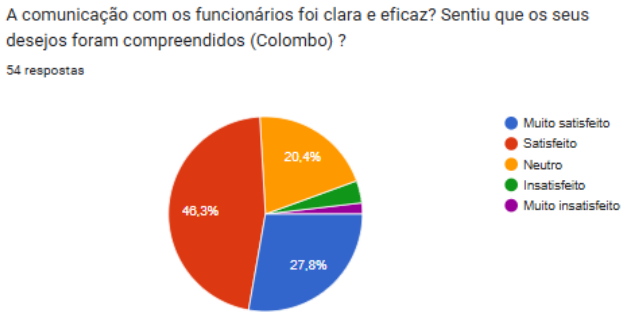


4.1.13. Was the communication with the employees clear and effective? Did you feel that your desires were understood?

Evaluation of the clarity and effectiveness of communication with employees at Rio Sul Shopping. Only 55.5% of customers are satisfied, while 24.1% remain neutral and 20.4% are dissatisfied — the highest negative rate in the survey. The result highlights an urgent need for improvements in active listening, empathy, and alignment between expectations and delivery.

Evaluation of communication with employees at Colombo Shopping. With 74.1% of customers satisfied and only 5.6% dissatisfied, this is one of the strongest points of the unit, demonstrating effective, clear communication that is well-aligned with customer needs (*Graphs following on the next page).*

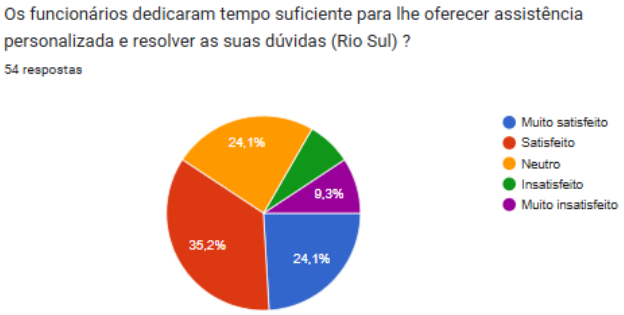


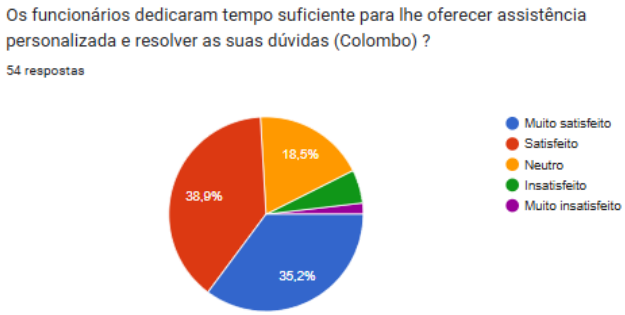


4.1.14. Do the employees dedicate enough time to offer you personalized assistance and resolve your doubts?

Evaluation of the time and attention dedicated by the employees of Rio Sul Shopping. Despite 59.3% of customers being satisfied, 16.6% expressed dissatisfaction, and 24.1% remained neutral, revealing the need for more personalized attention in customer service.

Evaluation of the attention and time dedicated by the employees at Colombo Shopping. With 74.1% of customers satisfied and only 7.5% dissatisfied, personalized service is one of the strengths of the unit, demonstrating care and availability in customer relations.



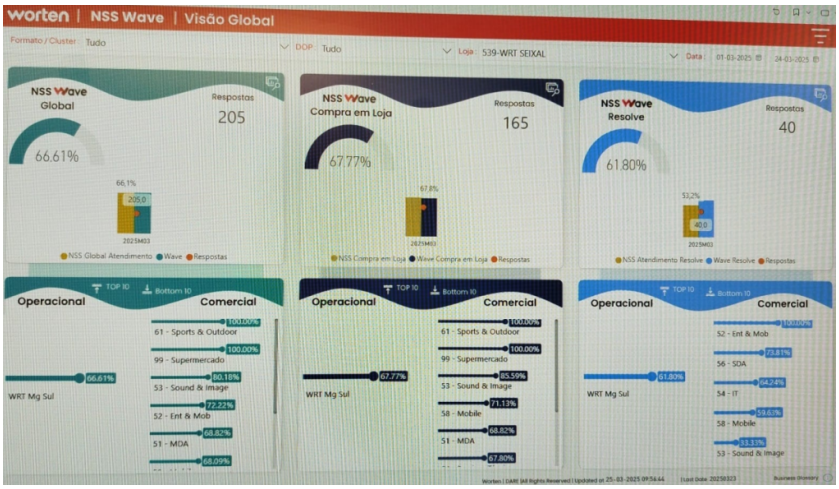


4.2. Internal data



We obtained this image by directly speaking with the company. From it, we can observe that there were 179 responses to the survey, and the approach rate of the employees at the Worten store in Rio Sul is 67.4%. More specifically, the check-in rate is 32.64%, meaning that 32.64% of customers were approached upon arriving at the store.

The zoom-in rate was 91.72%, indicating that 91.72% of customers had their questions answered. The specialist transaction rate was 76%, and 73.73% of customers felt that the employee provided a good check-out experience.



In this image, we can observe the overall wave rate of Worten, which corresponds to 66.61%. When comparing the overall rate with the rate at Rio Sul, a difference of approximately 1% is noted, leading us to conclude that this is a positive rate.

5. FINAL CONSIDERATIONS

Comparative analysis of service and operations at Worten stores (Riosul vs. Colombo)

The Colombo store demonstrated superior performance in 12 of the 14 dimensions evaluated, particularly standing out in communication, empathy, and perceived safety. In clear and effective communication with customers, for example, Colombo achieved 74.1% satisfaction, compared to 55.5% at Rio Sul—a difference of nearly 19 percentage points, reflecting a better alignment between expectation and delivery. Regarding safety and trust in interactions, Colombo scored 72.2% satisfaction, while Rio Sul was only at 57.4%. Furthermore, the Colombo store showed stronger results in aspects related to empathy and individualized attention, such as concern for customer needs and time spent, with a difference of over 10% in both metrics. These data reveal a more mature and humanized service model at the Colombo unit, with a stronger focus on customer experience and operational excellence.

Despite the lower performance in several subjective criteria, the Rio Sul store also had some strengths. These include meeting deadlines and product availability—metrics close to or slightly below those of Colombo—indicating a reasonably efficient logistics operation. It also stands out positively in store organization and employee appearance. However, the main challenge for this unit is translating its solid organizational structure into a more personalized and empathetic service.

The operational data from the NSS Wave, provided by Worten itself, reinforce the results seen in the comparative charts. The Rio Sul store has an NSS score of 67.4%, slightly above the company's global average (66.61%), indicating stable performance, though not remarkable. When analyzing the indicators by stage of the customer journey, critical failures are observed in the initial approach. The Check-in index is at 32.64%, meaning less than one-third of customers are approached when entering the store—which compromises engagement and connection from the start.

On the other hand, the subsequent stages show positive results: Zoom-in at 91.72%, Transition to Specialist at 76%, and Check-out at 73.73%. This indicates that service improves over the course of the journey but falters at the beginning. This analysis is confirmed by qualitative data, which show that the lack of initial attention negatively impacts customer perception regarding empathy, personalization, and understanding of their needs.

The main weaknesses identified at the Rio Sul store include low perceived empathy—16.7% of customers reported unsatisfactory service regarding personalization and time spent—and communication issues, with 20.4% dissatisfied, the highest negative index among all indicators. Additionally, there is a disconnect between the technical operation—which works well—and the human relationship, which still has flaws.

To align the Rio Sul store with the level of excellence seen at Colombo, several strategic actions are recommended. It is urgent to strengthen human training, focusing on active listening, empathy, personalization, and clear communication. It is also recommended to implement proactive engagement strategies to increase the Check-in index and initial customer contact. Conducting benchmarking activities with the Colombo store could help replicate successful practices, such as routines for interdepartmental integration and humanized check-out. Finally, continuous monitoring of qualitative indicators is essential, using NSS Wave dashboards to support agile and effective decisions.

In summary, the comparative study between Rio Sul and Colombo highlights that customer experience is the main differentiating factor between units with similar operations. Colombo demonstrates that with empathetic service and effective communication, it is possible to turn visits into positive experiences, even within the same network and corporate structure. The Rio Sul store, despite being close to the company's average, has the potential to evolve from a functional operation to a reference in customer experience—provided it strategically invests in the people who build this journey.

Study Limitations Despite the robustness of the analyzed data, the study has some important limitations. First, the analysis is based exclusively on quantitative customer satisfaction data and internal operational indicators, without including in-depth qualitative interviews with employees or customers, which could enrich the understanding of the reasons behind the observed perceptions. Additionally, the data collected are specific to a determined time frame, and may not reflect seasonal variations or recent changes in store operations. Finally, the lack of detailed demographic data on respondents limits segmented analysis by customer type. Suggestions for Future Research To deepen this investigation, the following is recommended:

- Include qualitative methods in future studies, such as in-depth interviews or focus groups with customers and employees, to capture emotions, expectations, and perceptions that quantitative data do not reveal.
- Expand the temporal sample by incorporating data from different months and promotional periods, which would allow for evaluating the consistency of the observed patterns.
- Investigate the impact of customer profiles (age, visit frequency, preferred purchase channel) on the experience perceived at each unit.
- Assess the impact of corrective actions proposed, should they be implemented, through longitudinal studies.
- Compare other Worten units to map whether the Colombo case is an exception or part of a broader trend of good practices in other regions.

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FROM SCREEN TO PLACE: FILM TOURISM, CULTURAL MEMORY AND PLACEMAKING IN THE BUD SPENCER–TERENCE HILL LEGACY

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business
papp-vary.arpad@uni-bge.hu

ABSTRACT

Bud Spencer and Terence Hill remain unusually visible in popular culture more than half a century after their breakthrough. This article examines one particular dimension of that longevity: how their screen-based cultural legacy has acquired a physical geography. Drawing on examples from Italy, Spain, the United States, Germany and Hungary, it follows the phenomenon from filming locations and screen-related destinations to museums, statues, public-space names, murals and festivals. The cases show that filming alone does not create tourism value: the connection between screen and place has to be recognised, interpreted and activated. At the same time, the relationship can also work in the opposite direction, when communities bring an established popular-cultural reference into a place that was not originally connected with filming. Five overlapping forms of spatial activation emerge: film-location tourism, screen-induced destination image, biographical or celebrity heritage, culture-led placemaking, and event-led temporary placemaking. The Spencer–Hill case therefore connects film-induced tourism with a broader process of culture-led placemaking and shows how shared popular-cultural memory can become part of destination experience and place identity.

Keywords: *Bud Spencer; Terence Hill; film-induced tourism; place branding; placemaking; cultural memory; popular culture*

1. INTRODUCTION

Bud Spencer and Terence Hill are an unusual case in popular culture. Their most successful joint films were made mainly in the 1970s and early 1980s, yet the duo is still watched, quoted and celebrated decades later. In Hungary and Germany in particular, their films became more than imported entertainment: dubbed dialogue, recurring television broadcasts, music and fan culture turned them into part of everyday cultural memory (Beretvás, 2017). Earlier studies examined this success from a marketing perspective and later described the renewed visibility of the cult (Papp-Váry, 2015, 2016, 2021). This article focuses on one consequence of that longevity: the Spencer–Hill phenomenon has gradually acquired a geography of its own. The most obvious examples are places that audiences recognise from the screen. Fans may visit a landscape where a Trinity film was shot, a Miami location used in one of the later comedies, or a town strongly associated with Terence Hill through television. Yet the geography does not end with filming locations. It also includes a Bud Spencer park and statue in Budapest, a mural in Tárnok, Hungary, a Terence Hill museum in Lommatzsch, Germany and festivals that temporarily transform their host cities. The central question is therefore simple: how does a screen-based cultural phenomenon become attached to physical places? The article follows this process step by step. It begins with film tourism and locations connected directly with production, then moves to destinations shaped by repeated screen representation, and finally to places where Spencer–Hill cultural memory has been materialised through names, monuments, museums, public art and events. The purpose is not to force the duo into an unnecessarily complicated theoretical construction, but to use a particularly visible popular-cultural case to show how screen memory can become a tourism resource and, eventually, part of place identity.

2. THE SPENCER–HILL PHENOMENON: FROM FILM SUCCESS TO CULTURAL MEMORY

Bud Spencer and Terence Hill constitute one of the most distinctive and enduring partnerships in European popular cinema. Together, they appeared in seventeen films, while both actors also developed substantial individual screen careers. Although the peak of their joint cinematic success occurred during the 1970s and the first half of the 1980s, their films have remained remarkably visible decades after their original theatrical release. Television reruns, home-video editions, streaming availability, fan communities, festivals, books, merchandise and, more recently, videogames and other forms of cultural reactivation have enabled the Spencer–Hill universe to survive well beyond the conventional commercial lifecycle of motion pictures. This longevity is particularly striking in Italy, Germany and Hungary, where the two actors continue to enjoy a level of recognition and affection that exceeds ordinary nostalgia for popular films of the period. The earlier studies on which the present analysis build (Papp-Váry, 2015, 2016, 2021) already identified this geographically uneven reception, noting especially the cult status achieved by the duo in Germany and Hungary, alongside their continuing importance in Italy. An earlier indication of the extraordinary international recognition of the pair came in 1999, when Time Magazine, in connection with the enormous success of Roberto Benigni's Life Is Beautiful, published a ranking of the best-known Italian actors in which Bud Spencer and Terence Hill reportedly occupied the first two positions. This was particularly striking given the presence of internationally celebrated Italian stars such as Sophia Loren, Gina Lollobrigida, Claudia Cardinale, Marcello Mastroianni and Franco Nero. The example illustrates how popular recognition of Spencer and Hill could exceed the prestige hierarchy traditionally associated with Italian cinema (Papp-Váry, 2016). The depth of this fan culture was already visible well before the current wave of reactivation. In Germany, for example, the Spencer–Hill Database created by Dennis and Eric Heyse had by 2016 catalogued approximately 330 productions connected in some way with Spencer or Hill and information on around 4,000 performers associated with these works (Papp-Váry, 2016). Such fan-produced archives indicate that the phenomenon had already developed forms of systematic preservation normally associated with much more formally recognised cultural subjects. This persistence is noteworthy because Bud Spencer and Terence Hill were never conventional representatives of prestigious European cinema. Their films were popular rather than highbrow cultural products, and their formula was deliberately straightforward. Bud Spencer himself humorously described their work in terms of the "infantilism of didactic films" (Spencer, 2014: 33). Yet this apparent simplicity has not prevented the duo from attracting scholarly attention. Christian Heger devoted a substantial academic study to their films under the title "Die rechte und die linke Hand der Parodie: Bud Spencer, Terence Hill und ihre Filme" (Heger, 2009), a title that playfully refers to the German title of "They Call Me Trinity" (1970), "Die rechte und die linke Hand des Teufels". Nevertheless, the apparent simplicity of the films may be one of the reasons for their extraordinary durability. Their cinematic universe was immediately understandable, highly recognisable and remarkably consistent. The audience knew what a Spencer–Hill film promised: two contrasting protagonists, comic conflict between them, villains who deserved punishment, spectacular but largely bloodless fights, memorable music, food, humour and, ultimately, the restoration of justice. The phenomenon therefore cannot be adequately explained by box-office success alone. Many commercially successful films disappear from collective memory within a relatively short period. Spencer and Hill instead developed what can retrospectively be interpreted as a highly distinctive cultural brand. Their names, faces, body language, fighting styles, musical themes, recurring situations and even particular foods became interconnected signs within a recognisable symbolic universe.

Yet neither dubbing, music, food nor fighting alone sufficiently explains the phenomenon. Its central element remains the duo itself. The basic formula was exceptionally simple: Spencer and Hill usually portrayed friends or brothers whose appearances, temperaments and methods could hardly have been more different, but who ultimately shared the same moral orientation. As Spencer explained, both characters were fundamentally good-hearted and, when the good defend the weak against the bad, the underlying appeal becomes almost universal (Papp-Váry, 2015, 2016, 2021). Their differentiation was therefore not a weakness that needed to be overcome but the very foundation of the product. In marketing terms, the contrast made the partnership recognisable; culturally, however, this formula was considerably older than either actor. That shared identity is important for the present article because it is precisely this recognisable cultural package – not a single film, prop or location – that fans later carry into physical places.

3. FROM FILM TOURISM TO PLACE: ANALYTICAL FRAMEWORK

Film tourism provides the natural starting point. Irimiás (2015) defines it as travel in which visiting a film location or film-production location constitutes the tourist's primary motivation. She approaches that motivation through three interrelated dimensions: Place, Performance and Personality. Place refers to the attraction of locations represented in or associated with films; Performance concerns the narrative, themes and experiences embodied by the screen product; and Personality highlights the motivational power of actors and stars. The Spencer–Hill phenomenon can involve all three at once: fans may want to see a physical location, symbolically re-enter a familiar cinematic world, or simply feel closer to the two actors. The transformation from fandom into mobility is visible even in later cultural products devoted to the phenomenon itself. "They Called Him Spencer" (2017) turns the search for Bud Spencer into a European road movie in which two fans travel through several countries while encountering people and places connected with the Spencer–Hill universe (Austrian Film Institute, 2017). The documentary provides an unusually literal illustration of the mechanism examined here: attachment created on screen becomes a reason to travel. However, the existence of a screen connection does not automatically create a tourism product. A location may have appeared in a famous film and still remain almost invisible to visitors if the association is not marked, explained or promoted. Conversely, a place that was never a Spencer–Hill filming location may later adopt the duo's cultural symbols and make them part of its own environment. This difference provides the basic structure of the analysis. The first part follows the conventional direction from screen to destination; the second examines the reverse movement, in which an established cultural memory is deliberately written into place.

The following analysis uses a qualitative, interpretive case approach. Rather than treating every place-related manifestation as the same form of film tourism, it compares how different screen, biographical and cultural connections can be activated as tourism resources or elements of place identity. The categories overlap: a single place may combine more than one mechanism, and the relationship can develop over time. The broader film-tourism literature provides a concise foundation for this distinction. Riley, Baker and Van Doren (1998) demonstrated that successful films can generate sustained increases in visitation to screen locations. Hudson and Ritchie (2006) emphasised that destinations can actively convert screen exposure into tourism value through coordinated marketing, while Beeton (2016) treats film-induced tourism as a broad field extending beyond filming sites to studio attractions, tours and other screen-related experiences. These perspectives are particularly useful for the Spencer–Hill case because its geography includes both conventional film locations and less conventional forms of cultural spatialisation.

4. FILMING LOCATIONS: FROM CINEMATIC RESOURCE TO TOURISM PRODUCT

The earlier Spencer–Hill research already revealed a paradox (Papp-Váry, 2015, 2016, 2021). Potential demand clearly existed, particularly among dedicated German and Hungarian fans, but the corresponding tourism supply appeared surprisingly underdeveloped. To borrow one of the duo's best-known Hungarian-dubbed lines, the situation on the supply side could almost be summarised as: "The pistachio is gone; there never was any chocolate." The joke fits because many destinations possessed the underlying cinematic resource but had done remarkably little to turn it into a visible tourism product. Many locations had disappeared since filming in the 1970s and early 1980s, while surviving sites frequently contained little or no indication of their connection to the films. Abruzzo provides an important exception. Pagello (2025) identifies "They Call Me Trinity" (1970) and particularly "Trinity Is Still My Name" (1971) as the most successful films ever to have been partially shot in the region and explicitly describes them as the origin of one of Abruzzo's relatively rare film-tourism phenomena. Campo Imperatore is especially significant. Although the landscape did not represent itself on screen but substituted for the American West, the adventures of Spencer and Hill introduced it into the collective imagination of mass audiences (Pagello, 2025). Today the association is also physically marked: a tourist sign identifies the location used for "Trinity Is Still My Name" (Pagello, 2025). The Campo Imperatore example shows why the cinematic meaning of a location matters as much as geographical authenticity. Irimiás (2015) emphasises that viewers invest screen places with emotions, moods and meanings derived from films. Visitors may therefore seek not simply the physical landscape but the imagined cinematic place superimposed upon it. Miami shows what happens when the physical connection survives but interpretation does not. Several Spencer–Hill-related productions were set or filmed there, including "Crime Busters" (1977), "Go for It" (1983), "Miami Supercops" (1985) and "Odds and Evens" (1978). The earlier research (Papp-Váry, 2015, 2016, 2021) identified surviving locations associated with recognisable scenes but found no interpretative signage connecting them with this cinematic history. The location used for the pelota (jai alai) sequence in "Odds and Evens" is particularly illustrative: the site itself can still be identified and visited by fans, yet its connection with the film appears to remain largely unmarked and unexploited for film-tourism purposes. A similar pattern can be seen around Tabernas near Almería, Spain. The landscape served as a location for numerous Westerns, including the duo's first joint film, "God Forgives... I Don't!" (1967), as well as Bud Spencer's later "Buddy Goes West" (1981). The area developed substantial film-tourism infrastructure, but it traditionally foregrounded the broader spaghetti-western heritage – especially globally recognised names such as Sergio Leone and Clint Eastwood – rather than the Spencer–Hill connection. The cinematic and advertising heritage of the landscape is even wider: it was also used for a 2002 Pepsi commercial starring David Beckham. The same scenery has therefore been repeatedly reactivated by internationally recognisable entertainment brands, while its specific Spencer–Hill associations have remained comparatively underdeveloped. These three cases lead to the first clear conclusion. Filming creates potential, not value by itself. A film-tourism asset emerges when the connection is identified, interpreted, communicated and made consumable as an experience. This is consistent with both Irimiás's (2015) supply-side perspective and Cauduro's (2025) emphasis on governance, promotion and dedicated strategies. Digital tools – movie maps, dedicated websites and applications – can also help connect screen narratives with geography, especially where surviving locations currently lack visible on-site interpretation (Cauduro, 2025). Digital tools have begun to change this supply-side situation, often through bottom-up fan activity rather than formal destination marketing. The German Spencer/Hill Datenbank provides a particularly developed example.

Its dedicated set-location section systematically compares frames from films with contemporary photographs taken at the original sites, allowing users to see how locations have changed over time. The database covers locations in Italy, Germany, Spain, the United States and elsewhere and, for individual scenes, may provide addresses and timecodes. The Piedone films provide a particularly revealing example. In 2013, German fans behind the Spencer/Hill Database travelled to Naples to revisit and document filming locations from all four films in Bud Spencer's "Piedone" series: "Piedone lo sbirro" ("Flatfoot Cop", 1973), "Flatfoot in Hong Kong" (1975), "Flatfoot in Africa" (1978), and "Flatfoot in Egypt" (1980). For "Piedone lo sbirro" alone, the database documents 40 scene–location connections in Naples, Pozzuoli and Rome, while other location reports have continued to be updated with photographs taken as recently as 2024 (Spencer/Hill Datenbank, 2026a). In this way, fan knowledge begins to perform a function that official tourism interpretation often does not: it identifies otherwise unmarked screen places and makes them findable for other visitors. A particularly revealing Hungarian example is TizenhatosDokk, a fan-created website devoted specifically to Bud Spencer and Terence Hill filming locations. Its core format is the comparison of film frames with present-day photographs taken from approximately the same viewpoint. The project has documented field visits to Naples and its surroundings, Vienna, Madrid, Rome and London, while each comparison provides GPS coordinates so that other fans can locate and visit the sites themselves (Molnár, 2026). The significance is not merely archival. By publishing coordinates, maps, photographs and practical location reports, the site effectively converts individual fan research into informal film-tourism infrastructure. Google Maps has become part of the location-discovery process itself. In a 2021 interview, the creator of TizenhatosDokk described using Google Maps to identify overseas locations before visiting them physically. For a difficult scene from "Crime Busters", he searched Miami from above for roads ending at the coast; in another case, placing the Street View figure on the map gradually revealed buildings that matched the film. Some locations could be identified quickly, while others required repeated searching over several years (Meronka, 2021). Earlier Hungarian fan activity had already produced an interactive map of Florida locations connected with films such as "Who Finds a Friend Finds a Treasure", "Odds and Evens", "Go for It", "Crime Busters" and "Miami Supercops", allowing users to compare original film images with Google satellite imagery (Firpo hadnagy, 2017). Digital mapping therefore enables a form of virtual location hunting even before travel occurs and can also stimulate later physical visitation. The process increasingly overlaps with social media. Meronka (2021) encountered the TizenhatosDokk project through Facebook, where 'then and now' location images were being circulated to fans. This adds another stage to the film-tourism cycle: a location can be identified digitally, visited physically, rephotographed from the cinematic viewpoint and then redistributed through websites or social platforms, where it may inspire further searches and visits. The visitor is no longer only a consumer of a destination; the fan can become a producer of location knowledge for the next visitor. Naples shows how this bottom-up logic can coexist with more formal digital film-tourism initiatives. The NapolinTour project presents a digitally mediated route through the city's extensive cinematic geography and explicitly includes Bud Spencer's four "Piedone" films among the more than 565 productions associated with Naples. Its 360-degree virtual-tour format links well-known screen works with streets, squares, buildings and cultural sites across the city (Remiam, 2026). It is not a Spencer-specific application, but it demonstrates how the "Piedone" legacy can be incorporated into a broader digital interpretation of Naples as a film city. Taken together, these examples suggest an additional mechanism of activation: screen -> digital identification -> physical visit -> digital documentation -> new visitor. Where official signage is absent, fan databases, GPS coordinates, Google Maps, online maps and social media can partially bridge the gap between cinematic memory and geographic space.

5. WHEN THE SCREEN SHAPES DESTINATION IMAGE

The relationship becomes more interesting when the screen does not merely point visitors towards a single location but helps shape the image of a destination. Terence Hill's later television career provides two particularly clear examples. Gubbio became closely associated with "Don Matteo", in which Hill portrayed the crime-solving priest. Re (2026) places the series within the broader visual construction of "Destination Italy", identifying its medieval villages and bucolic countryside as part of the television imagery that has contributed to particular perceptions of Italian territory. The series achieved exceptional popularity: even during its eighth season, it attracted more than 30 per cent of television viewers and reportedly outperformed UEFA Champions League broadcasts in audience share. The town actively communicated filming times and locations and linked the series to visitor interest. Lüdeke (2013: 181) also records a striking contrast after the 1997 earthquake: while visitor numbers across Umbria declined by approximately 20 per cent, Gubbio reportedly experienced an increase in advance bookings. This does not by itself prove causality, but it illustrates the possible economic significance of a strong screen–place association. "Un passo dal Cielo" shows the same mechanism at a much larger scale – and also its possible limits. With Terence Hill in the leading role during its early seasons, the series repeatedly exposed viewers to the landscapes of Val Pusteria and particularly Lago di Braies. Michielin (2022) notes that repeated appearance across episodes and seasons can create an increasingly familiar relationship between viewers and place. Moretto (2024) describes an "Un Passo dal Cielo effect": between June and September 2018, more than 1.2 million visitors were recorded at Lake Braies, with 17,874 visitors on the peak day. The resulting pressure contributed to concerns about overtourism and environmental sustainability and eventually to access restrictions. The lesson is important for place marketing: screen visibility can be underused, but it can also become too successful. Naples offers a third and conceptually different example because here the relationship is not centred on one picturesque location. It is built around a city with a long cinematic identity and a character who became inseparable from that city. Saracino (2024) describes Naples as an "open-air set" that has attracted local, national and international productions since the early history of cinema, but he also stresses that the city has increasingly functioned as more than a background: it has become a complex cinematic character capable of influencing narratives. This is particularly relevant to Bud Spencer's Inspector Rizzo, or "Piedone". The Piedone films connected Spencer's screen persona strongly with Naples, placing the character inside an already dense cinematic representation of the city. That relationship did not disappear with the original films. More than half a century later, the property was revived in "Piedone – Uno sbirro a Napoli", a four-part Sky Original series that premiered in December 2024, 51 years after the release of the original "Piedone lo sbirro" in 1973 (Sky TG24, 2024). Following Bud Spencer's death in 2016, the new series does not attempt to replace his legendary Commissario Rizzo, or Piedone. Instead, it introduces Vincenzo Palmieri, played by Salvatore Esposito, as a former protégé who carries forward Piedone's legacy and methods. The revival therefore creates a link between the original character and a new generation, while also reconnecting the Piedone legacy with a contemporary representation of Naples. What is being reactivated, therefore, is not simply a title or a character, but an established screen–place association. The sequence can be described as cinematic representation → cultural memory of place → revival of cultural property → renewed representation of place. Naples is consequently the point at which the analysis begins to move beyond conventional film-location tourism. Once a screen association survives its original production and becomes part of cultural memory, it can also begin to shape places in new ways.

6. FROM POPULAR CULTURE TO PLACE CULTURE

The relationship between popular culture and place can also develop in another direction. In the cases discussed so far, the place itself is central to what audiences see on screen: it is a filming location or becomes part of the destination image created through audiovisual representation. In the cases that follow, the starting point is different. It is the cultural significance already attached to Bud Spencer or Terence Hill that is translated into physical space. This may happen in a place with a genuine biographical connection to one of the actors, but it may also occur where the connection is weak or did not previously exist. Through museums, monuments, public-space names, murals and other forms of commemoration, popular-cultural memory becomes part of the physical and symbolic landscape. This is the sense in which the movement can be described as one from popular culture to place culture. The strength and nature of the original connection may vary considerably; what matters is that an established cultural meaning is subsequently materialised, interpreted or reinforced in a particular place. An early German example shows the bottom-up nature of the process. In Schwäbisch Gmünd, a public campaign sought to name a tunnel after Bud Spencer and attracted approximately 110,000 Facebook votes. The municipal authorities ultimately chose another name. Spencer himself joked about the weak connection between an Italian actor and a southern German tunnel; his principal historical link with the city was participation in a swimming competition there in 1951 (Spencer, 2014: 35). From a place perspective, however, that apparent absurdity is exactly what makes the case interesting. The proposal did not emerge from conventional local heritage. It emerged from popular attachment and an attempt to inscribe that attachment into the city's physical vocabulary. Terence Hill's relationship with Lommatzsch is more substantial and shows how even a relatively brief biographical connection can grow over time. Hill spent two years of his childhood in the Saxon town, which later made him an honorary citizen. The town also named its public outdoor swimming pool the Terence-Hill-Freibad, although it closed after the 2010 season. A small local exhibition dedicated to Hill later developed into a larger museum experience with costumes, props, photographs and memorabilia related to his life and films, including his partnership with Bud Spencer. A short childhood connection was thus transformed into a lasting element of local identity and a structured cultural attraction (Stadt Lommatzsch, 2015; Terence Hill Museum, 2026). Bud Spencer has similarly become the subject of museum-based memorialisation. A multimedia exhibition opened in Berlin in 2021, five years after his death, with the involvement of the Pedersoli family and more than 250 objects related to his film career; Naples had already hosted a temporary Bud Spencer exhibition in 2019 (Bud Spencer Museum, 2026). Such exhibitions mark another step in the transformation of popular entertainment into heritage-like material: costumes, props and personal objects are removed from their original production context and curated as artefacts worthy of preservation and visitation. Hungary provides perhaps the clearest examples of cultural memory becoming permanent urban space. Bud Spencer Park in Budapest's third district began as an unofficial, humorous bottom-up initiative in 2016 and was inaugurated through a playful mass-fight performance inspired by Spencer's films (Hungarian Two-Tailed Dog Party, 2016). Five years later, in 2021, the name received official recognition (Municipality of Budapest, 2021). The shift from fan-driven joke to recognised urban toponymy is unusually revealing: an informal cultural attachment became institutionalised place identity. The Corvin area in Budapest provides a particularly clear example of how temporary cultural activation can gradually develop into a more permanent place association. On 30 October 2016, only a few months after Bud Spencer's death, the Corvin Cinema hosted a Bud Spencer–Terence Hill Film Festival, bringing their films back to the big screen and combining the screenings with fan activities, exhibitions, merchandise and even the familiar onion-and-beans motif (Corvin Cinema, 2016).

The process acquired a permanent physical dimension the following year. On 11 November 2017, a 2.4-metre-high bronze statue of Bud Spencer was unveiled on the nearby Corvin Promenade (24.hu, 2017). The relationship between screen and place has continued since then: in summer 2026, the Corvin Cinema once again returned Spencer–Hill films to its largest screen (Corvin Cinema, 2026). Within the same urban area, the cultural figure has therefore been repeatedly activated through film, fan events and, eventually, a permanent monument. Street art provides another example of how the Spencer–Hill legacy can become temporarily embedded in urban space. Immediately after Bud Spencer's death in June 2016, the Hungarian graffiti artist TakerOne created a large photorealistic portrait of the actor on the legal graffiti wall at Filatorigát in Budapest (24.hu, 2016; Index, 2021). The work quickly became more than street art: fans visited the site, left flowers and candles, and used it as an informal place of remembrance. Its significance even reached Spencer's family. His grandson Alessandro Pedersoli used an image of the Budapest mural as his Facebook cover photo, while his son Giuseppe Pedersoli personally visited the site in October 2016 and publicly thanked Budapest for the affection shown towards his father. The mural was eventually painted over in April 2017, as works on the legal graffiti wall were not protected from replacement (Index, 2017). Its temporary existence is therefore particularly revealing from a placemaking perspective: an unofficial cultural intervention briefly transformed an otherwise ordinary urban surface into a fan pilgrimage site and place of collective memory. A decade later, Tárnok, a small town in the Budapest metropolitan area, offers a different example of culture-led placemaking. In July 2026, a large mural inspired by the Spencer–Hill film "Who Finds a Friend Finds a Treasure" (1981) became part of the settlement's "uTCHakultúra" initiative, which transforms otherwise monotonous railway noise barriers into an open-air visual environment (Kovács, 2026). Here, the Spencer–Hill legacy becomes a resource for giving character and cultural meaning to an everyday physical space. The film provides the shared cultural reference, while the mural translates that reference into a visible element of the local environment. In this sense, popular culture becomes a tool of placemaking: a familiar cinematic image is used to create a more distinctive, memorable and meaningful place. The distinction also fits Irimiás's (2015) discussion of symbolic urban space. Cities are more than collections of buildings, monuments and public spaces; media representations contribute to the emotions, associations and imagined meanings attached to them. A statue, an officially named park or a collectively respected piece of street art can therefore do more than commemorate a film star. It can add another layer to the symbolic geography through which residents and visitors experience the place.

7. FESTIVALS AS TEMPORARY PLACE CULTURE

Not every spatial manifestation needs to be permanent. Festivals create a temporary version of the same process by concentrating people, symbols, music, food, costumes, screenings and activities around the shared cultural universe. Unlike a statue or mural, the physical transformation lasts only a few days; unlike ordinary film viewing, however, the experience is spatially concentrated and socially performed. Cinecittà World provides a complementary Italian example in which film heritage, themed entertainment and fan culture come together in the same place. Located in Rome, Cinecittà World is a cinema- and television-themed amusement park covering approximately 300,000 square metres, with more than 40 attractions, film sets, themed areas and live shows designed to turn the world of the screen into an immersive visitor experience (Cinecittà World, 2026a,b). Importantly, the location itself also has a genuine connection with film production history. The park was built on the former Dinocittà studio site established by producer Dino De Laurentiis in the 1960s, where numerous Italian productions and spaghetti westerns were made. The site is also associated with Bud Spencer and Terence Hill: according to the park, both "They Call Me Trinity" and "Trinity Is Still My Name" were filmed there.

Cinecittà World therefore represents more than a conventional amusement park using cinema as a theme; it combines contemporary themed entertainment with the physical heritage of Italian film production. This combination made it a particularly meaningful setting for the three-day Bud Spencer Tribute held from 26 to 28 June 2026, marking ten years since Spencer's death. The event effectively transformed the already cinema-themed park into a temporary Spencer–Hill environment, combining live music, western and stunt shows, exhibitions, film vehicles, fan competitions and other activities drawn from their cinematic universe. The programme included music performances by the Oliver Onions, the Dune Buggy Band and the Bud Spencer Heart Chor, alongside western shows and car stunts. One particularly revealing element was the Dune Buggy Parade, which directly recalled the iconic red dune buggy with a yellow top from "Watch Out, We're Mad!" (1974). The vehicle is central to the film's story and has become one of the most recognisable visual symbols of the Spencer–Hill universe. Its reappearance more than fifty years later demonstrates how a film prop can survive as a cultural code and be reactivated as part of a contemporary visitor experience. The case is therefore particularly interesting from a film-tourism and placemaking perspective. The Bud Spencer Tribute did not simply bring a fan event into an arbitrary leisure venue. It reactivated the Spencer–Hill legacy on a site that already combined cinema-themed entertainment with genuine production history. Film heritage, contemporary entertainment and fan memory were thus layered onto the same physical space. Hungary provides a smaller-scale but remarkably persistent example of event-led spatial activation. The Hungarian Bud Spencer–Terence Hill fan festival is considerably more modest in size than the major international Spencerhill Festival, yet its significance lies in its continuity: fan gatherings have been organised since 2007 (Spencer/Hill Datenbank, 2026b). Over the years, the events have combined film screenings with activities that recreate familiar elements of the duo's cinematic world. Food plays a particularly visible role: fans can eat beans with onions, the iconic fish with potatoes, and sausages with beer, all recalling memorable scenes from the films. The programme has also included a beer-and-sausage competition, turning one of the best-known eating scenes into a playful fan challenge. Another distinctive activity is live dubbing: participants are shown scenes from the films and try to reproduce the Hungarian dialogue from memory, testing how well they remember lines that have become part of the local cult. Quizzes, music, costumes and other competitions further transform film memories into shared activities. In 2026, the Hungarian gathering celebrated two decades of this fan-festival tradition in Ráckeve (Spencer/Hill Datenbank, 2026b). Its relatively small scale is therefore part of what makes the case interesting. Without the resources or visitor numbers of the larger international festivals, a committed fan community has repeatedly created a temporary physical home for Spencer–Hill culture for almost twenty years. The location may change, but the underlying process remains the same: shared popular culture is repeatedly transformed into a place-based community experience. The same process could be observed in a more explicitly international festival setting in Germany. The 2026 Spencerhill Festival took place in Ilmenau over four days, from 3 to 6 September, marking the 25th anniversary of a festival tradition that began in 2001 (City of Ilmenau, 2026). The programme ran from a Thursday evening warm-up party through Friday and Saturday to a Family Sunday, combining film screenings, live concerts, competitions, stunt and action shows, film and U.S. cars, fan shops, themed food and activities for children. Organisers had expected up to 20,000 visitors for the anniversary edition (City of Ilmenau, 2026). For four days, Ilmenau became a meeting point for an international fan community centred explicitly on the two actors and their shared films. The playful renaming of Ilmenau as "Hillmenau", after Terence Hill, captured this exchange particularly well. The city gave the festival a physical location; the festival, in turn, gave the city a temporary cultural identity. What began as wordplay therefore illustrated the broader process at the heart of this article: popular culture became place culture.

8. DISCUSSION: FIVE FORMS OF SPATIAL ACTIVATION

The examples can now be brought together without treating every case as the same kind of film tourism. Table 1 summarises five forms of spatial activation identified across the cases.

Mechanism	Basis of place connection	Examples	Main place/tourism value
Film-location tourism	Actually filmed there	Campo Imperatore; Almería; Miami; Naples	Visitation; location-based experience
Screen-induced destination image	Place represented or strongly associated on screen	Gubbio; Lago di Braies; Naples	Destination image; recognition; visitation
Biographical / celebrity heritage	Actor has a personal connection with place	Lommatzsch; Schwäbisch Gmünd	Heritage attraction; local identity
Culture-led placemaking	Cultural legacy is brought into physical or symbolic space	Budapest; Tárnok	Place identity; symbolic urban value
Event-led temporary placemaking	Fan culture temporarily concentrates in a host place	Ilmenau / "Hillmenau"; Cinecittà World	Event tourism; temporary place identity

Table 1. Five forms of spatial activation in the Spencer–Hill case
(Source: Author's own compilation based on the cases analysed in this study)

The first form is film-location tourism, where visitors are drawn towards an actual filming location or a landscape recognised from the screen. Campo Imperatore is the clearest Spencer–Hill example of an activated location, while Naples offers numerous locations associated particularly with Bud Spencer's Piedone films. Miami and Almería demonstrate how cinematic heritage can remain only partly exploited when interpretation is weak. The digital cases add an important qualification: even where official interpretation is absent, fan databases, GPS coordinates, Google Maps and other online mapping tools can make otherwise invisible locations discoverable and visitable. Digital fan practices can therefore partly compensate for the absence of formal film-tourism infrastructure. The second is screen-induced destination image. Here repeated audiovisual representation does more than identify a shooting location; it contributes to a wider image of the destination. Gubbio, Lago di Braies and Naples represent three different versions of this mechanism. Gubbio demonstrates the deliberate use of a successful screen association; Lago di Braies illustrates the possibility of excessive success and overtourism; Naples shows how a city and a recurring cultural property can reinforce one another across different periods. In such cases, the screen does not simply show a place: it can influence how that place is imagined and recognised. The third is biographical or celebrity heritage, where the spatial connection derives from an actor's personal relationship with a place rather than from filming there. Lommatzsch and Schwäbisch Gmünd illustrate this form particularly well, through Terence Hill's childhood connection with Lommatzsch and Bud Spencer's biographical association with Schwäbisch Gmünd. Museums, commemorative initiatives and other forms of local interpretation can transform such personal connections into heritage resources. This demonstrates that screen-related tourism need not originate from the screen itself: the biography of a screen personality can also give a place cultural and tourism meaning. The fourth is culture-led placemaking. Here the direction is effectively reversed: an already established cultural memory is brought into physical or symbolic space. Budapest's Bud Spencer Park and statue and the Spencer–Hill-inspired mural in Tárnok are examples of places acquiring cultural meaning even though that meaning did not originate from filming there. This is the clearest point of contact with placemaking and place branding. The place does not preserve a production location or necessarily a biographical connection; instead, it adopts and materialises a popular-cultural reference that audiences already recognise.

The fifth is event-led temporary placemaking, in which the cultural universe becomes spatially concentrated in a host place for a limited period. Festivals can temporarily transform an otherwise unrelated or only loosely related location into a centre of Spencer–Hill culture. The 2026 Spencerhill Festival in Ilmenau provides a particularly revealing example. The playful transformation of the city's name into "Hillmenau" captures the mechanism: an international fan community needs a place in which to become physically visible, while the German city gains a distinctive cultural event and, temporarily, an additional cultural identity. Cinecittà World in Rome represents a somewhat different version because its event-led activation also overlaps with film-production heritage and themed entertainment. The five forms are analytically distinct but frequently overlap in practice. A biographical museum can become a tourism attraction; a statue created through culture-led placemaking can itself become a visitor destination; a festival can temporarily transform the image of its host city; and a television revival can renew an older screen-induced association between a character and a place. The categories should therefore not be understood as mutually exclusive. Rather, they identify different starting points through which popular-cultural memory can acquire spatial meaning.

The common element across all five forms is activation. A filming location, screen representation, biographical connection, shared cultural memory or fan community creates potential, but that potential becomes relevant to tourism and place only when it is recognised, interpreted or performed. In compact form, the broader process can be expressed as cultural connection → recognition → activation → place experience. The cases also blur the conventional boundary between popular culture and heritage. Cultural heritage does not have to begin with a canonical work, an official monument or a formally recognised historical event. Repeatedly shared films, quotations, music, foods and characters can acquire heritage-like functions when communities attach memories, identities and rituals to them over time. In the Spencer–Hill universe, even seemingly simple elements – a pan of beans, a comic fistfight or the red-and-yellow dune buggy from "Watch Out, We're Mad!" (1974) – can become meaningful cultural reference points through decades of repetition, recognition and shared memory. This process can also be strongly bottom-up. The Bud Spencer Park example is especially revealing because informal fan attachment preceded official recognition. More broadly, the cases suggest that place identity is not created only by municipal authorities or professional place marketers. Communities can introduce popular-cultural meanings into a place first; institutional recognition may follow later. Culture-led placemaking can therefore emerge from collective attachment before becoming part of formal place communication. This is also the main place-branding lesson. Places are not built only from official logos, slogans or campaigns. They accumulate meanings through stories, characters and cultural references that people already know, repeat and care about. Popular culture can provide such meanings, and the Spencer–Hill case demonstrates that these meanings can reach places through five different forms of spatial activation: filming locations, screen-induced destination images, biographical heritage, culture-led placemaking and temporary event-led placemaking.

9. CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

Bud Spencer and Terence Hill did not set out to create tourism destinations or place brands. They made popular films. Yet more than half a century later, those films and the cultural universe around them have acquired a remarkable physical geography. Some of that geography follows the familiar logic of film tourism: fans look for the landscapes of the Trinity films, surviving Miami locations or the Western scenery around Almería. Other examples show the broader power of screen representation: Gubbio, Lago di Braies and Naples demonstrate how actors, stories and places can become connected in the audience's mind. A third group goes further still. A Bud Spencer park, a statue, a mural, a museum or a festival can create a place association after the original cultural product has already become part of shared memory.

The practical implication is simple. Having a famous filming location is not enough; the connection has to be recognised, interpreted and made visible. Increasingly, that visibility need not begin with physical signage: fan-created databases, GPS coordinates, digital maps and social media can provide a first layer of interpretation and can direct visitors towards otherwise unmarked locations. But the reverse is also true: places do not need to have hosted filming in order to develop a meaningful popular-cultural association. Communities can create such connections themselves, and bottom-up attachment may later become part of official place identity. There is also a warning. Screen visibility can generate too little tourism value when it is ignored, but it can create too much pressure when it becomes overwhelmingly successful. The contrast between underused Spencer–Hill locations and the "Braies effect" shows why destination management matters alongside promotion. Perhaps the most interesting conclusion is also the simplest. Popular culture can become place culture. In the Spencer–Hill case, films created characters; the characters became cultural brands; the brands became shared memory; and shared memory increasingly became place. The present study nevertheless has several limitations. It is exploratory and case-based. It brings together documented examples rather than measuring visitor behaviour or destination-brand effects directly. The five forms should therefore be treated as an organising interpretation of the material, not as a finished model. A useful next step would be to compare actual Spencer–Hill filming locations with places that adopted the cultural phenomenon later. Interviews with visitors, residents, festival participants and destination managers could show whether these places are experienced primarily as tourist attractions, cultural memorials, community symbols or elements of a place brand. A second question is generational: as first-hand nostalgia weakens, will younger audiences continue to give these places meaning through games, festivals, social media and family transmission?

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ENERGY SYSTEMS OF SHIPS POWERED BY METHANOL DUAL-FUEL DIESEL ENGINES

Ivan Gospic
Maritime department University of Zadar, Croatia
igospic@unizd.hr

Luka Grbic
Maritime department University of Zadar, Croatia
lugrbic@unizd.hr

Mate Baric
Maritime department University of Zadar, Croatia
mbaric@unizd.hr

Dani Duka
dani.duka8@gmail.com

ABSTRACT

This paper examines the use of methanol as a primary alternative fuel to balance the various energy demands (propulsion, electrical, and thermal) encountered during a ship's service life, focusing on the environmental impacts associated with the fuel's origin. Environmental benefits compared to conventional diesel fuel are realized through the use of so-called "green methanol" (biomethanol and e-methanol), whereas the environmental impacts of methanol derived from fossil fuels ("grey methanol" from natural gas and "brown methanol" from coal) range from slightly positive to slightly negative, depending on the quality of the fossil fuel source. The paper briefly outlines the dual-fuel technological solutions for key energy components (main engines, auxiliary engines, and fired boilers) on modern ocean-going vessels—particularly container ships, where the adoption of methanol as a primary fuel is most prevalent. Additionally, it provides a brief overview of the timeline for introducing methanol propulsion across various vessel types, as well as the characteristic configurations of their energy systems.

Keywords: *Methanol, Fosile methanol, Green methanol, Methanol Dual-Fuel Engine, Ship energy system, GHG Emissions, Decarbonisation*

1. INTRODUCTION

The maritime sector accounts for approximately 3% of global greenhouse gas (GHG) emissions a figure comparable to that of industrialized nations like Germany and Japan [1], and these emissions are projected to rise by 17% by 2050 unless effective mitigation measures are implemented [2]. Through its regulatory frameworks, the International Maritime Organization (IMO) advocates for halving GHG emissions from international shipping by 2050 (relative to 2008 levels), with a 2023. revision targeting net-zero emissions by 2050 [3]. Achieving this ambitious goal requires not only improving energy efficiency but also a gradual transition to low-carbon alternative fuels [3–4] and the implementation of market-based measures, such as carbon pricing. The IMO has actively proposed various measures to accelerate decarbonization in the maritime sector and reduce ship-based GHG emissions [5], which include initial measures designed to improve the energy efficiency of ships built after 2012. such as the Energy Efficiency Design Index (EEDI) [6] and the Ship Energy Efficiency Management Plan (SEEMP) [7], as well as the Energy Efficiency Existing Ship Index (EEXI) measure [8].

According to DNV's research, IMO's ambitions can be achieved if a policy that encourages the development and use of alternative fuels prevails, as a 39% increase in demand for maritime cargo transportation is predicted by 2050. Under this scenario, energy consumption will decrease by an average of 35% to 40% by 2050 due to improved energy efficiency. In all modeled scenarios, LNG (which makes up 40-80% of the fuel mix in 2050) and ammonia are the predominant fuels, with ammonia representing the most promising carbon-neutral option for newbuildings [9]. Another possibility would be the gradual transition of the existing ships to the so-called "*drop-in*" fuels, compatible with current energy conversion systems (such as bio/electro-diesel as a replacement for liquid fuel or bio/electro-methane as a replacement for LNG, as illustrated in the attached Figure 1.

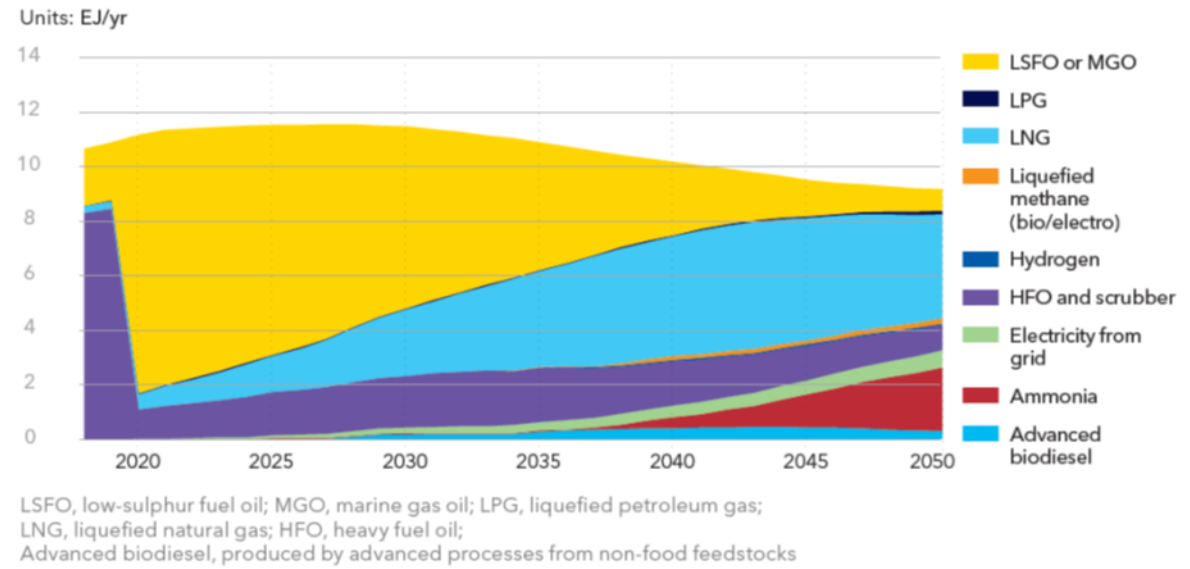

Figure 1: Energy consumption and projected fuel mix for the simulated pathway to achieving IMO decarbonization ambitions over the period from 2018 to 2050. [9]

Recently, so-called green methanol has become an increasingly important primary fuel in the maritime sector, driven by incentive policies and increasingly strict regulations on GHG emissions. This fuel emerged as a sustainable option more than a decade ago due to its low overall emission impact. Under normal atmospheric conditions, methanol is a liquid, making it easier to store, transport, and bunker compared to gaseous fuels such as natural gas, ammonia, and hydrogen; it is also safer to handle. Because of these advantages, it currently holds second place among alternative fuels in the maritime sector (right behind LNG), as seen in current order books where a total of 450 ocean-going ships have been ordered [10].

2. METHANOL AS MARINE FUEL

Methanol is a simple alcohol with the chemical formula CH_3OH whose physical properties are consistent across all production processes, regardless of whether it is classified as fossil (gray and brown) or green (biomethanol or e-methanol). In appearance, methanol is a clear, colorless liquid with a pungent alcoholic odor that is volatile, flammable, and completely soluble in water, as well as in most alcohols, esters, and other organic solvents, except in fats and oils where its solubility is low. It is easily flammable due to the release of flammable vapors at relatively low temperatures, and its flash point is 10–12 °C, which categorizes it as a dangerous cargo in terms of storage and handling. On the other hand, its explosion limits in air in the presence of an external ignition source (such as a spark) are characterized by molar fractions ranging from 6% to 36%, while its autoignition temperature is around 455–470 °C.

Its molecular mass is 32.04 kg/kmol, while at normal atmospheric pressure pa=1.01325 bar the density is 792 kg/m3, the boiling point is 64.6 °C, and the melting point is -98 °C. Of the other physical quantities, the lower heating value (LHV) of methanol is important with regard to the topic under consideration, which varies primarily due to the measurement methodology, fuel purity, and the influence of temperature - not due to any fundamental difference in the methanol molecule itself. Regardless of whether methanol is conventional, bio-based, or e-methanol, pure chemical CH_3OH has the same theoretical energy content, which is 19.9 MJ/kg according to the stoichiometric enthalpy calculation of complete combustion. Variations evident in the literature and specifications are a consequence of the way in which the value is measured and/or the type and quantity contained, so according to the standard specification (e.g., IMPCA – Internatioanal Methanol Producers and Consumer Association), LHV = 19.7–20.26 MJ/kg for slightly contaminated methanol. It should be kept in mind that in real applications, methanol is rarely 100% pure CH_3OH, and is most often contaminated with water, which directly reduces the LHV. [11, 12]

2.1. Fossil methanol (Grey and Brown methanol)

These types of methanol are of fossil origin, differing based on the feedstock used for their production. **Grey methanol** is produced from natural gas, the dominant global production method, accounting for approximately 65% of total output. **Brown methanol** is produced from coal, primarily in China, representing about 35% of global production. The fundamental process for both types is similar, involving the initial production of synthesis gas (a mixture of carbon monoxide (CO), hydrogen (H_2), and carbon dioxide (CO_2) from a fossil feedstock (natural gas or coal); this gas is then prepared and passed over a catalyst to synthesize methanol. The key difference lies in the method of synthesis gas production: grey methanol production employs steam methane reforming (SMR), where natural gas reacts with steam at high temperatures, whereas brown methanol production uses coal gasification, a process in which coal reacts with oxygen and steam at high temperatures and pressures. Chemically, they are identical to green methanol, but they have a significantly higher carbon footprint because they are produced from fossil fuels.

2.2. Green methanol

Green methanol is a low-carbon fuel produced from renewable sources, though it is currently significantly more expensive than very low-sulfur fuel oil (VLSFO). It is produced using renewable feedstocks, primarily in two ways: as e-methanol (by combining green hydrogen and captured CO_2) or as biomethanol (via biomass gasification). It is considered a practical "*drop-in*" fuel—one that can be used directly in existing systems—because it allows for the use of existing storage and transport infrastructure with minimal modifications.

2.2.1. Biomethanol

Biomethanol is a renewable, low-carbon fuel produced from organic waste rather than fossil fuels; as such, it offers a practical solution for decarbonizing the maritime sector. Classified as "green methanol," it is derived from sustainable biomass sources such as agricultural and forestry residues, municipal solid waste, and biogas. Unlike "grey methanol" (produced from natural gas), it can reduce lifecycle CO2 emissions by 60–95% compared to fossil fuels. Production primarily occurs via gasification, a process in which solid biomass is converted at high temperatures (approximately 600–1000°C) into synthesis gas (CO and H2) and subsequently catalytically converted into methanol; other production methods involve reforming biogas obtained through anaerobic digestion or recovering it from pulp production facilities.

It serves as a primary alternative fuel in the maritime industry, requiring only minor modifications to diesel engines, and reduces SOx emissions by more than 95% and NOx emissions by up to 80%. Despite extensive global efforts—characterized by over 80 projects led by China, Europe, and North America—current availability and costs remain inadequate relative to demand; this is most evident in the price of biomethanol, which remains two to ten times more expensive than fossil-based methanol. Although production is shifting from the demonstration plant stage to commercial scale, actual capacities are not expected to match the levels announced in ambitious projects.

2.2.2. e methanol

e methanol is a type of green methanol that is produced by combining renewable hydrogen and separated carbon dioxide. Today's predominant commercial production process is through the conversion of carbon to methanol (CTM), whereby green hydrogen (produced by electrolysis using renewable energy) reacts directly with the separated CO_2. It is the most discussed "electrofuel" in the context of maritime transport, although it is still significantly more expensive than fossil fuels. Production costs vary considerably depending on the location and the price of hydrogen, but the "*green premium GP*" as an additional cost for a more environmentally friendly option represents the difference in the production cost of green (CGM) and fossil methanol (CFM), i.e. GP=PGM-PFM takes on relatively high amounts ranging from 608-2710 €/t, ($643-2420/t), while the global reference value is around 1300 $/t.

2.3. Price comparison of fossil and green methanol versus VLSFO

VLSFO prices vary by region but generally range from $545 to $668 per tonne, based on 2026 averages for major hubs such as Rotterdam and Istanbul, although the current indicative price for Rotterdam is $683/t [13]. For a valid price comparison, it must be noted that the thermal energy equivalent of methanol is approximately 48.2% of that of VLSFO; thus, practically speaking, about 2.128 tonnes of methanol are required to yield the same amount of thermal energy. According to [11], the lower heating values (LHV) for methanol and VLSFO are: LHV_{CH3OH} = 19.9 MJ/kg and LHV_{VLSFO} = 41.3 MJ/kg. The indicative average prices per tonne of the fuels under consideration (for 2026) are as follows: VLSFO ($683/t), fossil methanol ($571/t), and green methanol ($1,264/t). The actual prices based on the energy equivalence of methanol versus VLSFO (expressed here symbolically per equivalent tonne, or "te") are 2.128 times higher, amounting to: fossil methanol ($1,185/te) and green methanol ($2,623/te), [14]. The current price difference is significant; on one hand, it stems from VLSFO price volatility driven by crude oil market trends, while on the other, green methanol carries a substantial "green premium" due to production costs. Production costs for green methanol are currently estimated at between €350 and €1,050 per tonne ($380 to $1,150), depending on the technology and region. When compared to VLSFO on an energy-equivalent basis, it is often cited as being four to five times more expensive, with some estimates placing the cost in the range of $800 to $1,200 per tonne.

2.4. The emissions effect at various stages of the methanol lifecycle compared to VLSFO

Two phases characterize the pathway of methanol and VLSFO: the first is the "Well-to-Tank" (WTT) phase, extending from the raw energy source to the ship's fuel storage tank; the second is the "Tank-to-Wake" (TTW) phase, extending from the fuel storage tank to the exhaust outlet of the reaction zone where combustion occurs (in marine power systems, these zones include steam generator furnaces, gas turbine combustion chambers, and internal combustion engine cylinders); and the overall "Well-to-Wake" (WTW) pathway, which represents the consolidation of the first and second phases.

For methanol, emissions are highest during the first phase, depending on its origin, whereas for VLSFO, emissions peak during the second phase, regardless of feedstock origin. Table 1 provides a concise illustration of the emission levels [15].

Fuel Type	Feedstock / Production Pathway	WTT Emissions (gCO_2e/MJ)	TTW Emissions (gCO_2e/MJ)	WTT Emissions (gCO_2e/MJ)
VLSFO	*Crude oil extraction, refining, and transfer to the vessel*	~12.2 – 16.8	~74 – 78	~91.16 – 91.4
Grey Methanol	*Natural Gas (Steam Methane Reforming)*	~28.6 - 39	~69 (3)	~97.6 - 108
Brown Methanol	*Coal (Gasification)*	~124.7 - 187	~69 (3)	~193.7 - 258
E-Methanol	*Renewable H_2 + Captured CO_2*	~5 - 26 (1)	~0 - 69 (4)	~74 - 95
Bio-Methanol	*Biomass / Waste*	~5 - 30 (2)	~0 (5)	~5 - 30

1.Highly variable, 2. Can be negative, 3. Fossil CO_2, 4. Depends on CO_2 source, 5. Biogenic CO_2

Table 1: The emissions effect at various stages of the methanol lifecycle compared to VLSFO

The impact on the environment is most pronounced with emissions in the technological processing phase from the energy source to the ship's storage tank (so-called „well-to-tank“). Both types of fossil methanol (grey and brown methanol) generate significant WTT emissions. WTT emissions of grey methanol: Life cycle emissions range from 1.12 to 1.25 kg CO_2e per kilogram of methanol. Another source states that emissions from production (from natural gas) alone amount to between 0.5 and 0.85 tons of CO_2 per ton of methanol.

3. A BRIEF OVERVIEW OF THE USE OF METHANOL AS A PRIMARY ALTERNATIVE FUEL IN THE MARITIME SECTOR

The promotion of methanol as a key alternative fuel in the shipping industry has been characterized by steady and deliberate growth; having evolved from experimental use in a relatively niche maritime sector, it is now considered one of the most widely adopted alternative fuels for newbuildings, despite existing limitations regarding technical readiness and availability. Building on land-based experience with methanol dating back to the 1980s and 1990s, such as its use in US race cars and Kawasaki’s development projects for methanol-fueled marine diesel engines in Japan (initiated in 1988), methanol only began to be introduced into the maritime industry in the 1990s through research into fuel cells for auxiliary power. A major turning point in the use of methanol as a primary marine fuel occurred in early 2015 with Stena Line’s RoPax ferry “Stena Germanica”; the vessel underwent a conversion from conventional diesel propulsion at a Polish shipyard, becoming the first to be equipped with a Wärtsilä four-stroke dual-fuel engine, and successfully demonstrated its feasibility and operational viability during its maiden voyage between Göteborg and Kiel that March. This was followed by the application of methanol as the primary alternative fuel on the oceanic methanol tankers of Waterfront Shipping and Methanex, equipped with MAN B&W dual-fuel diesel engines, which were delivered in 2016. Since then, the application of methanol as the primary alternative fuel in the maritime sector has intensified, which is characterized by a huge increase in newbuilding orders, so that nowadays its application in shipping exceeds the availability of green methanol.

According to the order books, methanol has already overtaken LNG as the primary alternative fuel in 2023; according to the latest DNV report in mid-2026 [DNV], 333 orders for new construction were recorded, with the total number of ships qualified for methanol fueling being over 450 (both ordered and in operation; in 2025 alone, the Clarksons company recorded orders for 66 such ships). The possibility of running on methanol using dual-fuel engines has extended to all major segments of maritime traffic:

3.1. Basic technical characteristics of methanol-powered ocean-going vessels newbuildings

According to the latest data from July 2026, the technological concept of using methanol as a primary alternative fuel in the shipping industry, which is applicable to vessels ranging from VLCC tankers to mega-container ships, is based on the use of dual-fuel diesel engines powered by methanol.

3.1.1. Overview of key technology

The standard solution involves powering the majority of newbuilds with both methanol and conventional diesel fuel, with the capability to switch between the two, although engines running exclusively on methanol are also being developed. Regarding engine technology, most units utilize direct methanol injection and are supplied by major engine manufacturers such as WinGD and MAN. The reduction in greenhouse gas emissions achieved by using green methanol during engine operation, compared to conventional diesel fuel, is reflected in the following potential reductions: CO_2 by up to 92%, SO_x by 99%, and NO_x by 60%.

3.1.2. Technical parameters and innovations by vessel type

<u>Container ships</u>

<u>Ultra-large container ships</u> (24000 TEU): The world's first ultra-large container ship „*OOCL Wisdom*“of CMA CGM, with a capacity of 24000 TEU, fueled by methanol, was delivered in 2026. [16], while other large shipping companies such as Maersk, CMA CGM, Evergreen, and Hapag-Lloyd placed significant orders. The vessel „OOCL Wisdom“ (the world's largest) has a length overall (LOA) of 399.99 m, a breadth of 61.3 m, a deadweight tonnage (DWT) of 225,000, and a capacity of 24,168 TEU. It is equipped with the world's largest methanol-capable main engine, while auxiliary systems utilize conventional fuel [17].

<u>Large container ships</u> (15000 – 16000 TEU):

Maersk's 16,000 TEU ships are 350 m long and 53.5 m wide and are leading the way in terms of orders; the "Laura Maersk" holds the title of the world's first methanol-powered container ship and was launched in 2023. The ship has a gross tonnage of 25,750 tons, was built at the South Korean shipyard Hyundai Mipo, and is 172 meters long and 32 meters wide [15]. CMA CGM's "CMA CGM Arthur" (15,000 TEU) is 366 m long and 51 m wide, and has a methanol tank capacity of 8,300 tons. Medium-sized container ships (9,000 TEU): The "TANGIER MÆRSK" has an overall length of 274 m, a beam of 45.6 m, a height of 24.2 m, and a deadweight of approximately 114,000 tons [18].

<u>Bulk Carriers</u>: In July 2026, Lemissoler Navigation named the first two in a series of four methanol-powered bulk carriers with a capacity of 65000 dwt, while COSCO also named a methanol-powered ore carrier with a capacity of 325000 dwt, scheduled for delivery in late 2026. The „*Guoyi Sea*“, a methanol-ready vessel, has a length overall of 229.95 m, a breadth of 32.26 m, and a deadweight tonnage of 80000. The propulsion system consists of a DMD-MAN B&W 6S60ME-C10.5 HPSCR main engine that produces 11.340 MW at 101 rpm and develops a ship's sailing speed of 15.5 knots, a boiler from *Zhangjiagang Hailu Shazhou Technology*, and methanol dual-fuel diesel generators of 860 kW and 809 kW, [19].

There are also designs for 23500-tonne deadweight vessels equipped with four 1.130 MW generators that run exclusively on methanol.
Tankers: The ECOMAR series, comprising four 49800 dwt methanol-powered chemical tankers for Hafnia and Socatra, was completed in early 2026, the first such series for the company. In the segment of VLCC tankers (very large crude oil tankers), the "New Explorer" was delivered in late 2025 as the world's first methanol-powered VLCC, has an overall length of 333 m, a beam of 60 m and a deadweight of 306,000 dwt, and a MAN B&W 7G80ME-C10-LGIM main engine developing power of 20.6 MW (MCR - maximum continuous power)., [20].
Methanol Bunker Tankers: To support the growing fleet, dedicated methanol-powered methanol bunker tankers are being introduced; notably, in 2026, "*Fratelli Cosulich*", launched its first IMO II methanol chemical bunker tanker, "*Maya Cosulich*", for operations in Singapore. A 7990-tonne deadweight bunkering and chemical tanker has an overall length of 99.98 m and a cargo capacity of 8200 m^3. The new MR tankers (Medium Range Product Carriers, ships for transporting chemicals such as methanol or refined petroleum products such as gasoline, diesel, and jet fuel refined in bulk) have a carrying capacity of approximately 49,900 tons and a total length of 183 m, [21].
Other vessels:
These include PCTCs (specialized car and truck carriers), tugs, and a cable-laying vessel (CLV) featuring methanol-capable Wärtsilä 32 dual-fuel engines.

3.1.3. Safety and regulations
Safety design:
The vessels are equipped with comprehensive fire protection systems, including fixed CO_2 extinguishing systems and high-pressure water cannons.
Regulatory compliance:
The newbuilds meet strict IMO (International Maritime Organization) requirements for harmful gas emissions under the Tier III standard. The IMO has also issued technical guidelines for dual-fuel systems intended for newbuilds.

3.2. Energy system of large and ultra-large methanol-powered container ships
3.2.1. Unified fuel supply systems
The approach is based on standardized fuel supply systems for main engines, auxiliary engines, and dual-fuel-fired boilers. A unified, automated low-flashpoint fuel supply system (LFSS) is frequently used for all consumers, enabling the preparation, routing, and pressurization of methanol to the appropriate pressure for the variable supply of the main engine, auxiliary engines, and boilers.

COSCO's new 16000 TEU container ships utilize Alfa Laval's first methanol dual-fuel boiler alongside the main engine. Alfa Laval's FCM Methanol system has logged over 450,000 operating hours since 2015, featuring automated leak testing and purging procedures for safety. In short, the prevailing trend is the centralization of methanol supply management within a flexible, automated system that supplies both engines and boilers.

3.2.2. Propulsion system (main engine)
The ultra-large container ship (24000 TEU) utilizes the MAN B&W 12G95ME-C10.5-LGIM, currently the most powerful dual-fuel methanol engine delivering 82440 MW of power at 80 rpm. Large container ships (16000 TEU) primarily use MAN B&W G95ME series methanol engines for propulsion and, to a lesser extent, WinGD X-DF-M engines.

Both types employ liquid methanol injection technology (LGIM), achieving a diesel-to-methanol substitution rate of over 95% of the total fuel energy input.

3.2.3. Electric energy system

All auxiliary diesel generators are dual-fuel units. Typical configurations consist of 3 to 4 diesel generators, each with a rated power of approximately 1.1 MW. A permanent magnet shaft generator is also often used, enabling economical balancing of the ship's electrical load during navigation. Modern container ships are introducing specialized dual-fuel generator sets, such as the MAN L23/30DF—a compact unit operating on methanol, heavy fuel oil (HFO), or biofuels—with key specifications including an output of 625–1200 kW, a speed of 720/750 rpm, and a power rating of 125 kW per cylinder. Plans are also in place to upgrade existing MAN 21/31 generator sets and to implement the recently certified MAN L35/44DF CD model, which is suitable for large vessels like 24000 TEU container ships; this model features real-time adjustable combustion control, 16% higher power output compared to competitors, and a reduction in methane emissions (methane slip) of up to 85%.It features adaptive real-time combustion management, 16% more power than the competition, and reduces methane emissions (so-called methane slip) by up to 85%.When controlling auxiliary generator sets adapted to operate on methanol, the key is the control logic that reflects the use of an electronic control unit (ECU) equipped with an „alcohol sensor“ that measures the fuel composition, allowing the determination of the exact air-fuel ratio (AFR) for optimal combustion, even during cold starts, without relying solely on the oxygen sensor, which is the key to the technology for adjustable combustion management.

3.2.4. Thermal system

Auxiliary marine boilers using methanol as fuel are integrated into the ship's thermal system. Alfa Laval Aalborg D Multi-fuel is a high-efficiency oil and gas boiler, designed for the demanding conditions of the offshore industry. Thanks to the advanced technological solution of the burner capable of burning liquid and gaseous fuels, it enables optimal combustion at various thermal loads. It is available in various variants, such as saturated steam boiler, superheated steam boiler, and economizer (for hot water production). It is ideal for balancing the ship's incoming thermal loads and producing additional mechanical power via a steam turbine plant. The Aalborg D multi-burner configuration allows the burners to operate simultaneously on gas and liquid fuels, as well as dual firing in different load ranges using advanced combustion techniques. With integrated flue gas recirculation it regulates the air/fuel ratio to reduce NOx emissions, ensuring compliance with international emission standards and supporting the desired sustainability goals. With steam capacity from 45 to 130 t/h and thermal rate for water heating up to 90 MWh, Aalborg D provides reliable, efficient, and flexible performance to meet the demanding requirements of offshore applications. Flexible production of both steam and hot water to meet various offshore needs thanks to design features as follows; robust design pressure up to 48 bar(g) for demanding operations, superheated steam available up to 415 °C, versatile multi-fuel capability, efficient, integrated multi-burner system with minimum refractory requirements, and comprehensive auxiliary systems available, such as combustion skids, gas valve units, and feedwater solutions.

3.2.5. Fuel storage and supply system

Tank capacity typically ranges from 15000 to 16000 m³. For instance, a 24000 TEU vessel has a 14300 m³ tank, while a 16000 TEU vessel has an 11000 m³ tank. The tanks are located forward of the engine room to optimize space and enhance safety, as illustrated in the attached Figure1. With a full tank, the vessel can sail up to 23000 nautical miles on methanol.

The supply system features a modular architecture for efficiency and utilizes double-walled piping with automatic monitoring for safety. Alfa Laval's Low Flash Point Fuel Supply System (LFSS) technology solution is proving to be a suitable solution for vessels powered by methanol dual-fuel engines. It enables the supply of methanol within defined flow, pressure, temperature, and filtration parameters specified by the engine manufacturer. This system represents a mature technology that has been used on methanol-fueled ships since 2015 and is capable of supplying methanol to dual-fuel marine engines (both main and auxiliary) as well as boilers. The automated FCM Methanol system is designed to be able to meet the process needs of multiple methanol consumers, while having adequate redundancy to allow for operation without intermittency due to purging the entire module, and as such is safe and reliable for the crew.

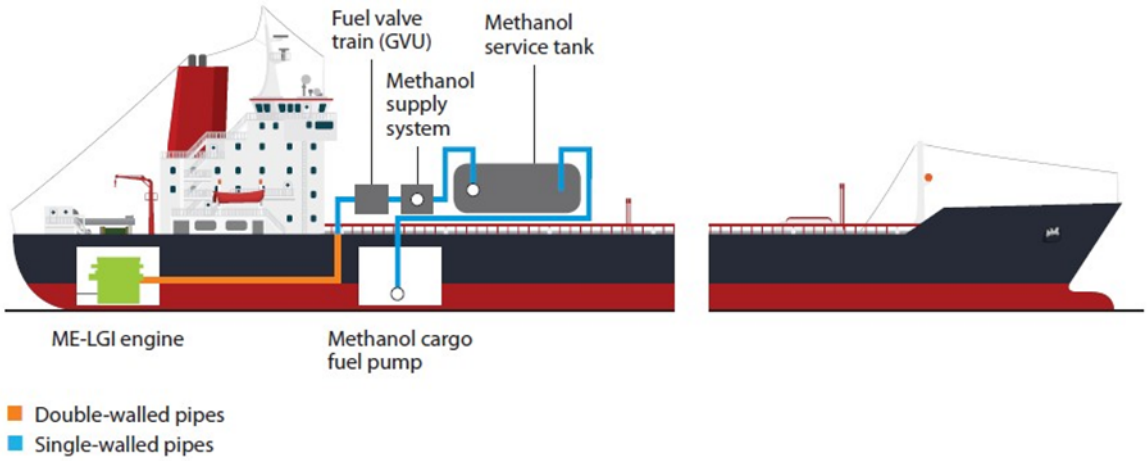

Figure 2: Instalation onboard new-build methanol tanker [Source MAN, 2015b]

3.2.6. The energy management system

Intelligent energy management is achieved through automated optimization, whereby an intelligent system automatically optimizes speed and power based on real-world navigation conditions. Continuous monitoring is ensured by an intelligent hull structure monitoring system that constantly checks the vessel's structural integrity.

3.2.7. Safety system

This system continuously monitors gas concentrations in all critical areas. Fire protection combines a fixed CO_2 system for enclosed spaces with high-pressure water monitors on deck. The fuel safety system employs nitrogen inerting and sealed connections to safely handle flammable and corrosive methanol.

4. CONCLUSION

Although the technical viability of methanol-powered ships using dual-fuel diesel engines (which have collectively accumulated over 600000 operating hours across the fleet) has been proven, the maritime sector faces a significant fuel supply bottleneck, as the availability of low-carbon, green methanol (biomethanol and e-methanol) is extremely limited. Global production stands at only about 2.2 million tonnes annually, far below the potential demand of 60 million tonnes by 2040. Due to production costs, green methanol is roughly three times more expensive than conventional marine diesel, creating a gap in the readiness of methanol-powered vessels, as green methanol is not yet economically or logistically available at scale.

Despite the growing number of orders for methanol-ready ships, actual e-methanol consumption remains negligible. Research indicates that the main obstacle lies in shipowners' willingness to pay such high prices; the average willingness to pay a "green premium" actually fell to 3% in 2025 (down from 4.5%), with none of the respondents willing to pay a premium exceeding 20%. Securing bankable long-term offtake agreements remains a critical hurdle for making final investment decisions on projects. Ships' energy systems based on dual-fuel diesel engines fuelled by green methanol have progressed from pilot projects to full-scale commercial application, proving to be one of the most advanced and reliable solutions for decarbonizing the maritime sector.

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FOREIGN DIRECT INVESTMENT AND DOMESTIC INVESTMENT: CROWDING-OUT EFFECT OR SPILLOVER EFFECT?

A panel data analysis of 73 countries

Hajar Rachdi

Ph.D. student in economics, Research Laboratory: Comparative Law, Applied Economics and Sustainable Development at Faculty of Law, Economics and Social Sciences Sale, Mohammed V University of Rabat.

hajar.rachdi@um5r.ac.ma

ABSTRACT

This paper examines the effect of foreign direct investment (FDI) inflows on domestic investment in a sample of 73 countries across the European Union, the MENA region, ASEAN and ECOWAS, observed over the period 2000-2022. Based on the analytical framework of Agosin and Machado (2005) and Jude (2019), we estimate a log-linear panel data model explaining gross fixed capital formation (GFCF) by FDI inflows, domestic credit provided to the private sector, gross domestic product (GDP) and inflation. The chosen specification procedure—homogeneity test, Hausman test, and then Breusch-Pagan Lagrange multiplier test—leads to a random effects model, in which the elasticity of gross fixed capital formation (GFCF) to foreign direct investment (FDI) is positive and statistically significant ($\beta \approx 0.040$), suggesting a partial spillover effect rather than a crowding-out effect. Diagnostic tests, however, reveal heteroscedasticity, first-order autocorrelation, and non-normality of the residuals, which invalidate the efficiency of the base model's standard deviations. A generalized least squares (GLS) reestimation renders the FDI coefficient insignificant, while the effects of credit, inflation, and GDP remain robust. This result calls for caution regarding the causal interpretation of the FDI-domestic investment relationship and argues, for future work, in favor of estimators robust to the error structure (Driscoll-Kraay standard deviations, dynamic panel GMM).

Keywords: *foreign direct investment, domestic investment, crowding-out effect, panel data, heteroscedasticity*

1. INTRODUCTION

Whether foreign direct investment (FDI) inflows stimulate or crowd out domestic investment remains one of the most debated topics in international economics. On the one hand, neoclassical investment theory (Munemo, 2014) and credit channel models suggest that FDI can ease financing constraints in host economies, transfer technologies, and improve institutional quality (Fan et al., 2009; Lederman et al., 2013), thereby generating a crowding-in effect on domestic investment. On the other hand, a substantial body of literature highlights the risk of crowding-out, where multinational firms capture market share, financial resources, or human capital at the expense of local businesses (Borensztein et al., 1998; Budang & Hakim, 2020). The theoretical ambiguity actually points to an empirical question, the answer to which largely depends on the institutional context and the level of development of the countries considered. This study aims to resolve this question using a large and heterogeneous sample of 73 countries, stratified into four contrasting economic zones—the European Union, the MENA region, ASEAN, and ECOWAS—observed over three decades (2000–2022). The objective is twofold: (i) to estimate the long-term elasticity of domestic investment to FDI inflows within a heterogeneous panel framework, and (ii) to subject this estimate to a battery of specification and diagnostic tests, a necessary condition for any robust inference in macroeconomic panel data.

The remainder of the article is organized as follows. Section 2 situates the study within the theoretical and empirical literature. Section 3 presents the data, the sample, and the chosen econometric specification. Section 4 details the testing strategy used to compare competing models. Section 5 presents the results and diagnostic tests. Section 6 discusses the scope and limitations of the results, and Section 7 concludes.

2. LITERATURE REVIEW

Three main families of models structure the literature on the determinants of investment. The accelerator model posits that firms' investment adjusts to anticipated changes in output, with future investment explained by past output taking adjustment costs into account (accelerator effect). The credit channel, for its part, emphasizes informational frictions between lenders and borrowers: a restrictive monetary shock reduces the net worth of firms, increases the external financing premium, and consequently reduces investment—a mechanism described as a financial accelerator (Bernanke & Gertler, 1995). The neoclassical theory of investment, to which this work belongs, posits that investment is determined by the difference between the marginal product of capital and its user cost, the latter depending on the real price of capital, the depreciation rate, and the real interest rate (Muet, 1979). The speed at which the capital stock adjusts to its desired level depends, in turn, on the quality of institutions (Fan et al., 2009; Lederman et al., 2013), the availability of financing (Borensztein et al., 1998), and the dynamism of growth (Budang & Hakim, 2020). Empirically, Agosin and Machado (2005) decompose total investment into domestic investment and investment by multinational firms, the latter being a function of current and lagged FDI inflows. Estimating a long-term elasticity βLT then allows us to distinguish three regimes: dollar-for-dollar equivalence ($\beta LT = 1$), a spillover effect ($\beta LT > 1$), or a crowding-out effect ($\beta LT < 1$). Jude (2019) adopts this logic in a dynamic panel model where gross fixed capital formation (GFCF) is explained by its lagged value, the growth rate, the real interest rate, the terms of trade, uncertainty, and a crisis indicator variable. Finally, Okara (2021) uses lagged FDI to capture its effect on institutional quality, a lag that also helps to mitigate the risk of reverse causality between FDI and the host macroeconomic environment. It is in the continuation of this work that we specify, in the following section, a log-linear panel model explaining GFCF by FDI, domestic credit, GDP and inflation, before submitting it to the standard panel data specification procedure (Bourbonnais, 2009; Hausman, 1978).

3. ECONOMETRIC DATA AND SPECIFICATION

3.1 Variables

Gross fixed capital formation (GFCF). Endogenous variable of the model, it measures domestic investment and covers net acquisitions of tangible fixed assets (land, equipment, infrastructure, buildings) as well as the net change in inventories, expressed in current dollars (World Bank).

Foreign direct investment (FDI). Measured by net FDI inflows in current dollars, defined by the World Bank as flows aimed at acquiring a lasting interest (10% or more of voting shares) in a resident company.

Domestic credit provided to the private sector (CR). Control variable capturing the intensity of domestic financial intermediation and, therefore, the availability of financing for national investors.

Gross domestic product (GDP). Control variable representing the usual accelerating effect — the level of economic activity — on the decision to invest.

Inflation (INF). Control variable representing the general price level, associated in the literature with macroeconomic uncertainty weighing on investment decisions.

3.2 Sample

The sample covers 73 countries over the period 2000–2022, divided into four contrasting economic zones in terms of their level of development and international financial integration: the 27 countries of the European Union, 21 countries of the MENA region, the 10 ASEAN countries, and the 15 ECOWAS countries. The sample size was determined according to the Krejcie and Morgan (1970) formula to ensure representative coverage of the maximum number of countries globally, including developed, emerging, and low-income economies. All data are from the World Bank's World Development Indicators database.

3.3 Model Specification

The chosen empirical model is written in functional form:

$$FBCF = f(IDE, CR, GDP, INF)$$

or, in its log-linear form with individual effects:

$$log(GFCF)_{it} = \alpha + \beta\, log(FDI)_{it} + \gamma\, log(CR)_{it} + \lambda\, log(GDP)_{it} + \omega\, log(INF)_{it} + \varepsilon_{it}$$

where i indexes the countries (N = 73) and t the period (T = 30).

The logarithmic specification allows for a direct reading of the coefficients β, γ, λ, and ω as elasticities of GFCF to the respective regressors. All variables are expressed in natural logarithms to homogenize the measurement scales and mitigate the heteroscedasticity inherent in macroeconomic data in levels.

4. ECONOMETRIC STRATEGY

Estimating a model in panel data requires a multi-step specification procedure (Bourbonnais, 2009), summarized below.

Step 1 — Homogeneity test. This involves testing whether the model coefficients are identical for all individuals (H0: homogeneity) or whether they vary across countries (H1: heterogeneity). A rejection of total homogeneity justifies the use of a panel structure with individual effects, whether fixed or random.

Step 2 — Hausman Test (1978). This test allows us to choose between the fixed effects model (FEM), which allows for a correlation between individual effects and regressors ($Cov(\alpha i, Xit) \neq 0$), and the random effects model (AEM), which is more efficient under the assumption of independence between individual effects and regressors. Under H0, the random effects model is preferred; under H1 ($p < 0.05$), the fixed effects model is the preferred model.

Step 3 — Breusch-Pagan Lagrange multiplier test. This test completes the arbitration by comparing the random effects model to the pooled OLS model, under the null hypothesis $Var(u) = 0$.

Step 4 — Post-estimation diagnostics. The inferential validity of the selected model is then examined through three tests: the Breusch-Pagan test / modified Wald test for grouped heteroscedasticity, the Wooldridge test for first-order autocorrelation of errors, and the Skewness-Kurtosis test for normality of residuals.

5. EMPIRICAL RESULTS

5.1 Descriptive Statistics

Table 1 presents the descriptive statistics of the model variables (in logarithms), based on a total of 1,062 observations. Gross fixed capital formation (GFCF) has a mean of 1.35 and a relatively low standard deviation (0.20), indicating limited dispersion of the endogenous variable. Among the regressors, GDP is the most volatile variable (standard deviation of 0.83), followed by credit (0.84—likely read from the raw scale), foreign direct investment (FDI) (0.68), and inflation (0.53). The Jarque-Bera statistics, all significant ($p < 0.05$), reject the assumption of normality of marginal distributions, which is typical for unconstrained panel macroeconomic series.

Variable	Average	Median	Max.	Min.	Standard deviation	Jarque-Bera	Obs.
log(FBCF)	1.3514	1.3505	2.4570	-0.0384	0.2020	6280.48***	1062
log(IDE)	0.4733	0.4774	2.6523	-2.8332	0.5788	698.09***	1062
log(INF)	0.4033	0.4286	1.7262	-2.0806	0.4755	152.23***	1062
log(GDP)	10.8571	10.9406	12.6294	8.5695	0.8354	20.79***	1062
log(Credit)	1.5028	1.6749	2.3966	-5.3638	0.9104	74828,3***	1062

*Table 1 — Descriptive statistics of variables (in logarithm). Note: *** significant at 1%.*

5.2 Correlation Matrix

The correlation matrix (Table 2) indicates generally positive relationships between variables, with the exception of inflation, which is negatively correlated with GDP (-0.144) and credit (-0.284), consistent with standard macroeconomic assumptions. All correlation coefficients remain below 0.5 in absolute value, which a priori rules out a serious problem of multicollinearity between the regressors.

	log(FBCF)	log(IDE)	log(INF)	log(GDP)	log(Credit)
log(FBCF)	1,000	0.016	0.036	0.110	0.132
log(IDE)	0.016	1,000	-0.038	-0.068	0.048
log(INF)	0.036	-0.038	1,000	-0.144	-0.284
log(GDP)	0.110	-0.068	-0.144	1,000	0.426
log(Credit)	0.132	0.048	-0.284	0.426	1,000

Table 2 — Correlation matrix of model variables

5.3 Choice of model: fixed effects or random effects?

Table 3 presents the estimates of the fixed effects (FEM) and random effects (RAE) models. In both specifications, FDI, inflation, and credit have a positive and significant effect on GFCF, while GDP is not significant. The Hausman test does not allow us to reject the null hypothesis of no systematic correlation between individual effects and regressors ($\chi^2(4) = 3.22$; $p = 0.522$), which leads us to retain the more efficient random effects model.

This choice is corroborated by the Breusch-Pagan Lagrange multiplier test, which strongly rejects the hypothesis Var(u) = 0 ($\chi^2(01) = 3203.17$; p = 0.000), thus rejecting the stacked OLS model in favor of the random effects model.

Variable	MEF — Coef.	MEF — t	MEA — Coef.	MEA — z
log(IDE)	0.0420***	4.97	0.0402***	4.83
log(INF)	0.0234**	2.57	0.0245***	2.72
log(Credit)	0.0637***	2.83	0.0481***	2.76
log(GDP)	0.0018	0.09	0.0091	0.55
Constant	1.2066***	6.04	1.1572***	6.81
Observations	1062		1062	
Groups (countries)	69		69	
R^2 within	0.0438		0.0434	
R^2 between	0.0166		0.0176	
R^2 overall	0.0189		0.0203	
F / Wald	F(4,989)=11.33***		Wald $\chi^2(4)$=44.93***	
ρ (variance share)	0.767		0.763	

Table 3 — Fixed effects (FEM) and random effects (RAE) estimates.
*Note: *** p<0.01, ** p<0.05.*

Hausman test: $\chi^2(4) = 3.22$; Prob>χ^2 = 0.522 → no rejection of H0 → random effects model retained.

Breusch-Pagan LM test: $\bar{\chi}^2(01) = 3203.17$; Prob>$\bar{\chi}^2$ = 0.000 → rejection of H0 → random effects preferred to stacked OLS.

5.4 Diagnostic Tests

The validity of the random effects model selected in the previous step is conditional upon compliance with the usual assumptions about the error structure. Three tests were conducted.

Heteroscedasticity. The modified Wald test for group heteroscedasticity strongly rejects the hypothesis of homoscedasticity ($\chi^2(69) \approx 3.1 \times 10^5$; p = 0.000). Therefore, the model errors exhibit non-constant variance between countries.

Autocorrelation. The Wooldridge test for panel autocorrelation rejects the null hypothesis of no first-order autocorrelation (F(1,40) = 58.26; p = 0.000), with an estimated autocorrelation coefficient ρ of 0.203.

Normality. The Skewness-Kurtosis test rejects normality of the residuals (Pr(Skewness) = 0.000; Pr(Kurtosis) = 0.000; p of the joint test = 0.000).

The combination of these three results indicates that the standard deviations associated with the random effects model in Table 3, although based on a statistically justified choice of specification (Hausman, LM), are not efficient and may lead to an overestimation of the significance of the estimated coefficients.

5.5 Generalized Least Squares (GLS) Corrected Estimation

To account for the error structure revealed by the diagnostic tests, the model is re-estimated using the full-feasible generalized least squares (FGLS) method, adapted to the presence of heteroscedasticity and intra-panel autocorrelation. The results, presented in Table 4, contrast sharply with those of the basic random-effects model: the coefficient associated with FDI loses all statistical significance (coefficient = 0.0062; z = 0.58; p = 0.562), while inflation, credit, and, this time, GDP remain significant at usual thresholds.

Variable	Coefficient	Standard error	z	p
log(IDE)	0.0062	0.0106	0.58	0.562
log(INF)	0.0347**	0.0134	2.58	0.010
log(Credit)	0.0275***	0.0077	3.59	0.000
log(GDP)	0.0169**	0.0081	2.07	0.038
Constant	1.1101***	0.0856	12.97	0.000

Table 4 — Corrected FGLS estimation (dependent variable: log(FBCF)).
*Wald $\chi^2(4) = 29.64$; $p = 0.000$. $N = 1062$, groups = 69. Note: *** $p<0.01$, ** $p<0.05$.*

The modified Wald test applied to the residuals of this new estimate continues to signal the presence of residual heteroscedasticity ($\chi^2(69) = 3.1\times10^5$; p = 0.000), which suggests that the applied FGLS correction only partially neutralizes the heteroscedastic structure of the errors and that further work — Driscoll-Kraay standard deviations or explicit reweighting by group — would still be needed to fully support the inference.

6. DISCUSSION

Three lessons emerge from this analysis. First, in its basic specification — the one retained by the Hausman/LM selection procedure — the model indicates a positive and significant effect of FDI on domestic investment, with an elasticity of the order of 0.040. This elasticity, much less than one, is interpreted, in line with Agosin and Machado (2005), as the signature of a partial multiplier effect (βLT < 1): FDI inflows stimulate GFCF, but in a proportion significantly lower than a dollar-for-dollar complementarity mechanism. Secondly, this conclusion must be strongly qualified in light of diagnostic tests. The combined presence of heteroscedasticity, autocorrelation, and non-normality of the residuals invalidates the usual inference based on the standard deviations of the random effects model. Once these shortcomings are corrected by an FGLS estimation, the effect of FDI ceases to be statistically distinguishable from zero, while the more traditional channels—domestic financing (credit), the level of economic activity (GDP), and the price environment (inflation)—retain robust explanatory power. This contrast illustrates a methodological risk common in the empirical literature on FDI and investment: significant results obtained under unverified assumptions about the shape of the errors may not withstand a correction of the variance-covariance structure of the residuals. Third, the static specification adopted here, while consistent with the log-linear theoretical framework presented in Section 3, fails to capture the dynamic adjustment highlighted in the literature (FDI lags, convergence towards a long-term investment rate). The lack of explicit treatment of the potential endogeneity of FDI—which may be correlated with shocks affecting domestic investment—constitutes a further limitation that a dynamic panel design (GMM system, à la Blundell-Bond) would overcome.

7. CONCLUSION

This study examined the effect of FDI inflows on domestic investment in a heterogeneous panel of 73 countries over the period 2000–2022. The panel data specification procedure led to the adoption of a random-effects model, in which FDI exerts a small but significant positive effect on GFCF, consistent with a partial spillover effect. This conclusion, however, proves fragile: diagnostic tests reveal heteroscedasticity, autocorrelation, and non-normality of errors which, once corrected by FGLS estimation, eliminate the significance of the FDI effect, while the classic domestic determinants of investment—credit, GDP, and inflation—remain robust. From an economic policy perspective, this result suggests that FDI attraction strategies should not be based solely on the assumption of an automatic boost to domestic investment: strengthening domestic financing channels (deepening credit) and macroeconomic stability (controlling inflation) appear, in this sample, as levers at least as robust as opening up to foreign capital. Methodologically, future work would benefit from mobilizing a dynamic panel specification (GMM system), explicitly addressing the endogeneity of the IDE through an instrumentation strategy, and using standard deviations robust to cross-sectional dependence and grouped heteroscedasticity (Driscoll-Kraay) — all natural extensions of the framework developed in this article.

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AI AND GENERATIVE AI: ANALYZIS OF SOME INDICATORS FROM THE EURO AREA

Paula C. R. Vicente
Universidade Lusófona - CUL; Intrepid Lab, Campo Grande, 376
1749-024 Lisboa - Portugal
p951@ulusofona.pt

Ana Lorga
Universidade Lusófona - CUL; Intrepid Lab, Campo Grande, 376
1749-024 Lisboa - Portugal
ana.lorga@ulusofona.pt

ABSTRACT

This study aims to begin with a comparison between Artificial Intelligence (AI) and Generative AI (GAI). As known, while AI helps machines think and make decisions, GAI helps machines create new content. Thus, GAI is a specialized branch within the broader field of Artificial Intelligence. Next, this work presents the historical evolution of GAI, its current forms, and a statistical analysis of selected GAI indicators in the Euro area. Generative AI has grown rapidly, moving from scientific research to everyday use, not only by companies driving business development across diverse sectors, but also through integration into both formal and informal education (personal one). Additionally, in this article, the use of GAI tools in the 27 countries of the European Union (EU), along with five more countries in the EU area, during the last quarter of 2025, is analyzed. Findings reveal that 39% of people in Portugal used GAI tools, a higher rate than both the EU27 and the wider EU area. The analysis highlights three main purposes for using these tools: personal, professional, and formal education. Portugal surpasses the EU27 and the EU area in all these categories. This work also analyses reasons for not using GAI tools, which include lack of need, lack of awareness, inability to use them, and concerns about privacy, security, and safety. In Portugal, 68% of respondents say they that do not need these tools, a proportion higher than that in the EU27 and EU area. Only 4.5% of Portuguese respondents are unaware of these tools, which is lower than 8.3% in the EU27 and 7.3% in the EU area. Furthermore, 15.34% of people in Portugal report not knowing how to use GAI tools, while 8% express concerns related to privacy, security, and safety.

Keywords: *AI, Euro area, Generative AI, Indicators*

1. INTRODUCTION

AI, particularly GAI, has become increasingly integrated into economic and social activities, transforming the ways individuals, businesses, and institutions create, process, and use information (Brynjolfsson & McAfee, 2017; OECD, 2024). Unlike traditional AI systems focused primarily on data analysis and automation, GAI enables the generation of original content across multiple formats, including text, images, audio, and video (Kaplan & Haenlein, 2020). Within the Euro area, the diffusion of these technologies raises important questions regarding productivity, innovation, competitiveness, and digital inclusion (European Commission, 2024). Using recent Eurostat data, this study analyses GAI adoption across member states by examining enterprise implementation, individual usage, and educational engagement (Eurostat, 2025). It also explores key barriers to adoption, including digital skills gaps, privacy concerns, lack of need or awareness and institutional constraints, assessing whether GAI contributes to economic convergence or reinforces existing digital inequalities across countries and population groups (OECD, 2024; European Commission, 2024).

2. AI AND GAI

The scientific basis of artificial intelligence appeared before its nomination in 1950 based on a work of Turing (1950), where he poses the question "Can machines think?", according to the author this question should be assessed through the Imitation Game (Turing Test), where a machine shows intelligence if it can converse in a way that's indistinguishable from a human being. Moreover, Turing anticipates key concepts of modern AI, arguing that digital machines can learn through experience, education, and adaptation, analogous to a child's cognitive development. Generative Artificial Intelligence is an extension of AI, so it can be considered to have the same origin of AI, as indicated in that scientific article. It should be noticed that sometimes people use GAI to mean Artificial General Intelligence, which is a hypothetical future AI capable of performing almost any intellectual task at a human level. However, in most business and technology discussions today, GAI usually refers to Generative AI. According to OpenAI (OpenAI, 2018), GAI refers to highly autonomous systems capable of outperforming humans in most economically valuable tasks. More generally, the literature describes GAI as systems able to understand, learn, adapt, and apply knowledge across multiple domains.

2.1. A Comparison between AI and GAI

As already described, AI is a technology that lets computers learn from information and helps people solve problems, create content, and make decisions more intelligently. We shouldn't fail to mention Narrow AI. Narrow AI emerged in the 1950s, when the first artificial intelligence systems were developed to perform specific tasks. It's the type of AI we use today in applications like virtual assistants, automatic translators, and recommendation systems. More recently, Generative AI (GAI) has expanded these capabilities by creating new content, such as text, images, audio, and code, based on patterns learned from large amounts of data, as described in the following table 1.

Text Generation (1)	**Image Generation (2)**	**Video Generation (3)**	**Music and Audio Generation (4)**	**Code Generation (5)**	**Design and Creativity (6)**
ChatGPT Microsoft Copilot Google Gemini Claude Jasper AI Copy.ai Notion AI	DALL·E Midjourney **Adobe Firefly** Stable Diffusion Ideogram	OpenAI Sora Runway Synthesia Google Veo Pika	Suno Udio ElevenLabs MusicLM	GitHub Copilot Amazon Code Whisperer Cursor AI Replit AI	Canva Magic Studio **Adobe Firefly** Microsoft Designer Figma AI

Table 1: The Different Types of GAI by goals
Source: Authors

(1)These tools can write emails, reports, articles, summaries, and answer questions. (Hashmeta AI, n.d.)
(2)These can create artwork,marketing materials, illustrations, and product concepts from text prompts. (Hashmeta AI, n.d.)
(3)These tools generate or edit videos from text description (Hashmeta AI, n.d.)
(4)These can create songs, sound effects, voiceovers, and realistic synthetic voice (Hashmeta AI, n.d.)
(5)These help developers write, explain, and debug code. (Aegis Softtech, n.d.) and (Hashmeta AI, n.d.)
(6)These assist with graphic design, presentations, logos, and marketing content. (Aegis Softtech, n.d.)and (Hashmeta AI, n.d.)

All these Applications of GAI are free until certain limits are set on its origin. “The past few years have witnessed unprecedented advancements in GAI. Notably, the AI system ChatGPT can communicate with humans in over 80 languages, and it can be used to perform almost any task for which text responses are appropriate. The capabilities of ChatGPT facilitate its use for generating visual, audio, and even multimodal content. This success stems from the development of GAI over half a century. For instance, representative events include the rise of deep learning, transformer architectures and foundation models” (He et al 2025).

However, while the conveniences and innovations brought about by generative AI are vast, they are not devoid of challenges. With the power to create comes the potential for misuse. Deepfakes, or hyper-realistic but entirely fake content, can deceive audiences, leading to misinformation and other malicious intents. Additionally, the indistinguishability between AI-generated content and human-produced content raises ethical questions about authenticity, intellectual property rights, and the devaluation of human creativity. (Wang, S. 2024)

2.2. Historical evolution of AI and GAI

As mentioned in the begining of this chapter, the foundations of AI are based on a work of Turning (1950). Several works follows this one, the official apearance of the expression AI, at the Dartmouth summer research project on artificial intelligence (Dartmouth, 1955), the Dartmouth proposal (1955) argued that all aspects of human intelligence could, in principle, be described so precisely that a machine would be able to simulate them. The goal was to investigate how computers could use language, form concepts, solve problems, learn, improve themselves, and even show creativity, thus laying the foundation for the area now known as Artificial Intelligence. In the period from 1956 to 1960, we find contributions (considered as foundations of AI) such as Newell, A. and Simon, H. (1956), this paper introduced the Logic Theorist, considered by many the first Artificial Intelligence program, capable of proving mathematical theorems automatically. The article by Newell et al (1959) was revolutionary for AI because it introduced the idea that intelligence can be modeled as symbolic information processing carried out by programs, laying the foundations for symbolic AI, heuristic problem-solving systems, and the conception of the mind as a computational system. Rosenblatt (1957) presents the Perceptron as a brain-inspired computational model capable of learning to recognize and generalize visual patterns through experience, laying the foundations for modern artificial neural networks. Referred to as the first AI winter, articles published in the 1970s (1970 – 1980) revealed that the initial expectations were too optimistic, due to encountering computational limitations and fewer results than expected, leading to a reduction in funding and scientific interest. The period between 1980 and 1987 is commonly known as the Age of Expert Systems, during which artificial intelligence achieved significant commercial success through knowledge-based systems. Expert systems were designed to emulate the reasoning abilities of human specialists by combining a knowledge base with an inference engine. Their widespread adoption in industry was driven by successful applications such as XCON at Digital Equipment Corporation, demonstrating that AI could provide substantial economic benefits. The central idea of this era was captured by Feigenbaum's Knowledge Principle, which argued that the power of intelligent systems comes primarily from the knowledge they contain rather than from sophisticated reasoning algorithms (Feigenbaum, 1982).

A second winter occurred approximately from 1987 to 1993, with difficulty in maintaining and expanding expert systems, and high computational costs, resulting once again in a decrease in investment and scientific publications. The period between 1990 and 2010 marked the rise of Machine Learning as a dominant paradigm in artificial intelligence. During this era, researchers shifted from knowledge-based and rule-based systems to data-driven approaches, enabling computers to learn patterns directly from data rather than relying on explicitly programmed rules. Advances in statistical learning methods, including Support Vector Machines, Bayesian Networks, and Decision Trees, together with the rapid growth of digital data and computational power, contributed significantly to the widespread adoption of Machine Learning (Jordan & Mitchell, 2015; Domingos, 2012). Following Figure 1, it is possible to track the historical evolution of AI and its "fusion" with GAI.

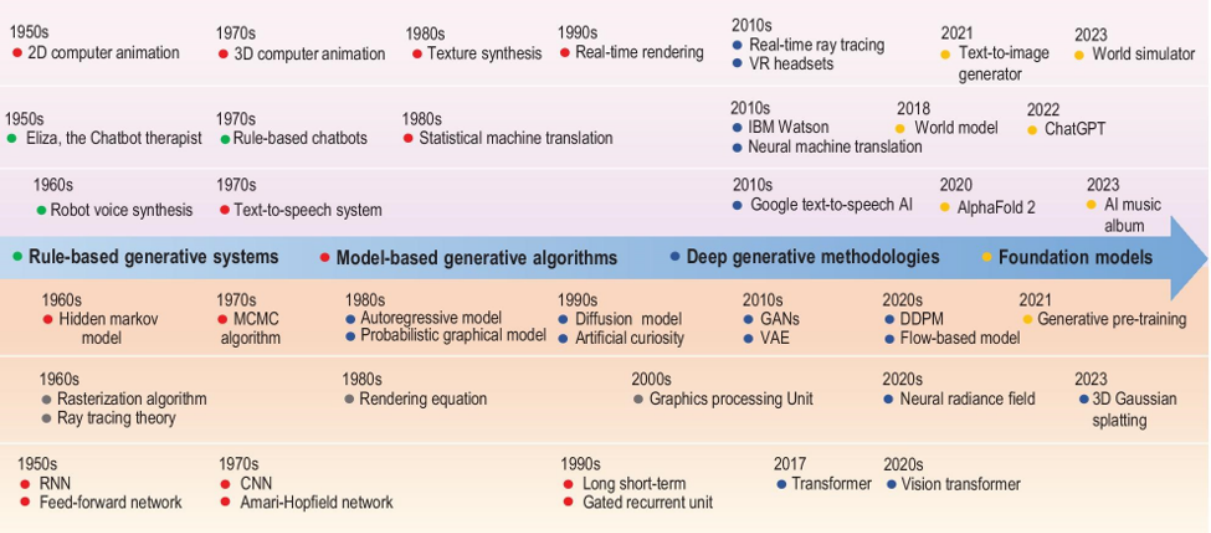

Figure 1. Timeline of the development of GAI methods and applications.
Source: He et all, 2026

From *Figure 1*, it is considered that the concepts of should be highlighted are the ones of:

- Recurrent Neural Networks (RNNs)
- Transformers

RNNs were the early foundation of sequential AI, processing text step-by-step in order, which made them slow and prone to forgetting long-distance relationships in a sentence. Transformers revolutionized this by introducing the "self-attention" mechanism, enabling models to process entire blocks of text simultaneously and weigh how words relate to one another regardless of their position. Building directly on this Transformer architecture

LLMs (Large Language Models) scale up these designs by training billions of parameters on massive datasets, allowing them to comprehend context, reason, and generate human-like text at an unprecedented scale. At the intersection of machine learning and natural language processing, the paradigm shift from foundational AI to GAI is anchored in architectural evolution.

Traditional deep learning approaches relied heavily on RNNs to process sequential data (Elman, 1990); however, their recurrent architecture inherently constrained parallel computation and suffered from vanishing gradients over long dependencies (Bengio et al., 1994).

The emergence of the Transformer architecture overcame these limitations through self-attention mechanisms (Vaswani et al., 2017), enabling simultaneous processing of token sequences and superior modeling of long-range contextual dependencies. Leveraging this Transformer foundation, LLMs - scaled to billions of parameters and trained on vast heterogeneous corpora - have expanded AI from rule-bound pattern recognition to emergent generative capabilities (Brown et al., 2020), fundamental reasoning, and complex natural language synthesis.

3. PURPOSES OF THE USE OF GAI ACROSS DISTINCT CONTEXTS

The generalized use of GAI tools among individuals represents a distinct paradigm in technology adoption. Unlike traditional enterprise-driven IT implementations, GAI tools (e.g., Large Language Models) have largely spread through bottom-up, individual-level adoption (Dwivedi et al., 2023). Recent empirical survey data across 35 European countries highlights the different purposes of the use of these tools, showing that individual usage may have distinct contexts such as, private life, professional settings, and formal education (Eurostat, 2025).

3.1 Private Life

Everyday personal or private use is a common form of GAI engagement across demographics, driven by low entry barriers, intuitive interfaces, and high perceived usefulness for informal tasks (Dwivedi et al., 2023). Users apply it, for information retrieval, personal productivity (e.g., scheduling and communication), creative expression (e.g., image generation), and self--directed learning. Adoption is strongly influenced by age and digital literacy, with younger groups experimenting more actively (Fletcher & Nielsen, 2024).

3.2 Workplace Integration and Professional Task Execution

Within organizational context, GAI adoption is largely bottom-up, driven by employees integrating the technology at the task level (Dell'Acqua et al., 2026). Task-based economic literature highlights that GAI departs from traditional automation by targeting non-routine, cognitive domains such as writing, software development, visual design, and data synthesis (Eloundou et al., 2023; Noy & Zhang, 2023). Consequently, workers selectively utilise GAI to augment specific task groups, thereby improving productivity and simplifying communication, rather than replacing entire jobs (Dell'Acqua et al., 2026; Noy & Zhang, 2023). Despite high exposure, a substantial adoption gap remains, with active utilization largely restricted to highly educated, digitally proficient workers in non-routine, cognitive occupations. (Eloundou et al., 2023). Furthermore, organizational constraints such as data privacy regulations, employer restrictions, and concerns over output accuracy create persistent friction to widespread implementation.

3.3 Formal Education and Academic Environments

The integration of generative GAI in formal education, at secondary and tertiary levels, constitutes one of its most widespread yet controversial applications (Cotton et al., 2023; Grassini, 2023). Students increasingly use these tools as dynamic ideation aids, personalized tutors, and research assistants (Strzelecki, 2024). According to some authors, theoretical frameworks such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) suggest that student adoption is primarily driven by performance expectancy, trust in the system's capabilities, and social influence (Kelly et al., 2023). However, the literature reveals a stark disconnect between student adoption and institutional alignment.

Although students frequently use generative AI for writing and coursework, scholars warn of ongoing challenges around academic integrity, diluted assessment validity, cognitive offloading, and varying levels of faculty AI literacy (Cotton et al., 2023; Grassini, 2023).

3.4 Obstacles to Adoption and Factors Influencing Non-Use

Despite the growing prominence of GAI, a substantial segment of the population remains non-users due to an interaction of perceptual, capability-based, institutional, and ethical constraints (Eurostat, 2025). The main factor is the perception of a lack of necessity, since people often consider conventional tools sufficient for their needs. (Venkatesh & Davis, 1996). Lack of skills and low levels of digital literacy, particularly among older and less educated populations, represent additional obstacles, fostering uncertainty regarding the effective design of instructions and the validation of results (Kelly et al., 2023). Furthermore, trust is undermined by persistent concerns about privacy, risks to data protection, and increased awareness of the model's limitations, such as biases and hallucinations (Dwivedi et al., 2023). Finally, institutional friction, manifesting as workplace restrictions, organizational bans, and ambiguous academic policies, creates formal barriers to adoption across both professional and educational environments (Cotton et al., 2023; Dell'Acqua et al., 2026; Grassini, 2023).

4. THE USE OF GAI IN EUROPE

The used dataset presents the percentage of individuals (with age between 16 and 74 years) reporting the use of GAI tools across 35 European countries, the 27 European Union (EU) members, along with eight additional countries in the EU area: Albania, Bosnia and Herzegovina, Kosovo, North Macedonia, Norway, Serbia, Switzerland, and Türkiye. Sourced from Eurostat website and covering the final quarter of 2025, it tracks usage across private, professional, and educational contexts, while also capturing key reasons for non-adoptions of these tools.

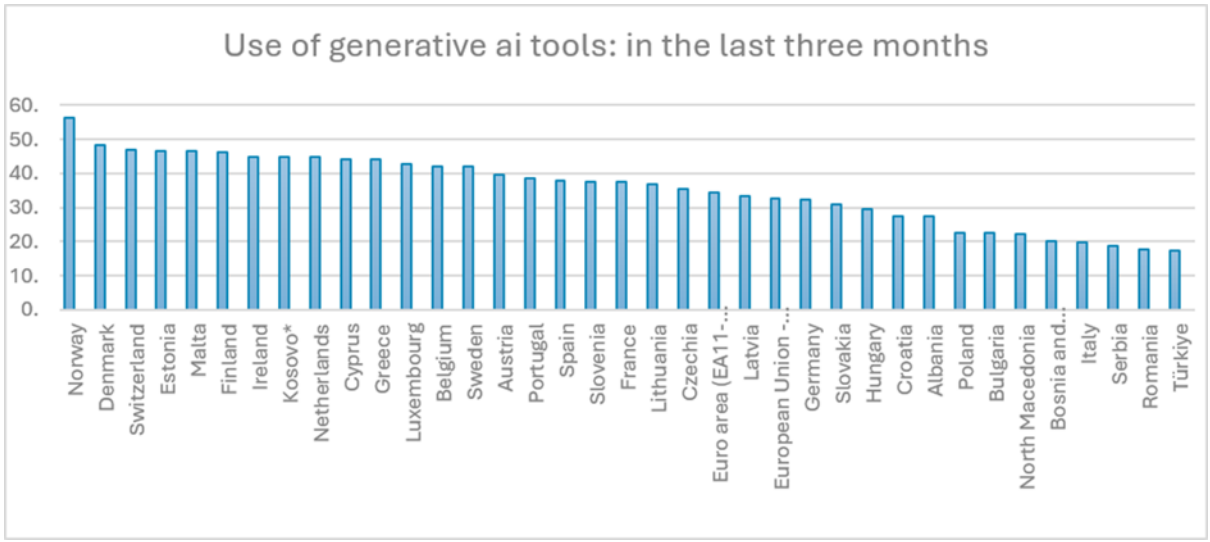

Figure 2. Percentage of individuals using GAI tools for the European countries in the last three months of 2025. Source: Authors

Figure 2 displays the percentage of individuals who reported using GAI tools in the final months of 2025. Norway exhibited the highest usage at 56.3%, followed by Denmark at 48.4% and Switzerland at 47.0%. Conversely, Türkiye recorded the lowest usage, with only 17.2% of individuals. Moreover, Portugal had a higher percentage of individuals using GAI tools (39%) compared to the EU area average (34.2%) or EU 27 (32.7%) and Germany (32.3%), which is one of the leading countries in the EU.

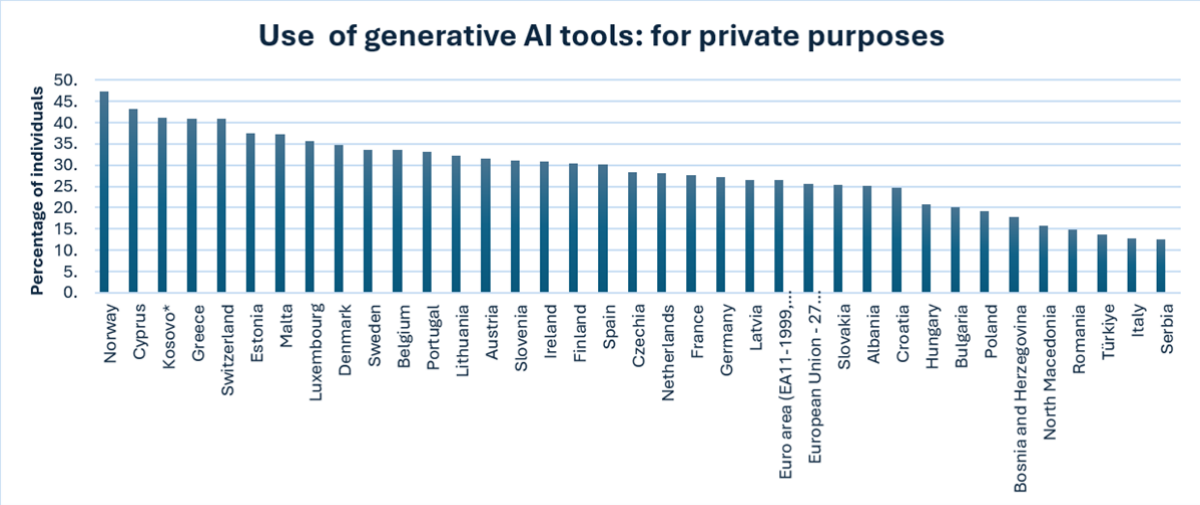

Figure 3. Percentage of individuals that use GAI tools for private purposes.
Source: Authors

Figure 3 shows the percentage of individuals who reported using GAI tools for personal or private purposes. Over 40% of respondents in Norway, Cyprus, Kosovo, Greece, and Switzerland indicated such usage. Serbia had the lowest at 12.7%, while Portugal, at 33.2%, surpassed the EU area average, which stands at 26.5% and the EU 27 average at 25.5%.

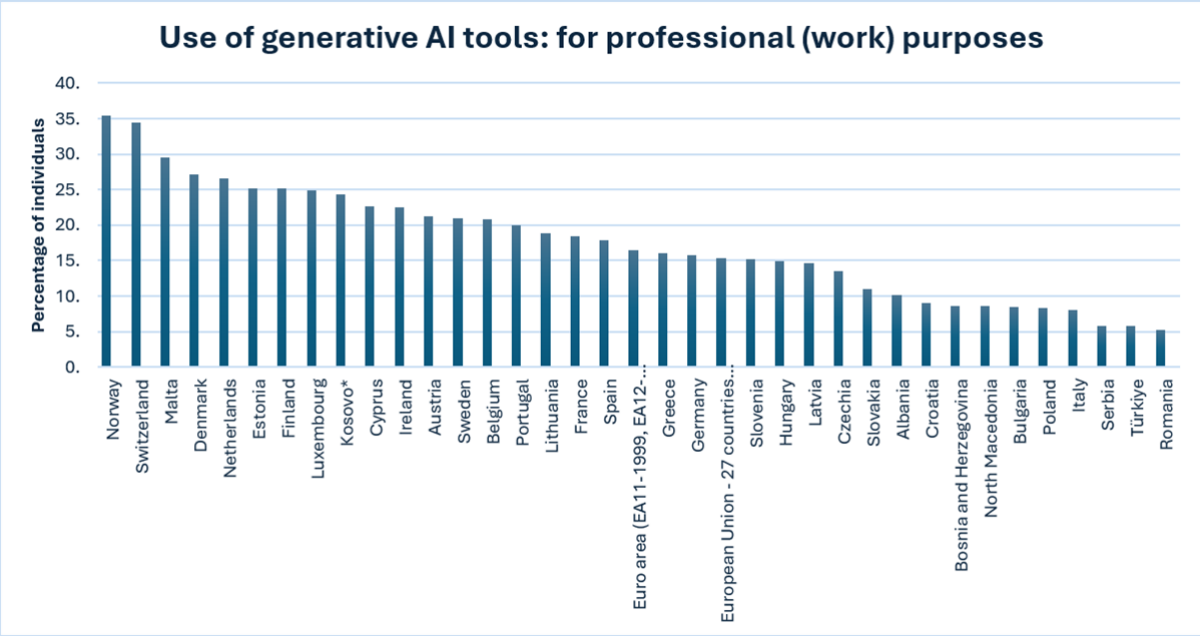

Figure 4. Percentage of individuals that use GAI tools for professional purposes.
Source: Authors

For professional purposes, Norway (35.4%) and Switzerland (34.4%) reported the highest percentages of individuals using these tools. Portugal reported a 19.9% usage rate, while the average across European countries is 16.5%. Germany slightly trails this average at 15.8%, and Romania has the lowest percentage in Europe, with only 5.2% of individuals using these tools for professional purposes, as shown in Figure 4. In the context of formal education, Switzerland, Kosovo, and Malta have the highest usage rates, each exceeding 20% (20.7%, 20.4% and 20.2%, respectively).

In contrast, Norway, despite leading in overall tool usage, has only 14.2% of individuals employing them for educational purposes. Portugal reports a usage rate of 14.5%. The average usage across European countries is 10.1% or 9.3% the average for EU 27 members, with Germany below this average at 6%. Romania has the lowest percentage in Europe, with just 3.4% of individuals using these tools for formal education, as illustrated in Figure 5. Across the 35 countries analyzed, non-users cite four primary factors for avoiding the use of GAI tools: lack of perceived need, unawareness, skill deficits and security concerns. Also, miscellaneous reasons (others) are registered (Eurostat, 2025).

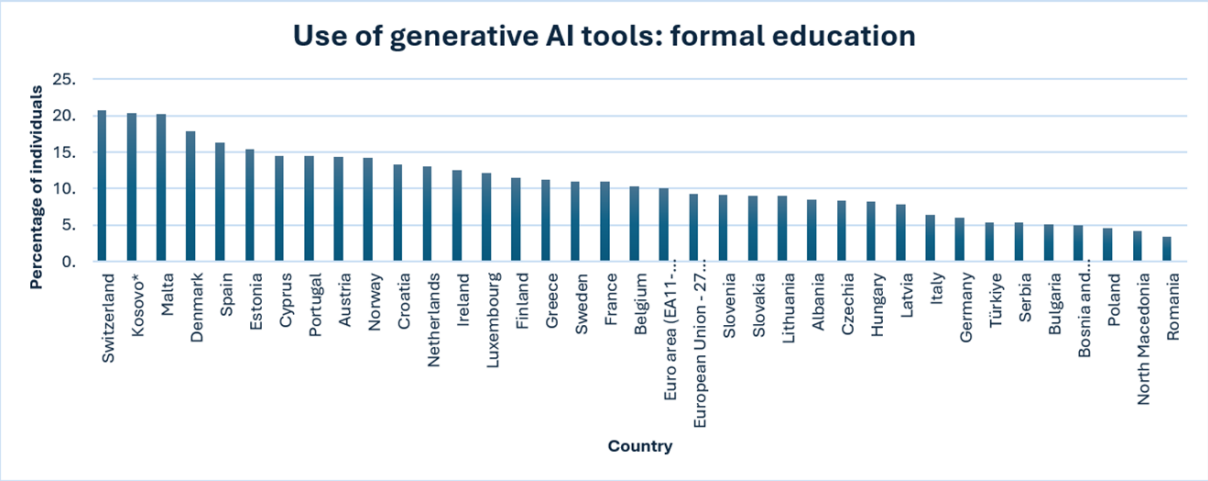

Figure 5. Percentage of individuals that use GAI tools for formal education.
Source: Authors

The primary driver of non-adoption is a perceived lack of need that is displayed in Figure 6. Over 80% of respondents in Estonia and Poland indicate they have no use for GAI tools, followed closely by Germany at 78%. More than 70% of individuals across ten other European nations, such as Czechia, Cyprus, Lithuania, Norway, Finland, Denmark, Denmark, Bulgaria, Slovenia and Greece, express the same view. At 67.9%, Portugal exceeds the average for EU 27 members of 64.3%. Conversely, Bosnia and Herzegovina (11.6%) and Spain (35.2%) record the lowest proportions of respondents reporting no need for these tools. It should be highlighted that only four European countries have values under 50%, Hungary, Albania, Spain and Bosnia and Herzegovina. Unawareness of GAI tools varies significantly by region, see Figure 7. Bosnia and Herzegovina reports the highest proportion of uninformed respondents at 59.8%, followed by Hungary at 36.4%. Across non-EU nations, unawareness generally remains above average, with Switzerland standing as a notable exception. Within the EU, unawareness drops significantly, averaging 7.3% in the EU area and 8.5% across the EU 27. Awareness is highest in Portugal and Ireland, where only 4.5% and approximately 1.3% of the population, respectively, remain unaware of GAI tools. A lack of technical knowledge for the use of these tools represents a key structural barrier to adoption in specific markets, as seen in Figure 8. In Albania and Spain, 35.3% and 27.5% of individuals, respectively, cite a lack of knowledge on how to operate GAI tools. Portugal (15.3%) sits slightly above the EU area baseline of 14.8%. Technical proficiency barriers are minimal in Cyprus with 5.3% and Germany with 6%. The analyze of Figure 9 allows to say that concerns regarding privacy, safety, and security are most pronounced in Ireland with 20%, Netherlands with 13.6%, France with 13.1%, and Switzerland with 12.9%. Germany also sits above the EU area average of 8.6% or the EU 27 average of 7.3%. In contrast, Portugal reports slightly below average at 8.3%, while Cyprus records the lowest level of security-related apprehension at 1.1%.

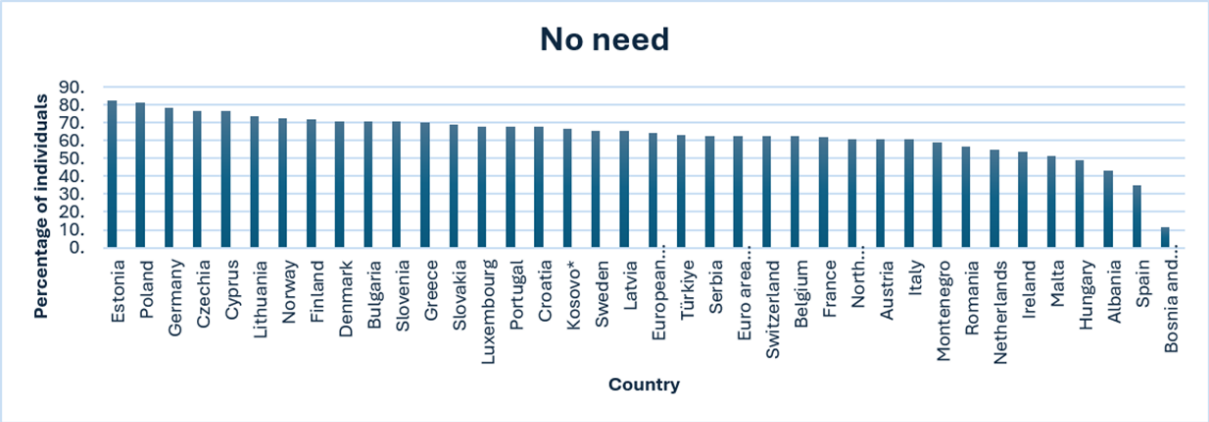

Figure 6. Percentage of individuals that do not need to use GAI tools.
Source: Authors

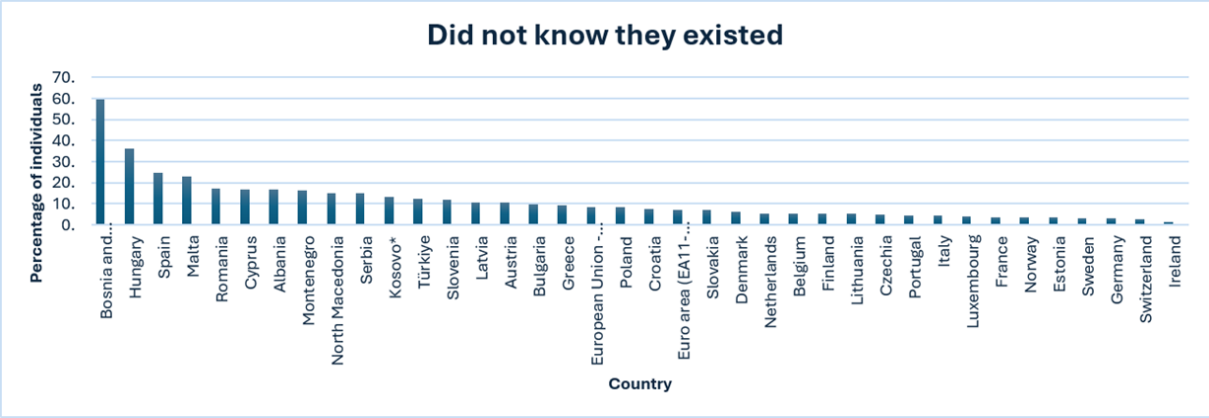

Figure 7. Percentage of people who are unaware of the existence of GAI tools.
Source: Authors

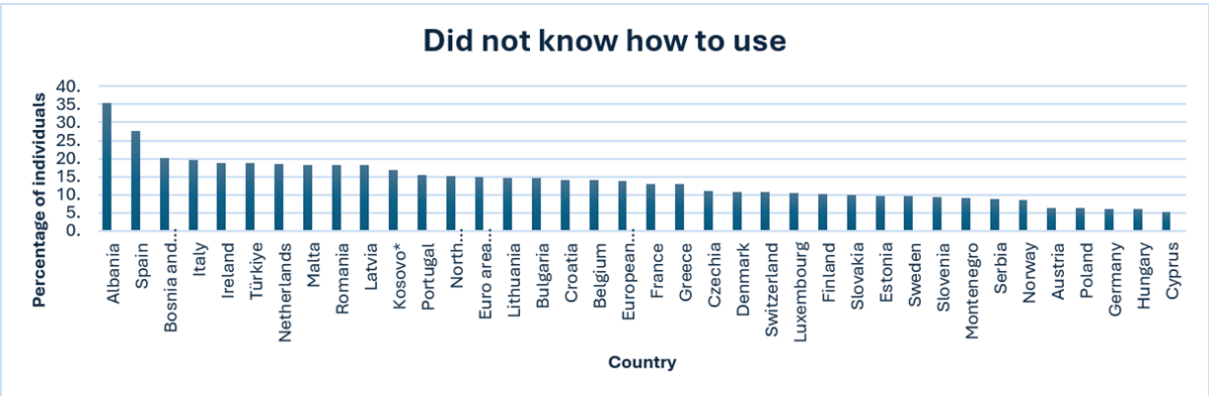

Figure 8. Percentage of people who don't know how to use GAI
Source: Authors

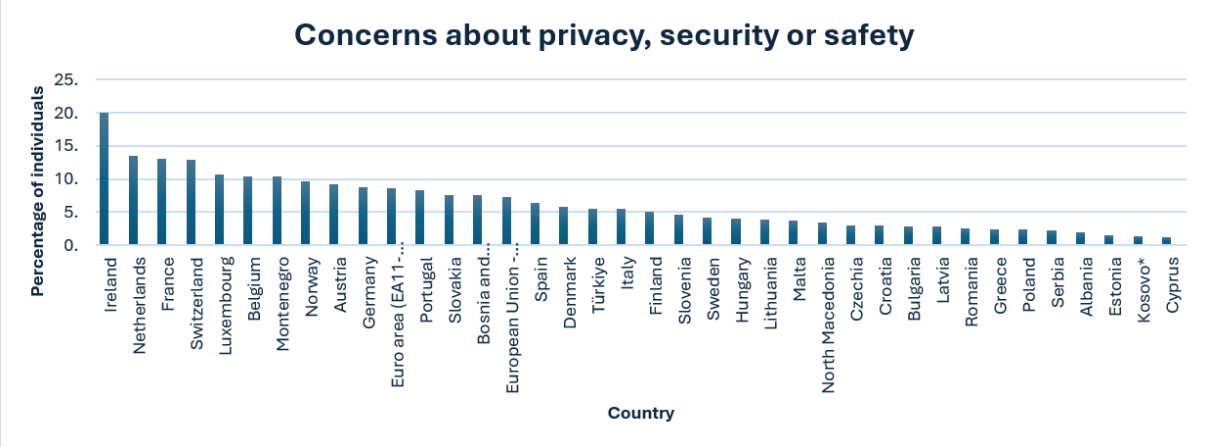

Figure 9. Percentage of individuals that have concerns about privacy, security or safety about GAI tools.
Source: Authors

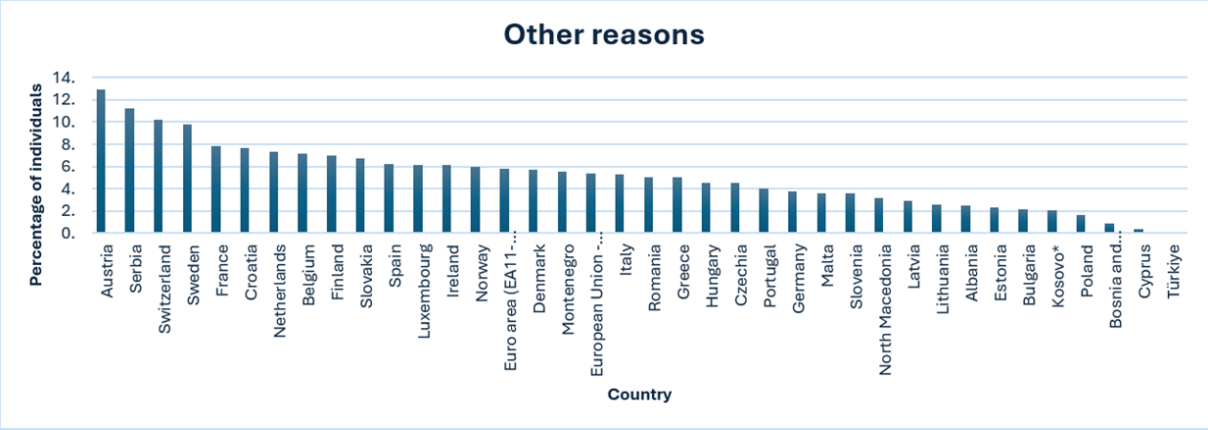

Figure 10. Percentage of individuals who have other reasons for not using GAI tools.
Source: Authors

Miscellaneous or unclassified reasons account for a minor share of non-adoption, averaging 5.8% across the EU area or 5.4% for EU 27 members. Rates peak in Austria at 12.9%, drop to approximately 4% in Portugal, and fall below 1% in Bosnia and Herzegovina, Cyprus and Türkiye as we can observe in Figure 10.

4. CONCLUSION

Given the widespread adoption of GAI globally and the ongoing discussions surrounding this thematic, Eurostat routinely publishes reports monitoring key indicators of its integration in European countries. Additionally, the reports cover the different domains in which these tools are used, and the reasons individuals choose not to use them. The data highlights a clear geographically driven divide in Generative AI adoption across Europe in the last quarter of 2025, with Nordic and Alpine countries, particularly Norway and Switzerland, consistently leading the continent in overall, personal, and professional usage. Also, in an educational context, Switzerland is at the forefront of utilizing these tools. Across all observed contexts, personal applications remain the primary driver of adoption, outpacing professional and educational uses in every country.

Meanwhile, Portugal consistently outperforms the European countries average (EU 27 members and EU area) across all metrics, contrasting with lower-adoption countries like Romania and Türkiye. These findings indicate that while GAI tools are gaining significant traction in everyday personal life, their integration into structured professional and formal educational environments remains at an earlier, more variable stage of maturity. The reasons for non-adoption of GAI across Europe is primarily driven by a widespread perceived lack of need rather than technical or safety barriers, with over 60% of the EU population, and up to 80% in countries like Estonia and Poland, seeing no utility in these tools. While general awareness is exceptionally high across most EU 27 member states, non-EU 27 members face a steeper information gap, led by Bosnia and Herzegovina where unawareness peaks at 60%. Structural and trust-based obstacles play a secondary, highly localized role in hindering uptake: operational skill deficits pose the main hurdle in countries such as Albania and Spain, whereas privacy and security concerns are most prominent in countries like Ireland, France, and Germany. Ultimately, these findings suggest that expanding GAI adoption will depend less on raising broad awareness and more on demonstrating tangible value and addressing region-specific skills and safety concerns.

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DIGITAL TRANSFORMATION OF HUMANITARIAN LOGISTICS: FROM AID DISTRIBUTION TO ANTICIPATORY ACTION

Dora Naletina
Faculty of Economics and Business, University of Zagreb, Croatia
dvuletic@net.efzg.hr

Hana Horak
Faculty of Economics and Business, University of Zagreb, Croatia

Ante Vuletic
Faculty of Economics and Business, University of Zagreb, Croatia

Ivana Stulec
Faculty of Economics and Business, University of Zagreb, Croatia

ABSTRACT*

Over the past few decades, humanitarian logistics has undergone a significant transformation, evolving from an operational function primarily focused on the transportation, storage, and distribution of humanitarian aid towards increasingly digitally connected, data-driven, and anticipatory humanitarian supply chains. The aim of this paper is to analyse how technological changes have influenced the evolution of the key capabilities of humaniatrian logistics and to demonstrate that the digital transformation of humanitarian logistics extends beyond the mere adoption of new technologies. This is achieved through a historical review of the development of humanitarian logistics. The literature analysis indicates that technological development has gradually transformed not only the execution of humanitarian logistics activities but also the timing of decision-making, the roles of humanitarian actors, and the ability of humanitarian organisations to identify and anticipate the needs of affected populations. The paper contributes to the relevant literature by conceptualising digital transformation as a capability development process within humanitarian supply chains, where technology serves as an enabler of transformation rather than its ultimate objective.

Keywords: *digital transformation, humanitarian logistics, humanitarian supply chain, digital technologies, artifical intelligence, anticipatory action*

1. INTRODUCTION

Climate change, rapid urbanization and geopolitical instability have been causing an increased number of disasters across the globe, with serious consequences affecting billions of people and causing substantial economic losses (Shrivastav and Bag, 2024). In such conditions, if logistics operations are delayed, the results can be fatal; lives can be lost and the suffering can be prolonged, which further underscores the critical importance of resilient infrastructure (Holguín-Veras et al., 2012). Humanitarian logistics needs to be viewed separately from traditional logistics activities. The former is directed towards saving lives and reducing suffering in conditions of extreme uncertainty, while the latter represent activities in commercial supply chains (Malem, 2026). Digital technologies offer those who operate in humanitarian supply chains tools for gathering a great amount of data. By analysing those data, managers of humanitarian supply chains can make better decisions regarding the allocation of resources, respond quicker to crisis situations and distribute humanitarian help more effectively (Dubey et al., 2022). According to the European Comission (January 2022), humanitarian supply chains make up between 60 % and 80 % of total global expenditure for humanitarian aid, including the activities from the phase of procurement to the final delivery.

Adequate implementation of digital tools in all phases of humaniatrian logistics can help optimize the costs, lead to better efficiency and release additional resources that can make humanitarian aid be of even greater help to the affected population. Because disasters have been occurring more often and on larger scales than ever before, humanitarian logistics and emergency supply chain management have become increasingly complex (Habibie et al., 2026). The complexity of catastrophic events has prompted humanitarian organizations to operate in conditions of great uncertainty, time pressure, inadequate infrastructure and partial information, so the demand for intelligent and responsive logistics decision-making has intensified (Abdulrashid et al., 2026). Traditionally, the goal of humanitarian logistics is to deliver aid to the affected population as quickly as possible. However, digital transformation has been gradually changing this approach, redirecting the focus from exclusively reactive activities to timely recognition of the needs and anticipatory response. The implementation of digital technologies and smarter information management enable the recognition of potential needs in advance, more effective decision-making and acting before the consequences of a disaster reach critical point. In that context, digital transformation does not simply represent technological modernization of humanitarian logistics but rather a shift in the understanding of how humanitarian needs are anticipated, assessed and responded to. Existing literature has mostly been focusing on individual technologies and very little attention has been given to understanding how technological advancements have been shaping humanitarian logistics capabilities collectively over time. This paper primarily focuses on examining the historical evolution of humanitarian logistics and analysing how technological advancements have transformed its key capabilities. Furthermore, it aims to demonstrate how digital transformation is not synonymous with adoption of new technologies, but rather represents a broader shift towards more connected, data-driven, and anticipatory humanitarian supply chains. The paper is based on the analysis of secondary data resources presented in four chapters. After the introduction, the terminology and the characteristics of humanitarian logistics are presented. The historical development of humanitarian logistics is presented in the third chapter, while the fourth chapter comprises the conclusions, limitations and recommendations for further research.

2. TERMINOLOGY AND CHARACTERISTICS OF HUMANITARIAN LOGISTICS

Humanitarian logistics is a process of planning, execution and control of an efficient flow of goods and material, and related information, from the point of origin to the point of consumation, aiming at relieving suffering of people affected by disasters (Daud et al., 2016). In a narrow sense, humanitarian logistics is a branch of logistics specialized in organizing delivery and storing supplies for the affected areas and for the people in need during emergency events. In its broader sense, humanitarian logistics includes anticipating and optimizing resources, supply management and information exchange. Humanitarian logistics encompasses different operations in different time frames as a response to different disasters. All those operations have a common goal of helping the people survive. Humanitarian operations mostly occur in the environments where the infrastructure is destabilized, i.e., there is no electricity, and/or the transportation infrastructure is damaged (Long & Wood, 2005). Van Wassenhove (2006) claims that disasters requiring humanitarian action can be divided into four categories:

1. Calamities – earthquakes, hurricanes, tornadoes etc.
2. Destructive actions – terrorist attacks, coups, industrial accidents
3. Plagues – famine, drought, poverty
4. Crises – political and refugee crises.

Humanitarian logistics has been developing in times of a growing number of natural disasters and crises caused by human actions.

These unfortunate events bring about many other unwanted disturbances that unfortunately result in relocation of many people who suffer the consequences (Sabri, 2018). During such emergency events, logistics serves as a set of measures and activities necessary for ensuring conditions for saving and caring for the affected population, removing the resulting consequences by organizing recovery actions and taking measures and activities for normal functioning of the community (Bačurin & Čendo Mentziger, 2014). Logistics support does not only imply ensuring the means for operating in such conditions but also encompasses and provides necessary resources, i.e., the supply of equipment and goods, their proper storage, checking that everything functions properly and providing education with the aim of building knowledge for efficiently completing tasks in the event of dire emergencies. The aim of logistics in these situations is to prevent the loss of life as one of the direct consequences of such catastrophies (Bačurin & Čendo Mentziger, 2014). Humanitarian operations represent a unique challenge in times of uncertainty and emergency demand in highly dynamic environments, where their success depends on the coordination inside the supply chains. Progress in the field of humanitarian logistics partly depends on better understanding why this process is in some cases more successful than in others, which depends on the capability to study complex and changeable logistics partnerships (Simpson, Tacheva and Kao, 2018). Humanitarian logistics, unlike commercial logistics, faces uncertainty regarding supply and demand (Van Wassenhove, 2006), but also the lack of coordination (Jahre, Ergun & Goentzel, 2015). Consequently, humanitarian logistics implies the implementation of a different approach to problem-solving. The areas affected by a disaster normally receive thousands of donations. However, the donations are not necessarily efficient, i.e., in line with the expectations of the affected population. This is the reason why it is of utmost importance to work on improving the integration (Christopher & Tatham, 2014). It is expected that humanitarian supply chains provide value to the end users or beneficiaries from the areas that need emergency response, not for the buyer in a traditional sense, as would be the case in commercial logistics (Blanco & Goentzel, 2006). Every crisis connects a new set of actors with different resources and obligations (Tomasini & Van Wassenhove, 2009). Humanitarian logistics enables the understanding of challenges in designing and modelling unexpected events that endanger lives and goods. Such events require an immediate reaction by using resources and procedures (more or less structured or organized), very often surpassing the capacity of the affected zone, therefore influencing the neighbouring of distant zones interested in cooperation. All of the above, considering the goals of saving lives and/or preserving assets, enables maintaining social, ecological, economic and political stability of the affected region, and the realisation of an efficient and effective logistics response (Yáñez-Sandivari, Cortés & Rey, 2021).

3. HISTORICAL DEVELOPMENT OF DIGITAL TRANSFORMATION OF HUMANITARIAN LOGISTICS

The critical event after which humanitarian logistics and its operations have gained more attention was the tsunami that happened in Asia in 2004. Since then, humanitarian logistics has been viewed as a series of operations whose purpose is to deliver help to the areas hit by disasters, and to offer support for a countinuous development of those areas (Kovacs & Spens, 2007). The development of humanitarian logistics can be observed as a gradual transformation from a dominantly physical function directed at delivering aid towards a more connected, information intense and anticipatory system of humanitarian supply chain management. In this context, digital transformation has not occured as a single technological shift but rather as a cumulative process in which new technologies have gradually expanded organisational capabilities of humanitarian actors.

The traditional capability of physical response has remained the basis, adding on the capability of coordination, visibility, connection, data analysis in real time and anticipation of future needs. This understanding is in line with the development of literature that has been viewing humanitarian logistics less and less through the lens of transportation and distribution and more and more as a complex management system of the flows of goods, resources, information and partnerships among many different stakeholders (Van Wassenhove, 2006; Kovács and Spens, 2007). The suggested periodization does not signify a complete exchange of one phase with another but a dominant development logic of the specific period. For example, contemporary application of artificial intelligence does not diminish the importance of transportation, storage or distribution; it changes the mode in which these activities are planned and set in motion. Likewise, digital transformation is not an exclusively technological process. It includes changes in the roles of the stakeholders, decision-making, coordination and information exchange (Naletina, 2026; Naletina et al., 2026). The section below observes the development of humanitarian logistics through seven developmental phases, defined according to the changes in the dominant focus and key organizational, information and technological capabilities. Their evolutionary cycle is displayed in Figure 1.



Figure 1: Phases of humanitarian logistics development
(Source: compiled by the authors based on the literature review)

3.1. Phase I – Physical response: *Relief Logistics*

In its early stages, humanitarian logistics was predominately viewed through the operational question of how to deliver aid to the affected population as quickly as possible. The focus was on physical flow of goods, i.e., transportation, storage, supply management and the end distribution of humanitarian aid. Such a model represented logistics as a form of support for the response after the disaster has already occurred and the successfulness depended on the speed of mobilization and the ability to deliver water, food, medicine, shelter and other means of help. Information technologies played a limited role and the exchange of information among the organizations often relied on traditional communication channels and fragmented systems. Although research on disaster management existed earlier as well, humanitarian logistics has only gradually started to be singled out as a separate research and management area. Subsequent literature reviews have shown that a significant portion of earlier research was directed towards operational issues relating to resource allocation, transportation, location and response to disasters, while an integrated humanitarian supply chain management was considerably less developed and underrepresented (Altay and Green, 2006). Therefore, the key cabability of this phase can be defined as physical response, i.e., the ability of physical mobilization and delivery of help in difficult conditions of high uncertainty, burdened by the time pressure and damaged infrastructure.

3.2. Phase II – Coordination: *Humanitarian Supply Chain Management*

During the 1990s, and especially at the beginning of the 21st century, the theory and practical application of humanitarian logistics gradually began to establish the notion that the effectiveness of humanitarian response was not defined exclusively by the ability of one organization to deliver humanitarian aid on time but rather that it depended considerably on the efficient management and coordination of the entire humanitarian supply chain.

The complexity of humanitarian operations derived, among others, from a great number of interdependent and heterogeneous stakeholders, including international humanitarian organizations, national and local authorities, non-governmental organizations, donors, suppliers, logistics services providers, military structures and local communities. Poor coordination and fragmentation of the above listed actors may result in duplication of activities, delivery failures, operational priorities disalignment and suboptimal allocation of limited material, financial and logistics resources. In this context, at the beginning of the 21st century a more intense transfer of the concepts and methods of supply chain management from the commercial into the humanitarian sector started to develop. Such development contributed to observing humanitarian logistics not merely as operational support in the form of transportation and distribution. This understanding shifted the conceptualisation of humanitarian logistics towards being an integrated management system operating the flows of materials, information and resources among different stakeholders in humanitarian supply chains. Van Wassenhove (2006) highlighted the importance of the development of basic capabilities of humanitarian logistics and the possibility of applying the knowledge and practices gained from commercial supply chains, with necessary adjustments to specific conditions of operating in areas affected by disasters. Additionally, Kovács and Spens (2007) isolated the characteristics that separate humanitarian supply chains from the commercial ones, some of them being high uncertainty regarding demand, instability and unpredictability of supply flows and involvement of many different stakeholders with different goals, responsibilities and operational capacities. Consequently, the development of humanitarian logistics during that period was marked by a shift from primarily being directed towards the delivery of help to a systemic management and coordination of the humanitarian supply chain, where coordination became one of the key organizational capability for realising an effective humanitarian response. This phase is important for understanding the later digital transformation because technology alone cannot eliminate institutional fragmentation. Digital tools can accelerate the flow of information, but their value depends on the readiness of the organizations to share the information and act in coordination. For this very reason, contemporary studies highlight the importance of the structure of the stakeholders in the humanitarian supply chain and their role in the process of digital transformation (Naletina, 2026), together with the influence donors have on the adoption of digital solutions, the transparency and the methods of reporting in humanitarian supply chains (Naletina et al., 2026).

3.3. Phase III – Information-supported humanitarian logistics

The period of roughly between 2005 and 2012 was marked with a pronounced realisation that the effectiveness of a humanitarian response was not determined only by the availability of the material resources but also by the ability to collect, process and exchange reliable information on time. In emergency conditions, humanitarian organizations have to build the picture of the situation quickly, considering the location, the condition of the transportation and other critical infrastructure, supply availability, accessibility of certain areas and timely distribution. Insufficient information visibility may result in uncoordinated resource allocation, duplication of activities, late deliveries and inadequate coordination of humanitarian actors (Balcik et al., 2010; Sangiamkul and van Hillegersberg, 2011). The literature from that period recognizes information systems as an important mechanism for connecting different parts of the humanitarian supply chain and for improving the quality of information flows among the organizations (Sangiamkul and van Hillegersberg, 2011). In this context, GIS, GPS, satellite images, digital data bases and various other forms of information and communication technologies have been gaining importance in assessing the situation, spatial identification of the needs and the coordination of humanitarian response.

Their value does not arise solely from the possibility to gather more data but rather from the capability to connect spatial, logistics and operational information in a comprehensive situational frame. In doing so, information infrastructure gradually becomes an integral part of logistics decision-making, especially in the environment where many organizations have access to different mandates, resources and information and it is necessary to have them coordinated (Balcik et al., 2010). The key capability of this phase of development can be defined as information visibility, i.e., the availability of relevant and timely information about the real-time situation in the field, the movement of resources and the needs of the population under threat in different levels of the humanitarian supply chain. The visibility goes beyond simple tracking of physical flow of goods and includes the exchange of information, supply, location and resource monitoring and support for decision-making processes. Subsequent studies confirm that better visibility can improve humanitarian operations through better availability of information in different parts of the supply chain (Privett, 2016). Information visibility is particularly important when it relates to the capability to recognize and organize the logistics response on time. Vuletić, Mišević & Jurčević (2026) highlight the importance of timeliness, clarity and information sufficiency in the early warning systems and their connection with the organization of the humanitarian response. In this way information capability stops having only the communication function and becomes an integral part of the capability to prepare, coordinate and execute logistics activities.

3.4. Phase IV – Connected humanitarian logistics

The period approximately between 2010 to 2016 was characterised by an intense connection of humanitarian actors via mobile technologies, social networks, crowdsourcing platforms and participation card systems. The catastrophic earthquake in Haiti in 2010 is often taken as a turning point in the development of digital humanitarian participation because it revealed the potential of distribution networks for gathering, processing and exchanging information. Platforms like OpenStreetMap, Ushahidi, GeoCommons and various CrisisCamp initiatives enabled the inclusion of a great number of individuals that were not formally a part of traditional humanitarian organizations but could contribute to geolocating the needs, updating the maps and processing information relevant for the disaster response (Zook et al., 2010). In this phase, the very structure of the information flows in the humanitarian system changed. The information was no longer obtained solely within the formal organizational and institutional channels but more often gathered from digital sources, including the local population, volunteers, diasporas and other non-institutional actors. Social media and collaborative platforms became an important mechanism for managing knowledge and the exchange of information among the heterogenous stakeholders in the humanitarian supply chain (Yates and Paquette, 2011). Consequently, the affected population stopped being viewed only as a passive reciever of help and started being a source of data, a communication partner and an active participant in creating a reliable picture of the event and its consequences. The core capability of this phase of development can be defined as connectivity, i.e., the ability to establish and maintain information connections among many different organizational and social actors included in the humanitarian response. Its importance did not arise solely from the increase of the amount of available data but primarily from the possibility to connect data, people and decision faster. In doing so, digital networks expanded the institutional limits of the humanitarian system and created conditions for more participative, distributive and flexible forms of coordination. Meier (2015) connected the phenomenon of the so-called digital humanitarians with the possibility of mobilizing global networks of volunteers with the aim of processing big amount of critical data and offering support to the formal humanitarian organizations. In addition, this phase also marked an important transition from digitalization towards digital transformation of humanitarian logistics.

While digitalization implies the implementation of digital technologies for a more efficient execution of the existing activities, digital transformation includes deeper changes in the way the information is created, distributed and used, as well as changes relating to those responsible for the decision-making processes. In this sense, the transformative effect of technology does not only lie in the replacement of the analogue processes with the digital ones but also in the reconfiguration of the partnerships between the stakeholders, boosting the speed and availability of the information flows and including new sources of knowledge in the humanitarian response. Due to that, individual digital technologies should not be considered separately but rather through the cumulative effect they exert on the coordination, participation and organizational capabilities of humanitarian supply chains.

3.5. Phase V – *Data-Driven Humanitarian Logistics*

Since the middle of the first decade of the 21st century, humanitarian logistics has been developing in the environment where huge amounts of data are collected. The key challenge in this phase is no longer the availability of information but the ability to integrate, process and interpret the data with the aim of making timely decisions. The data are gathered from different sources, including social networks, mobile devices, sensory systems, satellite images, unmanned aerial vehicles, logistics information systems and open data bases. Consequently, the focus is gradually shifted from gathering of information towards the development of analytical capabilities that enable the identification of the patterns, deviations and interdependence relevant for managing humanitarian operations. Big Data Analytics enables better assessment of the needs, smarter allocation of resources and stronger support for decision-making in conditions of heightened uncertainty (Gupta, Altay and Luo, 2019; Kondraganti, Narayanamurthy and Sharifi, 2022). At the same time, the implementation of interconnected digital technologies has been developing and expanding, including the Internet of Things (IoT), cloud computing, unmanned aerial vehicles, remote sensing and blockchain technologies. The IoT enables continuous monitoring of the location and the state of provisions, vehicles, equipment and infrastructure, while drones contribute to the efficiency of the transportation, tracking and gathering data in inaccessible or high-risk areas. Their implementation is mostly connected to transportation and delivery, monitoring and communication, and information support (Rejeb et al., 2021). Blockchain is in literature mostly connected to the increase of traceability, transparency and reliability of information and transaction flows, although the empirical confirmation of its effect in actual humanitarian operations still remains limited (Hunt, Narayanan and Zhuang, 2022). This confirms that technological availiability in itself does not imply transformation; it is rather a potential precondition for technological transformation. The core capability of this phase can be defined as operative intelligence in real time, i.e., the ability to connect multiple data sources, their timely processing and transforming them into the information relevant for operational and tactical decision-making. Its value arises from the possibility to boost situational awareness, accelerate the flow of information and reduce the time frame between the actual occurrence of the disaster and the organizational response. Here, digital technologies stop having an exclusively supporting role in communication and data recording and become an integral part of the process of managing humanitarian operations. Connected to this, the application of drones in health logistics can be observed as an example of the development of new operational capabilities, especially in conditions of poor accessibility, where activities are time sensitive and there is a need for a speedy distribution of medical supplies. However, their full effect does not arise from the application of technology but from its integration into the systems of planning, coordination, distribution and decision-making (Naletina, Štulec & Marinić, 2026).

This represents an important connection between information-based and intelligent humanitarian logistics because it establishes a data and analytical basis that predicitive and anticipatory capabilities will be developed on in the next phase.

3.6. Phase VI – Intelligent humanitarian logistics

Since the beginning of the second decade of the 21st century, a transition towards intelligent humanitarian logistics has been more and more prominent. Here, artificial intelligence, machine learning, predictive analytics, computer vision and related digital systems are not just there to support the understanding of the current situation, but they also anticipate future events. The application of artificial intelligence changes the way data are used when decisions are made. While earlier digital systems primarily relied on gathering, processing and interpretation of data for better understanding of the current situation in the field, modern AI-supported systems increasingly enable the recognition of patterns, assessment of probable scenarios and early decisions. In this way, humanitarian logistics gradually moves from a mostly reactive approach towards anticipatory action, in which the needs, risks and potential disturbances are tried to be recognized in advance, before they reach their full intensity. In this context, artificial intelligence and related analytical methods are investigated and applied for anticipating humanitarian needs, assessing demand, choosing locations and prepositioning of supplies, optimizing routes and allocating resources, assessing damages and processing satellite and areal images. Special value of such solutions arises from their ability to integrate big and heterogeneous data sets and offer more timely and precise support to decision-making in unfavourable conditions. A systemic review of the study by Abdulrashida et al. (2026) reveals how AI approaches, including machine learning, deep learning, NLP and reinforcement learning, are connected with the functions such as anticipation of demand, facility location, prepositioning, transportation routing and last-mile distribution. Similarly, Lythreatis, Acikgoz and Yassine (2026) identify the applications of AI in early warning systems, information flows, damage assessment, help distribution and optimization of transportation routes. The core capability of this phase can be defined as predictive capability, i.e. the ability to use data, models and analytical methods to recognize future needs, risks and disturbances in the humanitarian supply chain on time. Its importance does not arise only from the increase of the accuracy of the anticipatory function but primarily form the possibility to move the point of intervention from post- to pre-catastrophic phase. Timely assessment of possible needs enables humanitarian organizations to position their supplies earlier, to ensure enough transportation capacities, to activate financial and operational resources and to prepare distributional networks before the consequences of an emergency event are fully materialized. In this sense, predictive analytics becomes an important precondition for the development of anticipatory humanitarian action, where decisions and interventions are set in motion based on predefined tresholds, prognoses and risk assessments, and not after humanitarian action is already required (de la Poterie et al., 2023; Galindo and Batta, 2017). This development is directly connected to the practice of prepositioning of resources, which in humanitarian logistics has long been viewed as an important mechanism for improving preparedness and ensuring quick response. Prepositioning supplies and other assets before an emergency event has occurred can reduce logistics burden after the event and speed up the distribution of help, especially when decisions about the location and quantities of supplies are connected with the assessment of risk and prognoses of future scenarios (Rawls & Turnquist, 2010; Sabbaghtorkan, Batta & He, 2020). In this regard, predictive capabilities represent a connection between digital intelligence and anticipatory logistics because they enable the information about future risk to transform into a concrete logistical action before a crisis has occurred or fully escalated.

However, literature warns about new challenges AI brings: incomplete and fragmented sets of data, limitations of explanatory models, partiality, interoperability, privacy and ethical issues related to aid distribution (Abdulrashid et al., 2026). Therefore, digital transformation in this phase does not imply letting algorithms make autonomous decisions but rather developing a capability for humanitarian organizations to combine data, algorithm recommendations and human judgement.

3.7. From digitalization towards digital transformation of humanitarian logistics

By observing the phases above cobmined, it can be concluded that the development of humanitarian logistics cannot be reduced to a chronological cycle of implementing new technologies. The application of organizational capabilities that are developed and upgraded with their implementation is much more important. Physical response was gradually added the capabilities to coordinate, be visible and to connect, after which the development of advanced analytics has enabled smarter use of data in real time, while the application of artificial intelligence has been considerably strengthening predictive and anticipatory capabilities of humanitarian organizations. Such development points to the fact that technological advancement has a transformative effect only when it results in the changes in the coordination of the participants, exchange of information, decision-making and timely responses. In particular, it is important to consider digital transformation of humanitarian supply chains in the context of a network of interconnected stakeholders. The analysis of key participants shows that technological solutions do not act isolated. Their value depends on the relationships among the public institutions, humanitarian organizations, the business sector, donors and other participants (Naletina, 2026). The role of donors in itself already suprasses the sole financial support because they can influence the decisions about digital solutions, demands for transparency and reporting and, indirectly, the way the capabilities in the humanitarian supply chain are developed (Naletina et al., 2026).

Furthermore, the studies of early warning systems confirm that the effectiveness of the humanitarian response is not only defined by the availability of technology but also by the timeliness, clarity and usefuleness of the information it provides. In this way, information infrastructure gradually transforms from a supporting system into an integral part of logistics capability to respond and be prepared (Vuletić, Mišević & Jurčević, 2026). On the other hand, the application of drones in health logistics shows that certain digital technologies can expand the possibilities of operational distribution, monitoring and access to areas that are difficult to reach, but its transformative effect only arises from the integration into a broader logistics and organizational system (Naletina, Štulec & Marinić, 2026). For this exact reason, digitalization should be distinguished from digital transformation. Digitalization is primarily related to the application of digital tehnologies for a more efficient execution of the existing activities, while digital transformation implies a deeper change of the method in which the humanitarian supply chain functions, how the stakeholders are connected, how information is transformed into decisions and how organizations prepare for disturbances and mainatain the continuity of their operations. Research on resilience and continuity of humanitarian systems further confirm the importance of the capabilities that go beyond individual technological tools and include organizational learning, cooperation and adaptation to changing conditions (Naletina, Vuletić and Petljak, 2026). Reviews of contemporary literature confirm that the research focus in the last years strongly shifts towards technologies such as artificial intelligence, blockchain, IoT, Big Data Analytics, automatization and cloud systems and, at the same time, towards the capabilities that arise from their combinations – transparency, coordination, agility, resilience and quality of decision-making (Karami, 2026).

In line with that, it is justifiable to observe digital transformation of humanitarian logistics as a process of development and reconfiguration of the capabilities of the humanitarian supply chain, where technology functions as an enabler of changes, while real transformation is evident in the improved coordination, transparency, resilience, preparedness and the ability to make timely decisions. It is this understanding that enables the detachment from the technologically determinist approach and directs the attention towards the question crucial for humanitarian logistics: not only which technologies are available but what new capabilities can the humanitarian system develop with their implementation.

5. CONCLUSION

The analysis of the historical development of humanitarian logistics shows that its role has been gradually changing from a predominantly directed at physical mobilization and distribution of aid towards an increasingly integrated, data-based and technologically-supported humanitarian operations management system. This paper has displayed the development of humanitarian logistics through seven interconnected phases: physical response, coordination, information support, connectivity, data-based logistics, intelligent humanitarian logistics and digital transformation. Such developmental cycle shows that technological progress has not only influenced the speed and the effectiveness of individual logistics activities; it has changed the key capabilities of humanitarian logistics. The focus has shifted from the ability to deliver aid physically and to coordinate many participants towards the exchange of information in real time, the integration of different data sources, advanced analytics, anticipation of the needs and support for the decision-making processes. Considering the above-mentioned phases, the digital transformation of humanitarian logistics can be viewed as a result of a cumulative development of organizational, information and technological capabilities and not simply as an isolated consequence of the implementation of individual digital technologies. Information systems, digital platforms, mobile technologies, geospatial data, Big Data Analytics and artificial intelligence have been expanding the possibilities of humanitarian organizations to gather, exchange and analyse information and, based on them, to make timelier decisions. The transition from a dominantly reactive approach, where logistics response follows after the crisis has already occurred, towards the anticipatory approach which enables earlier recognition of the needs and potential distrubances. This confirms that technological progress transforms not only the tools humanitarian logistics uses but also the ways in which humanitarian operations are planned, coordinated and executed. Considering that this paper is based exclusively on secondary sources, the display of the seven phases of development represents an analytical synthesis of the existing scientific and technical literature and not an empirically supported model with clearly defined time frames for individual phases. For this reason, the phases should be viewed as interconnected and partially overlapping development patterns that enable a more systematic understanding of the core capabilities of humanitarian logistics. Future research could build on the presented framework with a primary empirical research and examine the extent to which modern digital and intelligent technologies are actually integrated into humanitarian supply chains and their effect on efficiency, resilience and anticipatory capability of humanitarian response. This would provide a deeper understanding of the transition of certain logistics processes towards a wholesome digital transformation of humanitarian logistics.

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FROM DRIVE-THRU TO CULTURE CUE: HOW QUICK-SERVICE RESTAURANTS COMBINE GEO-TARGETING AND CULTURAL ADAPTATION

Jui Chi Yang
Budapest University of Economics and Business, Marketing Master's Programme
Yang.JuiChi.52@unibge.hu

Tran Phuong An
Budapest University of Economics and Business, Marketing Master's Programme
Tran.PhuongAn.14@unibge.hu

Worthy Sheikh Rifah Tasnia
Budapest University of Economics and Business, Marketing Master's Programme
tasniatas97@gmail.com

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business, Marketing Master's Programme
papp-vary.arpad@uni-bge.hu

ABSTRACT

The rapid development of mobile technologies, location-based services, and data-driven marketing has fundamentally transformed how global quick-service restaurant (QSR) chains engage with consumers. At the same time, increasing cultural diversity and changing consumer expectations require multinational brands to adapt not only where they communicate, but also how they communicate across different markets. This paper examines how leading QSR brands, including McDonald's, Burger King, and KFC, combine geo-targeting and cultural adaptation to create highly localized marketing strategies. Drawing on academic literature and international case studies, the paper analyses geofencing, location-based mobile promotions, behavioural targeting, localized menus, and culturally tailored communication campaigns. The findings demonstrate that integrating location intelligence with cultural adaptation enables companies to increase customer engagement, strengthen brand relevance, and enhance competitive advantage across diverse markets. The paper also discusses managerial implications and the ethical challenges associated with increasingly personalized location-based marketing.

Keywords: *geo-targeting, location-based marketing, cultural adaptation, quick-service restaurants, geofencing, localization, consumer behaviour, mobile marketing, global marketing*

1. INTRODUCTION

The rapid diffusion of smartphones, mobile applications, and location-based services has fundamentally transformed marketing communication in the quick-service restaurant (QSR) industry. Among these developments, geographically targeted promotions have emerged as one of the most effective tools for attracting consumers at the right place and the right time. Burger King's well-known Whopper Detour campaign, which offered customers a one-cent Whopper when they were located near a McDonald's restaurant, demonstrated how real-time location data can influence purchasing decisions and redirect customer traffic (Fang et al., 2015).

Similarly, mobile app notifications such as "You're near McDonald's – get a free side with your Big Mac" illustrate the growing adoption of location-based services (LBS), enabled by the widespread use of smartphones and location-aware applications in consumers' everyday lives (Huang et al., 2018). At the same time, technological advances alone are no longer sufficient to ensure marketing success. As businesses increasingly operate across diverse international markets, consumers expect brands to recognize and respect local cultures, traditions, languages, and consumption habits. Research suggests that brands reflecting local preferences and cultural identities are perceived as more authentic and relevant than those relying solely on standardized global communication (Zhang et al., 2024). Consequently, cultural adaptation—including localized products, marketing messages, visual identities, and promotional campaigns—has become a critical component of international marketing strategies. For multinational QSR brands, geo-targeting and cultural adaptation are not separate marketing tools but complementary strategies. A location-based offer becomes considerably more effective when it also reflects local cultural values, consumer preferences, and purchasing behaviour (Gauthier et al., 2020). The integration of geofencing, behavioural data, localized menus, and culturally adapted communication enables companies such as McDonald's, Burger King, and KFC to create highly personalized customer experiences while maintaining the consistency of their global brands. Rather than applying a one-size-fits-all approach, these companies increasingly combine digital technologies with local market knowledge to strengthen customer engagement and competitive advantage. This paper examines how leading global QSR chains integrate geo-targeting and cultural adaptation within their marketing strategies. Drawing on academic literature and international case studies, it explores the main concepts underlying both approaches, analyses their practical implementation through campaigns by McDonald's, Burger King, and KFC, and discusses the strategic benefits, managerial implications, and ethical challenges associated with increasingly localized and data-driven marketing. More broadly, the study demonstrates how marketing in the quick-service restaurant industry has evolved from standardized mass communication towards highly personalized, context-aware, and culturally relevant customer engagement.

2. CONCEPTUAL FOUNDATIONS

2.1. Geo-Targeting

Geo-targeting refers to the practice of delivering personalized content or advertisements to online users based on their geographical location. Advertisers can identify a PC user's location through an IP address, while a mobile user's location can be determined through GPS technology. Location-based services enable advertisers to deliver text messages, email alerts, or app notifications when a user enters the vicinity of a firm's location (known as geofencing) (Fang et al., 2015) or even a competitor's location (known as geoconquesting) (Fong et al., 2015). Studies have shown that the distance between a store and a user has a significant impact on consumer decisions, including ad clicks, coupon redemption, and purchase intention. According to Tobler's (1970) First Law of Geography, "everything is related to everything else, but near things are more related than distant things." Geographic proximity therefore increases relevance for users and improves the effectiveness of online advertising (Molitor, 2013). In the fast-food context, geo-targeting can involve sending a coupon when someone is near a restaurant, adjusting marketing messages for urban versus suburban locations, or dynamically promoting a breakfast or coffee offer during the morning in a specific area.

2.2. Cultural Adaptation

According to Ady (1995), cultural adaptation is "the evolutionary process by which an individual adjusts his or her personal habits and customs to fit into a particular culture."

It can also refer to the gradual changes that occur within a culture or society when people from different backgrounds contribute their own views and practices. Kotler (1986) defines cultural adaptation more broadly as the adjustment of ways of thinking and behaving to fit local cultural practices. Although these definitions primarily focus on individuals, they provide a useful foundation for understanding how organizations must also adapt when operating across diverse markets. In marketing, cultural adaptation refers to adjusting marketing strategies and brand communications to the cultural values, norms, symbols, and preferences of the target market. Such adaptation is essential to ensure that brand messages are well received across different cultures, thereby increasing promotional effectiveness and product acceptance (Kotler & Keller, 2016). Applied to multinational QSR brands, cultural adaptation explains why restaurant chains such as McDonald's and KFC localize their menus, visual identity, and advertising campaigns to enhance relevance and authenticity for consumers in each market.

2.3. Why Geo-Targeting and Cultural Adaptation Matter in the Fast-Food Industry

The fast-food, or quick-service restaurant (QSR), industry is highly competitive, convenience-oriented, and characterized by relatively low consumer involvement. Consequently, both geo-targeting and cultural adaptation have a strong influence on customers' purchasing decisions. Consumer decisions in the QSR sector are often made quickly and are strongly affected by situational factors, including distance, time pressure, and advertising stimuli (Kotler & Keller, 2016). Since fast-food purchases are frequently impulsive, location-based marketing can significantly influence store choice and customer traffic by reaching consumers at the moment of decision-making (Fang et al., 2015). At the same time, cultural adaptation is equally important because food preferences, eating habits, and taste expectations vary considerably across markets. Research in global marketing shows that culturally appropriate products and communication increase relevance, trust, and willingness to purchase (Massey et al., 2013). Therefore, multinational QSR brands adapt their menus, visual communication, and marketing campaigns to local cultural contexts in order to strengthen consumer acceptance. The combination of these two strategies allows QSR brands to connect with consumers both situationally (where they are) and culturally (who they are), resulting in more effective customer engagement, higher conversion rates, and stronger market competitiveness.

3. REAL-WORLD IMPLEMENTATIONS

3.1. Geo-Targeting in Practice

Burger King – Whopper Detour

The Whopper Detour campaign by Burger King represents one of the best-known applications of geo-fencing within the QSR sector and provides an illustrative example of how location-based marketing can influence consumer decision-making. The primary objectives were (1) to increase adoption of the Burger King mobile application and (2) to strategically redirect consumer traffic away from McDonald's. Because fast-food choices are often proximity-driven and low-involvement, influencing consumers at the point of decision aligns with established research on situational determinants of food purchasing behaviour. Burger King implemented geofences with a radius of approximately 600 feet around more than 14,000 McDonald's restaurants in the United States. When consumers entered these zones and opened the Burger King application, the system automatically unlocked an offer allowing them to purchase a Whopper for US$0.01, redeemable only through mobile ordering. This mechanic ensured that location was not merely an informational variable but a direct trigger for promotional activation, which is consistent with the logic of real-time, context-aware targeting.

The campaign relied on two reinforcing mechanisms:

1) Spatial proximity – targeting consumers who were already in a fast-food decision context.
2) Competitive salience – amplifying the message by delivering it directly at competitor locations.

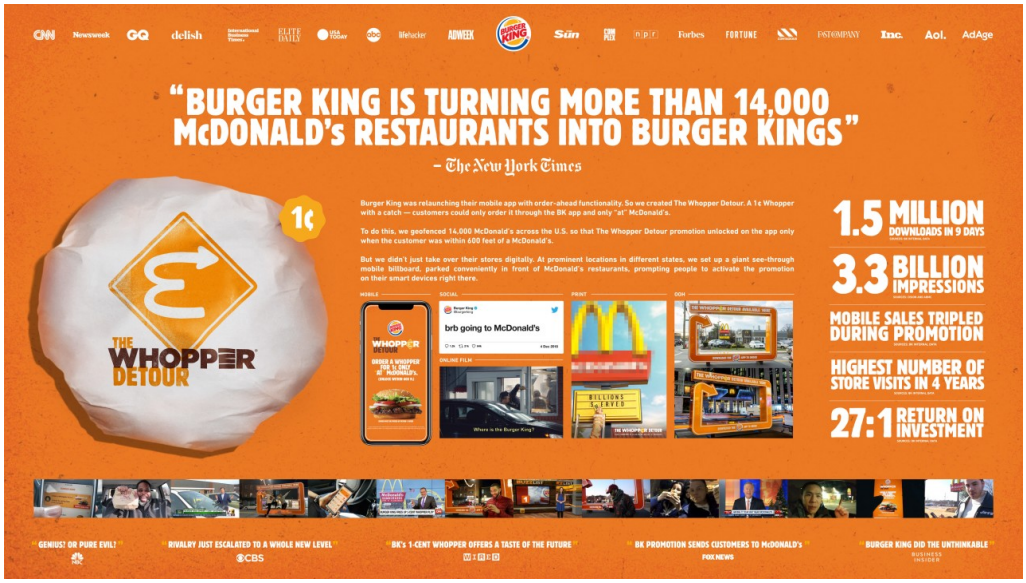

Figure 1. Burger King's Whopper Detour campaign demonstrating geo-fencing and competitive location-based targeting
Source: Burger King & FCB New York (2018). The Whopper Detour campaign. Reproduced from the official campaign material.

Although fundamentally based on geo-targeting technology, the campaign also incorporated a cultural dimension by drawing upon the widely recognized rivalry between Burger King and McDonald's. This framing increased consumer engagement and shareability, transforming the promotion from a simple price-based incentive into a culturally meaningful competitive gesture. The campaign generated substantial behavioural and digital results, including approximately 1.5 million mobile app downloads within nine days and one of Burger King's highest recorded increases in store visits and mobile orders. These results suggest that geo-fenced promotions can meaningfully influence consumer mobility patterns when deployed at scale.

McDonald's – Geofencing Roll-out

The primary objective of McDonald's Ready on Arrival initiative was to improve the efficiency of the mobile ordering process and reduce customer waiting times. Unlike earlier examples of geo-fencing used primarily for promotional purposes, this initiative focused on operational optimization and enhancing the customer experience (Restaurant Dive, 2023). McDonald's mobile application incorporates geo-fencing technology that detects when a customer is approaching a restaurant. Once the user enters a predefined radius, the system automatically notifies the kitchen, allowing staff to begin preparing the order before the customer arrives. This feature was introduced as part of the company's digital modernization strategy to reduce the time between order placement and order fulfilment (Restaurant Dive, 2023).

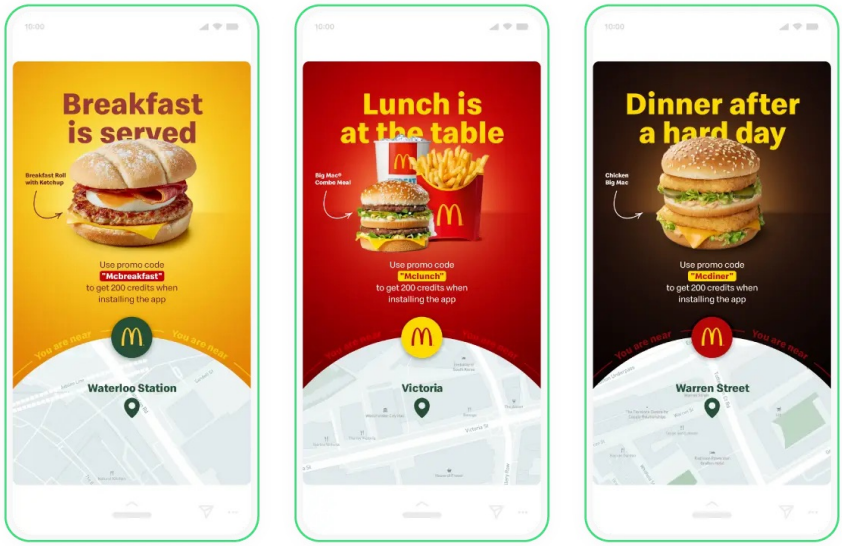

Figure 2. McDonald's location-based mobile advertising using geo-fencing and time-specific promotional messages
Source: McDonald's. Ready on Arrival and location-based mobile marketing campaign. Reproduced from Restaurant Dive (2023), McDonald's doubles down on geofencing. Retrieved 14.07.2026 from https://www.restaurantdive.com/news/McDonalds-doubles-down-geofencing-loyalty-growth/701753/

Industry analyses indicate that customers often become dissatisfied when mobile orders still involve waiting upon arrival. By minimizing this delay, McDonald's aligns its service model with contemporary consumer expectations for speed, automation, and convenience. As QSR Magazine (2023) notes, these "micro-efficiencies" contribute significantly to perceived service quality, particularly during peak periods when waiting costs are highest. Strategically, the feature strengthens digital adoption while reinforcing McDonald's positioning as a leader in fast-food digitalization. The initiative has produced measurable improvements in both operational performance and customer engagement. Reports indicate faster service times and higher customer satisfaction following implementation. In addition, internal metrics reported in trade publications suggest increased repeat app usage when geo-fencing is active, indicating stronger customer loyalty and greater perceived convenience. Overall, this case demonstrates that location-based technologies create value not only by driving customer traffic but also by improving operational efficiency and strengthening long-term customer relationships.

3.2. Cultural Adaptation in Practice

McDonald's Japan and South Korea: Region-Specific Product Localization

McDonald's aims to increase consumer relevance in East Asian markets by tailoring its core products to local taste preferences. This strategy enables the company to position itself as both a global and culturally responsive brand. Menu innovations include products such as the Teriyaki Burger in Japan and rice-based burgers in South Korea. These products incorporate familiar local flavours and food formats, aligning the Western hamburger concept with regional culinary traditions. Localizing flavours represents a classic form of cultural adaptation. In East Asian markets, where traditional eating habits remain strong, incorporating recognizable local ingredients enhances perceived authenticity. Prior research on cultural preference alignment suggests that such adaptation increases consumer acceptance by reducing the perceived "foreignness" of global brands.



Figure 3. McDonald's Japan's Gohan Burger campaign illustrating product localization through adaptation to local food culture
Source: McDonald's Japan. Gohan Burger advertising campaign. Reproduced from McDonald's Japan official marketing materials. Retrieved 14.07.2026 from https://www.mcdonalds.co.jp/

These localized products have consistently ranked among the best-selling seasonal and permanent menu items in their respective markets. Their success has strengthened McDonald's cultural resonance and customer loyalty while supporting long-term market stability despite strong local competition.

Creative Localization in Communication: Burger King's Pride Whopper (Europe) vs. Asian Markets

Burger King also adapts its communication style—including humour, symbolism, and tone—to align with cultural communication norms across different markets. In 2022, Burger King Austria launched the Pride Whopper campaign, featuring "two equal buns" as a symbolic and humorous reference to LGBTQ+ equality. The campaign relied on playful, visually explicit symbolism that reflects the characteristics of low-context Western communication, where directness, irony, and bold humour are generally well accepted. In contrast, Burger King's campaigns in Asian markets, such as Japan and South Korea, avoid such direct humour and visual provocation. Instead, they emphasize politeness, subtlety, traditional motifs, and food-centred storytelling, reflecting high-context communication cultures in which indirect expression and social harmony are given greater importance. Cross-cultural communication theory distinguishes between low-context cultures, which favour explicit and direct communication, and high-context cultures, where messages are conveyed more implicitly through relationships and context. While Western audiences often perceive provocative humour as creative and engaging, the same approach may conflict with cultural expectations of appropriateness and public modesty in many Asian societies. Kotler and Keller (2016) argue that communication styles should align with local cultural norms to maintain both message effectiveness and brand acceptance.



Figure 4. Burger King's Pride Whopper campaign demonstrating the adaptation of brand communication to local cultural values
Source: Burger King Austria. Pride Whopper campaign (2022). Reproduced from Burger King Austria official campaign materials. Retrieved 14.07.2026 from https://www.burgerking.at/

The Pride Whopper campaign generated substantial visibility throughout Europe while also provoking public debate because of its bold symbolism. Nevertheless, it successfully attracted attention and stimulated discussion—outcomes that are generally consistent with communication practices in low-context cultures. In Asian markets, Burger King's more culturally sensitive and tradition-oriented campaigns have maintained brand relevance without creating unnecessary cultural controversy. The comparison illustrates that effective creative localization requires sensitivity not only to language but also to humour, symbolism, and broader socio-cultural expectations.

3.3. Integrating Geo-Targeting and Cultural Adaptation (Hybrid Strategies)

Across different markets, fast-food chains increasingly adopt a hybrid approach that combines cultural adaptation with geo-targeting. By aligning cultural cues—such as festivals, local customs, humour styles, and regional tastes—with spatial and contextual signals, including store location, event venues, weather conditions, and delivery radius, brands can deliver marketing interventions that are both location-specific and culturally meaningful.

KFC China – Localization and Mobile Delivery Integration

KFC China, operated by Yum China, is a prime example of how glocalization and digital technology can be successfully combined. The brand has developed numerous region-specific menu items, including Old Beijing Chicken Rolls, Hot Dry Noodles, Xiaolongbao, and local breakfast products such as congee and tofu pudding. For example, when Hot Dry Noodles were introduced in Wuhan, more than one million servings were sold within a single week, making them the best-selling limited-time breakfast offer in three years. On average, each KFC restaurant in China offers more than 50 menu items—considerably more than in the United States—allowing the brand to respond to diverse regional tastes and time-specific eating habits. At the same time, KFC has deeply integrated digital ordering and delivery services through its proprietary mobile application, partnerships with food delivery platforms, and a CRM system that utilizes membership data.

This enables personalized promotions and menu recommendations based on customers' location and time of day—for example, promoting breakfast products to morning commuters in Tier-1 cities. The combination of localized menus, digital ordering, and a localized supply chain has enabled KFC to maintain strong market relevance in China, expand successfully into Tier-3 and Tier-4 cities, and strengthen its competitive position against both domestic and international competitors.

Burger King Brazil – Carnival and Festival Campaigns
Burger King Brazil demonstrates a digital-first marketing approach through the innovative use of mobile applications and augmented reality (AR). The Burn That Ad campaign allowed users to scan competitors' advertisements and "burn" them virtually in exchange for a free Whopper. The campaign generated more than 400,000 virtual ad burns, significantly increased app downloads, boosted in-app sales by approximately 55% during the campaign period, and generated around one billion media impressions, demonstrating exceptionally high levels of consumer engagement. Although there is no publicly available evidence that the campaign employed precise geo-targeting during Carnival or other street festivals, it illustrates how mobile applications, augmented reality, and interactive experiences can successfully engage consumers, stimulate purchases, and increase brand awareness. More broadly, the campaign demonstrates the potential for combining location-based marketing technologies with culturally significant events to create highly engaging customer experiences.

4. KEY IMPLICATIONS

Consumer responses to fast-food marketing vary considerably across different cultural and situational contexts. Values such as harmony, seasonality, and food-related traditions influence consumer behaviour in many Asian countries, making regionally adapted flavours and limited-edition products particularly successful. In contrast, European consumers often respond more positively to expressive humour, individuality, and social commentary, enabling brands to adopt more creative and provocative communication approaches. Academic research supports these observations. Van 't Riet et al. (2016) demonstrate that advertising aligned with consumers' immediate goals performs better than advertising relying solely on location congruence. Book and Wallach (2015) further show that integrating contextual signals such as time of day, geographical proximity, and previous consumer behaviour significantly enhances advertising effectiveness. Similarly, Yoon et al. (2022) demonstrate that combining weather conditions and temporal cues with location-based messaging further increases campaign effectiveness. Lian et al. (2019) further argue that effective geo-targeting should integrate temporal targeting, behavioural targeting, and promotional incentives into a comprehensive contextual targeting framework, thereby maximizing the relevance and effectiveness of location-based marketing. Implications for QSR marketers include the following:

- Combine location with context. Geofencing around restaurant locations (e.g., within a 200–300 metre radius) should trigger promotional messages when consumers are in purchase-ready situations, such as lunchtime or while visiting shopping centres.
- Refine targeting signals. Incorporating variables such as time of day, weather conditions, previous purchases, and mobile app engagement improves message relevance and conversion rates.
- Localize creative content and offers. Visual elements, communication style, promotional messages, and menu offerings should reflect local culture, language, and consumer preferences.
- Provide genuine customer value. Push notifications should deliver meaningful incentives rather than generic promotional reminders.

- Measure campaign performance. Monitor store visits, app redemptions, and location-triggered interactions to evaluate foot traffic and return on investment.
- Respect customer privacy. Maintain transparency regarding location tracking and ensure explicit user consent.
- Connect campaigns with the brand story. Local festivals, holidays, sporting events, and community activities can reinforce brand relevance.
- Think globally, adapt locally. Maintain global brand consistency while allowing sufficient flexibility to accommodate local cultural differences.

By integrating cultural understanding with context-aware geo-targeting, QSR chains can increase advertising relevance, attract more customers to their restaurants, and strengthen brand resonance across diverse international markets.

4. CHALLENGES AND ETHICAL CONSIDERATIONS

Although geo-targeting and cultural adaptation offer significant marketing advantages, their implementation also presents several challenges and ethical considerations.

Privacy concerns: Consumers are becoming increasingly aware of how their location data and mobile app usage are collected and processed. Geo-targeting that is perceived as overly intrusive or "creepy" may generate negative reactions and reduce trust in the brand. Therefore, marketers must balance personalization with transparency by clearly explaining what data are collected and how they are used.

Cultural missteps: Successful localization requires much more than simple translation. Marketing campaigns must respect local customs, values, traditions, and cultural sensitivities. Advertisements that ignore cultural differences, use inappropriate language, or rely on culturally insensitive imagery may generate negative publicity and reduce campaign effectiveness. For example, a fast-food advertisement that contains culturally inappropriate visuals may discourage rather than attract potential customers.

Over-targeting fatigue: Sending excessive location-based notifications may lead to customer fatigue. Users who receive too many messages may begin to ignore notifications or disable them entirely, thereby reducing the effectiveness of future marketing communication.

Data and infrastructure challenges: Effective geo-targeting and cultural adaptation require robust technological infrastructure, including mobile applications, location-based SDKs (Software Development Kits), customer databases, and segmentation engines. In some markets, uneven technology adoption or poor data quality may limit the effectiveness of personalized marketing campaigns.

Measurement and attribution: Measuring the direct impact of geo-targeted campaigns is often challenging. Companies must determine appropriate attribution windows, estimate incremental store traffic, and distinguish campaign effects from other marketing activities. Reliable analytics are therefore essential for evaluating return on investment and optimizing future campaigns.

The importance of goal congruence: Academic research suggests that matching advertising to consumers' immediate goals is more effective than targeting based solely on geographical location. Rather than simply informing consumers that they are near a restaurant, marketers should consider whether they are in an appropriate purchase situation by combining location data with contextual factors such as time of day, weather conditions, or previous purchasing behaviour.

5. CONCLUSION

Geo-targeting and cultural adaptation are reshaping the way QSR brands connect themselves with consumers. Instead of using generic messages, brands are improving relevance by connecting consumers 'geographical locations with their cultural background. Geo-targeting can enable timely, location-specific action, like discounts launched when near stores or during lunch time, as cultural adaptation can enhance impact through local tastes, styles, and symbolic elements. The combination of these strategies makes fast food marketing more accurate, contextual, and significant. Academic findings support this shift: campaigns perform best when location indicators are combined with targeted and culturally relevant messaging. In other words, effectiveness comes not just from being "near," but also from reaching consumers at the right time with cultural relevance. These tactics do present certain difficulties, though. Brands must execute targeting carefully and responsibly due to privacy expectations, potential cultural drawbacks, notification fatigue, the need for data infrastructure, and the complexity of information distribution. In general, QSR marketers' competitive edge comes from combining cultural and contextual intelligence to provide timely, pertinent, and courteous information. Companies are able to strike a balance between local responsiveness and global scale will develop deeper relationships with customers in a variety of markets.

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NEVER LET ME GO:
PREDICTING CUSTOMER CHURN BEFORE IT HAPPENS

Davit Kupatadze
Budapest University of Economics and Business, Marketing Master's Programme
Kupatadze.Davit.94@unibge.hu

Dora Csikos
Budapest University of Economics and Business, Marketing Master's Programme
Csikos.Dora.90@unibge.hu

Eunice Owusu
Budapest University of Economics and Business, Marketing Master's Programme
Owusu.Eunice.88@unibge.hu

Kirubel Mekonnen
Budapest University of Economics and Business, Marketing Master's Programme
Mekonnen.KirubelAshebir.48@unibge.hu

Arpad Ferenc Papp-Vary
Budapest University of Economics and Business, Marketing Master's Programme
papp-vary.arpad@uni-bge.hu

ABSTRACT

Customer churn has become one of the most critical challenges facing organizations in increasingly competitive and data-driven markets. As customer acquisition costs continue to rise, retaining existing customers has become a strategic priority across industries. Advances in customer analytics, artificial intelligence, and machine learning now enable companies to identify early warning signs of customer disengagement and intervene before customers decide to leave. This process, known as churn prediction, has evolved into a key component of customer relationship management and data-driven marketing. This paper examines the concept, strategic importance, and practical applications of churn prediction in contemporary marketing. It discusses the main types of customer churn, the behavioural indicators that precede customer attrition, and the analytical process through which predictive models estimate churn probability. Furthermore, the paper presents a range of customer retention strategies, including personalized offers, recommendation systems, proactive customer support, predictive timing, and user experience improvements. To illustrate these approaches, the study reviews practical examples from Netflix, Spotify, Amazon, and the telecommunications industry. Finally, it addresses the ethical considerations surrounding predictive analytics and outlines future developments driven by artificial intelligence, real-time analytics, and increasingly personalized customer experiences. The paper argues that effective churn prediction is no longer merely a technical capability but a strategic marketing tool that enables organizations to strengthen customer relationships, improve customer lifetime value, and achieve sustainable competitive advantage.

Keywords: *churn prediction, customer retention, predictive analytics, machine learning, customer relationship management, personalization, customer lifetime value, recommendation systems, artificial intelligence, customer experience*

1. INTRODUCTION

Imagine a romantic relationship that begins perfectly. Communication is frequent, both partners invest time and attention in each other, and the relationship appears stable. Over time, however, subtle changes emerge. Messages become less frequent, meetings become less common, conflicts remain unresolved, and the emotional connection gradually weakens. Long before the relationship officially ends, clear warning signs have already appeared. Businesses experience remarkably similar patterns in their relationships with customers. Rarely do customers disappear without warning. Instead, they gradually reduce their engagement by visiting less frequently, making fewer purchases, ignoring marketing communications, or spending less time using a product or service. These behavioural changes often signal an increased likelihood of customer churn long before the customer formally terminates the relationship. The rapid growth of digital platforms, customer relationship management systems, and advanced analytics has enabled organizations to monitor these behavioural signals with unprecedented precision. Today, companies collect vast amounts of transactional, behavioural, demographic, and engagement data that can be transformed into valuable insights through predictive analytics. As markets become increasingly competitive and customer acquisition costs continue to rise, customer retention has become a fundamental element of sustainable business strategy. Research consistently demonstrates that retaining existing customers is significantly more cost-effective than acquiring new ones, making the prevention of customer churn essential for long-term profitability (Reichheld & Sasser, 1990). Churn prediction therefore has become a central application of artificial intelligence and machine learning within customer relationship management. Modern predictive models, including logistic regression, decision trees, random forests, gradient boosting algorithms, and deep learning techniques, are capable of identifying customers who are at risk of leaving with increasingly high levels of accuracy. These predictions enable organizations to intervene proactively through personalized marketing campaigns, recommendation systems, targeted retention offers, proactive customer support, and other customer-centric strategies before customer relationships deteriorate further. This paper provides an overview of churn prediction from both theoretical and managerial perspectives. It introduces the concept and different forms of customer churn and explains how predictive models identify customers at risk. It also discusses the main strategies used to reduce customer attrition and improve customer loyalty (Kurhasku-Hoti & Rrustemi, 2025). These strategies are illustrated through practical examples from companies such as Netflix, Spotify, Amazon, and the telecommunications sector. Finally, the paper examines the ethical implications of predictive customer analytics and highlights future developments driven by artificial intelligence and real-time personalization.

2. UNDERSTANDING CUSTOMER CHURN

Customer churn can be classified based on the customer's intention to leave, the reason for departure, or the nature of disengagement. The primary types of customer churn are:

- *Voluntary churn* occurs when a customer makes a conscious decision to end their relationship with a brand, usually because of dissatisfaction with the product or service or because they have found a better offer from a competitor.
- *Involuntary churn* occurs when a customer stops using a service due to reasons beyond their immediate control, such as payment failures or expired credit cards. This type of churn is often preventable through effective billing management systems.
- *Behavioral churn* occurs when customers gradually reduce their level of participation or engagement without formally terminating their relationship with the company.
- *Inactivity churn* refers to situations in which customers slowly drift away from a product or service without communicating their intention to leave.

- *Subscription churn* occurs when a customer actively cancels a subscription-based service, such as YouTube Premium, Netflix, or Spotify.

There is also a less traditional form of customer attrition known as silent churn. This occurs when customers do not complain or explicitly cancel a service but gradually reduce their usage until they eventually stop interacting altogether. Research suggests that silent churn is particularly problematic because companies often receive no direct warning signals, making it much more difficult to identify problems and intervene before customers leave (Fader & Hardie, 2009). Service management research further indicates that most dissatisfied customers never formally complain, even when they experience poor service quality. According to the well-known TARP research, only 4% of dissatisfied customers complain, while the remaining 96% simply leave without providing any feedback (Goodman, 2009). As a result, companies may develop a false sense of customer satisfaction simply because no complaints are received. Silent churn is particularly common among digital platforms and subscription-based businesses, where customers can stop using a service without formally cancelling it. Detecting this type of churn therefore relies heavily on behavioural analytics, engagement metrics, and predictive modelling capable of identifying the early signs of declining customer interest. Customer churn represents one of the greatest challenges facing modern businesses. Running a business requires substantial investments in products, employees, marketing, technology, and day-to-day operations. Consequently, losing customers can quickly translate into serious financial problems. When customers leave, companies immediately lose future subscription fees, repeat purchases, and cross-selling opportunities. Research consistently shows that retaining an existing customer is considerably less expensive than acquiring a new one, making customer churn a direct threat to long-term financial performance (Reichheld & Sasser, 1990). Customer churn also reduces Customer Lifetime Value (CLV), which represents the total profit a company expects to generate from a customer throughout the entire business relationship. When customers leave prematurely, businesses often fail to recover their acquisition costs, making sustainable long-term growth more difficult to achieve (Gupta et al., 2006). Furthermore, dissatisfied customers frequently share negative experiences with others. Studies indicate that negative word of mouth spreads more rapidly and often has a stronger influence than positive recommendations, discouraging potential customers from choosing the business (Anderson, 1998). For these reasons, customer churn is far more than simply losing individual customers; it threatens a company's financial performance, reputation, and future growth.

The consequences of customer churn are well illustrated by the Leaky Bucket Effect. Many business owners assume that customers who leave can simply be replaced by acquiring new ones. In reality, however, the more customers a company gains, the more it may lose if customer churn is not properly managed. The concept is similar to pouring water into a leaking bucket: regardless of how much water is added, the bucket never fills because it continues to leak. In business, the "leak" represents customer loss. Research demonstrates that relying solely on customer acquisition is both costly and unsustainable when existing customers continue to leave (Reichheld & Sasser, 1990). The most effective solution is strong customer retention. This means keeping customers sufficiently satisfied to continue purchasing products or services over an extended period. Studies have shown that even relatively small improvements in customer retention often have a greater impact on long-term profitability than comparable investments in customer acquisition, because loyal customers generate higher lifetime value while requiring lower maintenance costs (Gupta et al., 2006). The Leaky Bucket Effect therefore reminds businesses that stopping customer loss is just as important, if not more important, than continuously acquiring new customers.

3. UNDERSTANDING CHURN THROUGH CUSTOMER DATA

Customer data makes churn both visible and measurable. By collecting and analyzing different types of customer data, businesses can identify not only which customers are likely to leave but also the reasons behind their decision. Usage data, such as login frequency and session duration, reveals how actively customers interact with a product or service (Shivkumar, 2025). Transaction data, including purchases, renewals, downgrades, and refunds, highlights the economic dimension of the customer relationship. Engagement data, such as email open rates, click-through rates, and campaign responses, reflects how customers respond to marketing communications. Finally, feedback data, including customer support tickets, online reviews, and satisfaction scores, helps identify pain points and overall customer sentiment. When these data sources are analyzed together, meaningful patterns emerge that would be difficult to detect individually. For example, many customers who eventually churn follow a similar behavioural pattern: product usage gradually declines, purchases become less frequent, responses to marketing communications decrease, and customers may leave negative feedback or stop communicating altogether (Sneha, 2025). Customer segmentation further improves churn prediction by identifying groups that consistently exhibit higher churn rates, such as highly price-sensitive customers, discount-oriented buyers, or users from regions where engagement is naturally lower. A practical example of data-driven churn analysis can be found in the telecommunications sector through the use of Tableau, one of the most widely used business intelligence and data visualization platforms. Tableau dashboards transform complex customer data into intuitive visualizations, enabling managers to identify behavioural patterns and support strategic decision-making. The following three dashboards, adapted from Reddysakshi (2023), illustrate how customer churn can be analysed within a telecommunications company.

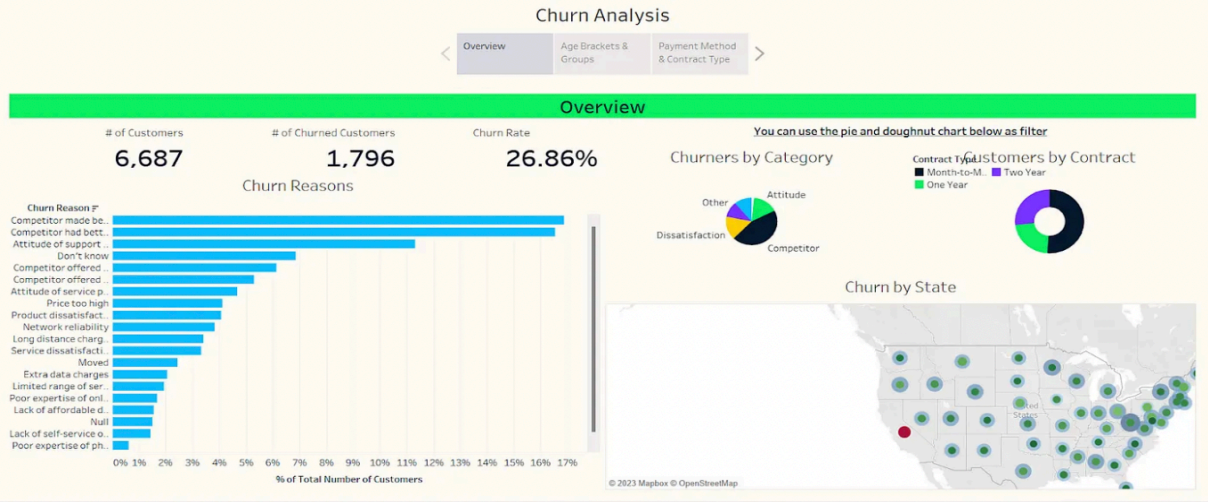

Figure 1. Customer Churn Overview Dashboard
Source: Reddysakshi. (2023). Unveiling the Story of Customer Churn Through Data Visualization for a Telecommunication Company. Medium.com

The first dashboard provides an overview of the entire customer base. Out of 6,687 customers, 1,796 had churned, representing a churn rate of 26.86%. A horizontal bar chart further illustrates the main reasons for churn, showing that competitive offers, pricing, and dissatisfaction with service quality were the primary drivers of customer attrition.

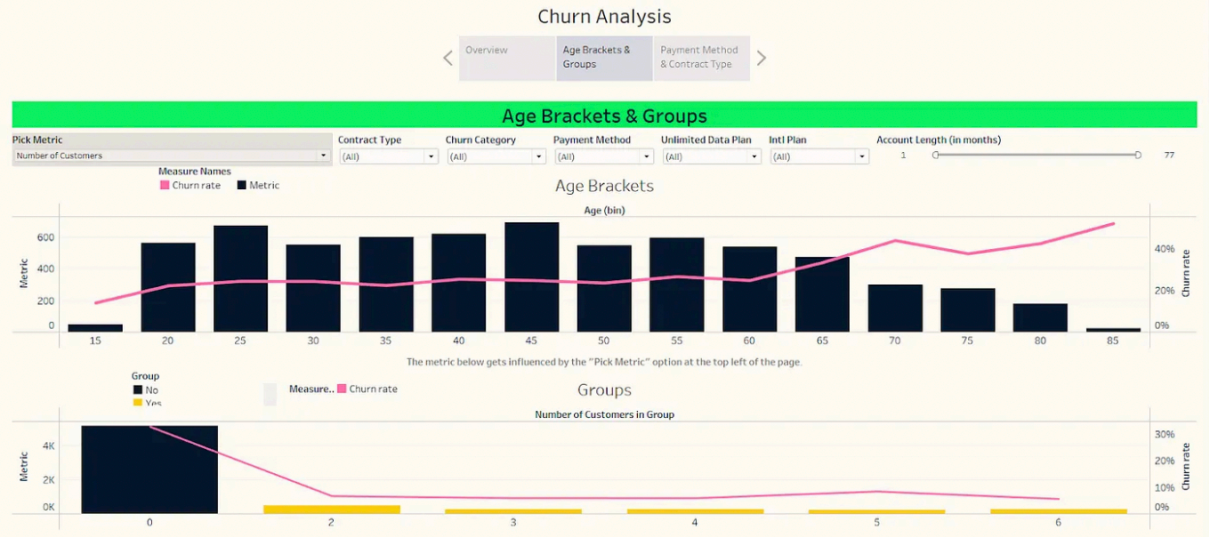

Figure 2. Customer Demographics Dashboard
Source: Reddysakshi. (2023). Unveiling the Story of Customer Churn Through Data Visualization for a Telecommunication Company. Medium.com

The second dashboard focuses on demographic characteristics, particularly customer age. A dual-axis chart combines the number of customers within each age group with the corresponding churn rate, illustrating how customer loyalty varies across different age segments. Interestingly, the highest churn rate is observed not among the youngest or oldest customers but among middle-aged customers.

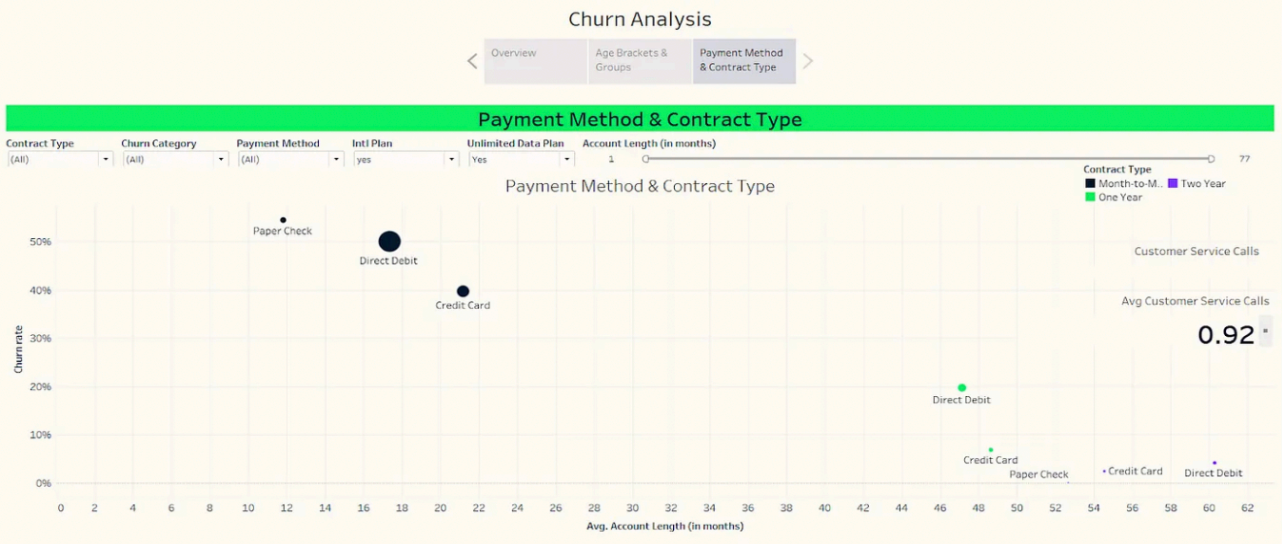

Figure 3. Payment Method and Contract Type Dashboard
Source: Reddysakshi. (2023). Unveiling the Story of Customer Churn Through Data Visualization for a Telecommunication Company. Medium.com

The third dashboard explores the financial characteristics of churn. A scatter plot compares churn rates with average account duration across different payment methods and contract types. The analysis indicates that customers using month-to-month contracts together with paper check payments exhibit the highest churn rates, suggesting that contract structure and billing methods significantly influence customer retention.

Together, these dashboards demonstrate how visual analytics transforms large volumes of customer data into actionable managerial insights, allowing organizations to identify churn patterns, understand customer behaviour, and design more targeted retention strategies. Rather than simply presenting historical information, visual analytics enables managers to detect emerging trends, recognize high-risk customer segments, and support faster, evidence-based decision-making. Beyond visualizing historical churn patterns, customer data also enables companies to identify early warning signs before customers actually leave. Research consistently demonstrates that customer churn is usually preceded by a gradual decline in engagement rather than a sudden termination of the relationship (Shivkumar, 2025). Typical behavioural indicators include fewer logins, reduced usage of key product features, declining purchase frequency, and failure to adopt newly introduced services. Warning signs also emerge through customer communication. Customers who stop opening marketing emails, ignore in-app notifications, or become less responsive to promotional campaigns and social media interactions often disengage well before formally cancelling their subscriptions (Lim & Rasul, 2022; Sneha, 2025). Likewise, an increasing number of support tickets, lower participation in customer surveys, or progressively more negative feedback may indicate growing dissatisfaction and unmet expectations. By continuously monitoring these behavioural and communication signals, organizations can intervene proactively and implement retention strategies before customer churn becomes inevitable.

4. HOW CHURN PREDICTION WORKS

Customer churn prediction follows a structured analytical process that transforms raw customer data into actionable business insights. Although different organizations use different technologies and algorithms, the overall process generally consists of four main steps.

Step 1. Data Collection: Churn prediction begins with gathering customer data from different parts of the business. This includes behavioural patterns, such as login frequency, time spent using the service, or actions taken within the platform; purchase history; engagement metrics; demographic information; and customer experience signals, such as complaints, customer support tickets, or service requests. When these data sources are combined into a single dataset, companies can identify behavioural patterns that would be difficult to detect when analysing each source separately (Verbeke et al., 2012).

Step 2. Feature Engineering: Once the data has been collected, it must be transformed into meaningful variables through a process known as feature engineering. This involves creating indicators such as the number of days since the last purchase, changes in login frequency, average spending, recent support activity, or subscription plan type. Research demonstrates that these engineered features capture early behavioural changes and significantly improve the predictive accuracy of churn models (Lemmens & Croux, 2006).

Step 3. Predictive Modelling: After the features have been prepared, machine learning models are trained using historical customer records to identify behavioural patterns that are most strongly associated with customer churn. Commonly applied techniques include logistic regression, decision trees, random forests, and gradient boosting algorithms. These models have consistently demonstrated strong predictive performance because they can recognize both simple and complex combinations of risk factors that precede customer attrition (Neslin et al., 2006).

Step 4. Churn Probability Score: The trained model assigns every active customer a churn probability score, usually ranging between 0 and 1, representing the estimated likelihood that the customer will leave. Companies typically classify customers into low-, medium-, and high-risk segments based on these scores. These risk categories support more efficient allocation of marketing resources. For example, high-risk customers may receive personalized retention offers or direct contact from customer support teams, while medium-risk customers may receive reminder emails, loyalty incentives, or targeted marketing campaigns. As a result, retention activities become more focused and cost-effective.

The effectiveness of churn prediction lies in its reliance on actual customer behaviour rather than intuition. By comparing historical data from customers who remained with those who left, predictive models learn which behavioural patterns consistently precede customer churn (Verbeke et al., 2012). Once these patterns have been identified, organizations can recognize similar warning signals among their current customers, often long before customers formally terminate their relationship with the company. Another important advantage is the efficient allocation of business resources. Discounts, loyalty rewards, personalized communication, and customer support interventions all require financial investment. Since not every customer generates the same business value, predictive models help organizations prioritize retention efforts by identifying high-value customers who are also at high risk of leaving. This enables companies to maximize the return on their retention investments. Finally, churn prediction continuously improves over time. After retention campaigns have been implemented, companies can observe which customers remained loyal and which still decided to leave. These new outcomes are incorporated into the training dataset, allowing predictive models to learn from both successful and unsuccessful interventions. This continuous feedback loop gradually improves prediction accuracy while helping organizations develop increasingly effective customer retention strategies.

5. CUSTOMER RETENTION STRATEGIES

Churn prediction creates value only when companies act upon the insights generated by predictive models. The real challenge is not identifying customers who are likely to leave but transforming churn scores into effective and personalized retention strategies. High-risk, high-value customers often require direct outreach, dedicated customer support, or personalized offers, while medium-risk customers may benefit from lighter interventions such as educational content, product recommendations, or engagement reminders (Ng et al., 2020). Effective retention programmes also rely on continuous experimentation. Marketing professionals regularly test different messages, communication channels, offers, and timing to determine which interventions are most successful for different customer segments. A/B testing and online controlled experiments have become the industry standard for evaluating the causal impact of retention interventions and identifying the most effective strategies (Kohavi & Longbotham, 2017). In many cases, the most successful intervention is not a discount or promotion but a product or service improvement that addresses recurring customer pain points. This creates a continuous feedback loop in which churn predictions guide interventions, while customer responses generate new data that further improves predictive models and deepens the organization's understanding of customer behaviour. Several customer retention strategies are commonly implemented for customers who are likely to churn or who have already disengaged.

5.1. Personalized Retention Offers

Personalized retention offers help retain customers by providing incentives that reflect their individual preferences and needs.

Research demonstrates that personalized communication increases customer satisfaction, loyalty, and long-term retention (Kumar & Reinartz, 2016). Common approaches include:

- Exclusive discounts, which help retain customers who are primarily motivated by price.
- Personalized bundles, using previous purchase behaviour to recommend products or services that match customer preferences.
- Free trials or premium upgrades, allowing customers to rediscover the value of a product or service without additional risk. This strategy is particularly effective for subscription-based businesses.
- Birthday and loyalty rewards, which strengthen emotional attachment by demonstrating customer appreciation and encouraging positive word-of-mouth.

5.2. Win-Back Journeys

Win-back journeys aim to re-engage customers who have already begun to disengage. These automated recovery campaigns typically include personalized emails, push notifications, or retargeting advertisements delivered at carefully selected moments. Research suggests that timely communication can successfully reactivate inactive users, particularly when it reminds them of the value they previously received. Automated recovery flows are effective because they respond quickly to early warning signs and provide personalized incentives that encourage customers to return.

5.3. Fixing User Experience (UX) Problems

Churn prediction frequently reveals that customers leave because of poor digital experiences rather than dissatisfaction with the product itself. Complicated checkout processes, confusing navigation, slow-loading pages, and unclear interface design create unnecessary friction that discourages continued usage. Recent research in e-commerce and mobile commerce demonstrates that usability, website quality, and intuitive design significantly influence customer satisfaction, trust, and retention (Salamah et al., 2022). Consequently, improving the user experience should be viewed not only as a design activity but also as an important customer retention strategy.

5.4. Recommendation Engines

Recommendation engines reduce customer churn by presenting personalized products or content based on previous behaviour. Netflix recommends films and television series according to viewing history, Spotify generates individualized playlists based on listening preferences, and Amazon recommends products using browsing and purchasing behaviour. This type of personalization keeps customers engaged by continuously presenting relevant content while reducing the effort required to discover new products or services. Research shows that recommendation systems improve customer satisfaction and long-term retention by increasing relevance and convenience (Gomez-Uribe & Hunt, 2016; Jannach et al., 2016).

5.5. Predictive Timing

Predictive timing focuses on delivering the right message at the moment when customers are most likely to disengage. Rather than reacting after customer churn has already occurred, predictive models identify behavioural changes that indicate a growing risk, such as declining activity levels or missed subscription renewals. Timely reminders, personalized offers, and proactive support messages are considerably more effective than generic communications. Customer lifecycle research confirms that intervention timing plays a critical role in determining the success of retention initiatives (Fader & Hardie, 2009).

5.6. Proactive Customer Support

Proactive customer support means contacting customers before they experience serious problems or decide to leave. Instead of waiting for complaints, companies use churn indicators to identify customers who may require assistance and offer support before dissatisfaction escalates. Solving problems early strengthens customer trust, reduces frustration, and lowers the probability of customer churn. Service recovery research demonstrates that customers respond positively when organizations resolve issues proactively, resulting in higher levels of customer loyalty and retention (Johnston & Michel, 2008).

6. PRACTICAL APPLICATIONS OF CHURN PREDICTION

This section presents three well-known examples of how leading digital platforms use churn prediction and personalized interventions to strengthen customer retention.

6.1. Netflix

Netflix is one of the strongest examples of how churn prediction can be effectively applied in practice. The company continuously monitors early behavioural signals, such as declining viewing activity, to identify users who may be losing interest. Research on the Netflix recommendation system shows that when users' viewing patterns begin to slow down, their likelihood of cancelling their subscription increases, making behavioural monitoring a central element of Netflix's retention strategy (Gomez-Uribe & Hunt, 2016). To reduce this risk, Netflix delivers a highly personalized homepage. Every recommendation row, thumbnail, and content suggestion is tailored to each individual user based on previous viewing behaviour. Studies on recommender systems demonstrate that this high level of personalization increases engagement because users can discover relevant content more easily (Jannach et al., 2016). For customers showing signs of disengagement, Netflix proactively promotes newly released or highly relevant content to encourage continued platform usage before cancellation becomes a realistic option. By detecting churn risk early and responding with personalized recommendations, Netflix maintains high customer engagement while reducing subscription cancellations.

6.2. Spotify

Spotify applies similar principles by continuously monitoring changes in users' listening behaviour. When declining activity or reduced engagement is detected, Spotify responds by generating highly personalized playlists such as Discover Weekly and Daily Mix, which are tailored to individual listening preferences and moods. These playlists function as effective re-engagement tools by reminding users of the platform's value. Spotify also targets former subscribers through limited-time free subscription offers designed to encourage them to return. In addition, mood-based and context-aware playlists integrate naturally into users' daily routines, helping to establish long-term listening habits. By constantly refreshing personalized recommendations and automatically introducing new content, Spotify creates a continuous cycle of discovery and engagement. Research suggests that this type of habit-forming design contributes significantly to reducing customer churn in digital subscription services (Bangera et al., 2024).

6.3. Amazon

Amazon's customer retention strategy focuses on identifying subtle behavioural changes long before customers completely stop purchasing. One of the strongest warning signals is a decline in purchase frequency or an interruption in previously established buying patterns. Research indicates that Amazon's recommendation system is designed not only to increase sales but also to re-engage customers showing early signs of disengagement (Smith & Linden, 2017).

When churn risk is detected, Amazon typically responds through several personalized interventions:

- Personalized discounts and special offers based on previous purchasing behaviour.
- Restock reminders for products that customers purchase regularly.
- Related product recommendations based on browsing and purchasing history.
- Email reminders and mobile notifications about abandoned shopping carts or saved products.

Rather than simply recommending products, Amazon's objective is to reinforce customers' shopping habits. Behavioural economics research demonstrates that relatively small interventions, such as reminders and personalized recommendations, can substantially influence customers' decisions to return (DellaVigna, 2009).
Amazon further strengthens its retention strategy through micro-segmentation. Instead of treating all customers equally, the company identifies different behavioural groups, including:

- Customers who purchase only during promotional periods.
- Regular customers whose purchasing patterns suddenly change.
- High-value customers who stop exploring new product categories.

Each segment receives different retention interventions, allowing Amazon to maximize the effectiveness of its churn reduction strategy. Consequently, Amazon's competitive advantage lies not only in accurately predicting churn but also in delivering personalized interventions at precisely the right moment.

7. ETHICAL CONSIDERATIONS AND THE FUTURE OF CHURN PREDICTION

Although churn prediction provides substantial business benefits, it also raises important ethical considerations. Companies must be transparent about the data they collect and the purposes for which it is used, while complying with privacy regulations such as the General Data Protection Regulation (GDPR). Customers should clearly understand how their personal information contributes to predictive analytics and personalized marketing activities. Equally important is the responsible use of predictive models. Churn prediction should support better customer experiences rather than manipulate customer behaviour or pressure individuals into remaining with a service. Organizations must also continuously evaluate predictive models for potential algorithmic bias to ensure that different customer groups are treated fairly and consistently. When implemented responsibly, churn prediction strengthens customer relationships by providing more relevant services while respecting customers' privacy and autonomy. Looking ahead, several technological developments are expected to further transform churn prediction. Real-time predictive analytics will enable organizations to detect churn risk immediately and respond without delay. Research indicates that real-time analytics improves both managerial decision-making and customer retention performance (Chen et al., 2012). Emotion-based analytics will increasingly use artificial intelligence to analyse customer sentiment expressed through reviews, chat conversations, emails, and social media interactions, enabling companies to identify dissatisfaction even before behavioural changes become visible (Cambria et al., 2013). AI-driven personalization will continuously adapt customer journeys by automatically adjusting recommendations, content, offers, and customer support according to predicted customer needs. Research has consistently shown that personalization increases customer engagement while reducing churn (Gomez-Uribe & Hunt, 2016). Finally, predictive loyalty programmes will proactively reward customers before they decide to leave, further strengthening long-term customer relationships and increasing customer lifetime value (Lemon & Verhoef, 2016).

8. CONCLUSION

In today's highly competitive and data-driven marketplace, where customers can switch brands with just a few clicks, customer retention has become a strategic priority for organizations across industries. Churn prediction plays a central role in this process by identifying early warning signs of customer disengagement and enabling companies to intervene before customers decide to leave. As this paper has demonstrated, effective churn prediction extends far beyond the application of machine learning algorithms. It requires the integration of customer data, behavioural analytics, predictive modelling, and well-designed retention strategies. Organizations can use these insights to deliver personalized offers, improve customer experiences, optimize communication timing, strengthen recommendation systems, and provide proactive customer support. The practical examples of Netflix, Spotify, and Amazon illustrate how leading digital platforms successfully combine predictive analytics with personalization to strengthen customer loyalty and reduce customer attrition. At the same time, the growing use of customer data requires responsible and ethical implementation. Organizations must ensure transparency, protect customer privacy, comply with data protection regulations, and continuously monitor predictive models for potential bias. The future of churn prediction will increasingly be shaped by artificial intelligence, real-time analytics, emotion recognition, and highly personalized customer journeys, making predictive customer relationship management even more effective. Ultimately, churn prediction is not simply a technical or analytical tool. It represents a strategic approach to building stronger and longer-lasting customer relationships. By understanding customer behaviour, recognizing early warning signals, and responding proactively, organizations can improve customer lifetime value, strengthen customer loyalty, and achieve sustainable competitive advantage in an increasingly dynamic business environment.

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IDENTIFYING EXPORT PROFILES IN THE EUROPEAN COUNTRIES ENVIRONMENTAL GOODS AND SERVICES SECTOR: EVIDENCE FROM MANUFACTURING INDUSTRIES

Paula C.R. Vicente
Universidade Lusófona - CUL; Intrepid Lab, Campo Grande, 376
1749-024 Lisboa - Portugal
p951@ulusofona.pt

Isabel Soares de Moura
Universidade Lusófona - CUL, Campo Grande, 376
1749-024 Lisboa - Portugal
p1702@ulusofona.pt

ABSTRACT

The triple planetary crisis, encompassing climate change, biodiversity loss, pollution, and increasing pressure on natural resources, highlights the need to transform production and consumption models. The manufacturing industry, due to its economic relevance and contribution to environmental pressures, plays a central role in this transition, particularly through decarbonisation, circular economy practices, and improvements in energy and material efficiency. Against this background, this study analyses the export performance of the Environmental Goods and Services Sector (EGSS) across the 27 European Union Member States and five additional European countries for the period 2020–2022, with a particular focus on manufacturing activities. A k-means cluster analysis is applied to identify distinct country profiles according to EGSS export values, followed by an analysis of the behaviour of individual countries within each cluster. The results identify three main country profiles, ranging from countries with high and medium export values to countries with minimal or very low export values. Germany emerges as a clear outlier, exhibiting substantially higher export values than the other countries analysed, while Hungary presents an atypical trajectory, characterised by a marked increase in exports between 2020 and 2022. The findings highlight heterogeneity across European countries in environmental goods and services exports and offer a comparative perspective on the relative positioning of European manufacturing industries within the environmental transition.

Keywords: *Cluster analysis, Decarbonization, Environmental exports, Environmental goods and services, European countries, k-means, Manufacturing industry.*

1. INTRODUCTION

The transition towards a climate-neutral economy has turned the production of environmental goods and services into a strategic dimension of industrial competitiveness. Within the European Union this transition is framed by the European Green Deal, by the Net-Zero Industry Act (Regulation (EU) 2024/1735) and by the Clean Industrial Deal, which explicitly connect decarbonisation targets to the capacity of European manufacturing to supply low-carbon technologies to domestic and international markets (European Commission, 2024, 2025). Despite this policy emphasis, the international projection of the Environmental Goods and Services Sector (EGSS) remains unevenly documented across European countries. Comparative work has concentrated on gross value added and employment, while exports - the variable that most directly captures the ability of national producers to compete beyond their domestic market - have received considerably less attention.

This study therefore addresses the following research question: which export profiles emerge among European countries in the manufacturing segment of the Environmental Goods and Services Sector, and to what extent do these profiles reflect economic size rather than environmental specialisation? To answer it, a k-means cluster analysis is applied to Eurostat EGSS export data for the 27 European Union Member States and five additional European countries over the period 2020-2022. The remainder of the paper is organised as follows. Section 2 outlines the global context of the triple planetary crisis. Section 3 discusses the role of industry in emissions and the opportunity offered by circularity. Section 4 addresses industrial decarbonisation. Section 5 characterises the Environmental Goods and Services Sector in Europe. Section 6 presents the data and methods, Section 7 the results and discussion, and Section 8 concludes.

2. GLOBAL CONTEXT: THE TRIPLE PLANETARY CRISIS

We are currently facing three major and interconnected global crises, commonly referred to as the planetary triple crisis, which simultaneously threatens the planet, human societies, and economic development. This constellation of challenges is widely recognised as one of the most significant global threats to sustainable development. Specifically, these crises comprise climate change, biodiversity loss, and pollution/pressure on natural resources. Their mutually reinforcing nature renders their resolution increasingly complex and urgent (United Nations, 2024). At the global level, key objectives include limiting global warming to 2°C, and ideally to 1.5°C, preserving and fostering a healthy economy, promoting equity and a just transition, and protecting the environment, while maintaining a realistic and pragmatic perspective.

3. THE ROLE OF INDUSTRY IN EMISSIONS AND THE OPPORTUNITY FOR CIRCULARITY/RESOURCE MANAGEMENT

The industrial sector accounted for approximately 24% of global direct anthropogenic greenhouse gas (GHG) emissions in 2019, equivalent to 14.1 GtCO2-eq, a share that rises to 34% once indirect emissions from electricity and heat generation are allocated to end-use sectors. Industrial processes and product use alone accounted for 4.7 GtCO2-eq (IPCC, 2022). Over the past century, the dominant model of industrial development has been grounded in a linear logic of production and consumption, characterised by intensive extraction of natural resources, the transformation of raw materials into products, and the disposal of waste at the end of their life cycle. Although this model has driven economic growth and technological progress, it has proven environmentally unsustainable, significantly contributing to the worsening of climate change, the accelerated loss of biodiversity, and the increase in pollution and pressure on natural resources. Within this context, the circular economy emerges as a new paradigm for industrial systems, proposing a structural shift in how resources are designed, used, and valued. In contrast to the linear model, circularity is based on reducing raw material extraction, maintaining materials and products in prolonged use cycles, recovering and reusing resources, and preventing waste and emissions from the design phase onward. This approach enables the decoupling of economic growth from the consumption of finite resources, promoting more efficient use of energy and materials without compromising industrial competitiveness. The relationship between circularity and the planetary triple crisis is direct and systemic. By reducing the need for primary production and the associated energy consumption, the circular economy contributes to climate change mitigation through lower GHG emissions. Simultaneously, by limiting natural resource extraction and land use, it reduces pressure on ecosystems, supporting biodiversity protection and the preservation of essential ecological systems. Finally, by eliminating the concept of waste and promoting closed material loops, circularity acts on pollution prevention, reducing discharges into air, water, and soil, as well as associated risks to human and environmental health.

Thus, environmental protection and resource management in industry should be understood as fundamental instruments for transitioning toward a more resilient, equitable, and sustainable economic model, one capable of addressing the structural drivers of the planetary triple crisis in an integrated manner. Its implementation represents an opportunity to align environmental, economic, and social objectives, positioning industry as an active contributor to the solutions required to meet the global challenges of the twenty-first century and the Sustainable Development Goals (SDGs).

4. DECARBONISING THE INDUSTRY

Decarbonising the industrial sector is essential for ensuring resilient and equitable systems, constituting both an ethical and climatic imperative. At COP30, held in Belém, Brazil, in 2025, the decarbonisation of manufacturing industries was framed as an indispensable condition for meeting the Paris Agreement, with particular emphasis on hard-to-abate industries, including cement, steel, chemicals, and aluminum. The central message highlighted that reducing industrial emissions requires a combined strategy involving energy efficiency, electrification powered by renewable energy, circularity and low-carbon materials, alternative fuels (including low-carbon hydrogen where appropriate), and, for inherently emissive processes, carbon capture, utilization, and storage (CCUS). The agenda also reinforced the need for harmonized carbon metrics and accounting frameworks to ensure credibility in "low-carbon" claims and enable comparability across products and value chains. The most tangible outcome for industry was the Belem Declaration on Global Green Industrialization, launched on 14 November 2025 by Brazil together with a coalition of governments, international organisations and industry associations, which establishes a shared coordination framework for scaling clean industrial capacity (COP30 Presidency, 2025; UNIDO, 2025). The accompanying Global Climate Action Agenda outcomes report sets the objective of advancing decarbonisation in hard-to-abate sectors by 2030 through green industrial hubs combining renewable power, hydrogen, CCUS and circular-economy solutions (UNFCCC, 2025). The sectors with the highest energy consumption include automotive and transport industries (such as automobile manufacturers, airlines, maritime and freight transport), construction, industrial machinery, manufacturing industries, consumer goods, and high-tech sectors.

5. THE ENVIRONMENTAL GOODS AND SERVICES SECTOR IN EUROPE AND EUROPEAN MANUFACTURING EXPORT PERFORMANCE

According to the European Environment Agency (EEA, 2025), the contribution of the Environmental Goods and Services Sector (EGSS) to the European Union economy has increased substantially over the past decade. The sector's gross value added (GVA) rose from 2.1% of EU GVA in 2010 to 3.3% in 2022, reaching EUR 601 billion when expressed in 2025 constant prices. This sustained growth reflects the expanding role of environmental protection and resource-efficiency activities within European production systems and highlights the structural integration of environmental objectives into the EU's economic model. The EEA attributes this rise primarily to significant increases in activities related to renewable energy production, energy efficiency improvements, and waste management, all of which have become central components of Europe's environmental and industrial transition. These domains have benefited from strengthened regulatory frameworks, technological innovation, and targeted investment, particularly under the European Green Deal and associated policy instruments. As a result, EGSS has evolved from a specialised niche into a strategic sector supporting competitiveness, innovation, and employment across Member States.

The indicator also underscores the importance of EGSS in achieving the EU's long-term climate and sustainability objectives. The European Union aims to complete a green transition and achieve a carbon-neutral economy by 2050, a goal that requires further substantial expansion of environmental economy activities. The continued growth of EGSS is therefore essential not only for environmental protection but also for the transformation of industrial value chains, the diffusion of low-carbon technologies, and the consolidation of Europe's leadership in sustainable production systems. Global demand for environmental technologies and resource-efficiency solutions is expected to grow substantially over the coming decade, reflecting the increasing strategic importance of environmental economy activities worldwide. Recent market assessments estimate that the global volume of environmental technology and resource-efficiency sectors will expand by 7.3% annually until 2030, driven by the accelerating transition toward low-carbon production systems. Major international analyses, including the International Energy Agency's World Energy Outlook and Energy Technology Perspectives, highlight the emergence of new economic opportunities in sectors that contribute directly to achieving net-zero emissions, such as renewable energy, energy-efficient industrial processes, and advanced waste and resource-management technologies. Within the European Union, the environmental economy has strengthened its position across most Member States. Between 2014 and 2022, the share of environmental economy activities in total national economies increased in 23 EU countries, signalling a broad and sustained integration of environmental protection and resource-efficiency activities into European economic structures. This expansion reflects the combined effects of regulatory pressure, technological innovation, and investment in clean energy, circular-economy solutions, and pollution-control systems, all of which are central to the EU's long-term climate and industrial strategies. Despite this overall positive trend, the relative weight of the environmental economy varies considerably across Member States. In 2022, national shares ranged from approximately 0.5% in Hungary to more than 4% in Finland, Austria, and Estonia, illustrating substantial heterogeneity in industrial specialisation, innovation capacity, and policy implementation. These differences underscore the importance of comparative analyses of environmental goods and services, particularly in manufacturing activities, to understand how European countries position themselves within the evolving landscape of environmental technologies and how these dynamics shape the broader transition toward climate neutrality. In this context, analysing EGSS export performance, particularly in manufacturing activities, provides a critical point of view for understanding how European countries position themselves within global markets for environmental technologies, and how they contribute to the broader environmental transition. In 2021, Finland was the first Member State with the highest relative weight of exports of environmental goods and services in the national total (11.6%). Relative export intensity varies widely across Member States. In 2022, environmental goods and services accounted for around 12% of economy-wide exports in Denmark and Finland, more than 9% in Austria and approximately 9% in Czechia, but for less than 1% in Malta and Ireland (CE, 2025). These shares measure the weight of environmental products within total national exports and should not be confused with the export propensity of the sector itself, that is, the share of EGSS output that is sold abroad. It is important to note that, in recent decades, the idea that exports are fundamental to corporate success and national prosperity has gained significant prominence in various studies. Many authors consider exports to be one of the primary drivers of a country's economic growth (Griffith & Czinkota, 2012; Oo et al., 2019; Wang & Sun, 2021). Their importance stems from several factors, notably the accumulation of foreign exchange reserves, GDP growth, the development of domestic industries, job creation, reduced reliance on the state budget, and improvements in corporate development and productivity; furthermore, exports can generate a multiplier effect in other sectors, such as transportation and logistics (Kabaklarli et al., 2018).

6. PROFILES OF THE EUROPEAN COUNTRIES IN THE ENVIRONMENTAL GOODS AND SERVICES SECTOR

6.1. Data

The used dataset includes the export values (in million euros) of the manufacturing industry in the environmental goods and services sector for the 27 European Union (EU) country members, along with five additional countries in the EU area: Iceland, North Macedonia, Serbia, Switzerland, and Türkiye. Data for 32 European nations were collected for the period from 2020 to 2022, ensuring consistency throughout these years. The data is available on the Eurostat website. Missing values were excluded from the analysis, resulting in Norway not being considered, as data were only available for the year 2020 (Eurostat, 2025).

Exports are measured according to the concepts of the EGSS accounts (Eurostat, 2025). They correspond to the market output of environmental goods and services sold by resident producers to non-residents, compiled under national accounting rules pursuant to Regulation (EC) no 691/2011.

6.2. Descriptive statistics

Figure 1 displays the export values of the 32 analysed countries for the year 2020. It shows that Germany recorded the highest export value at €26,806.37 million euros, followed by Austria at €11,740.93 million euros. The countries with the lowest export values are Cyprus, Hungary, Iceland, and Malta, with Malta reporting an export value of only €0.06 million euros.

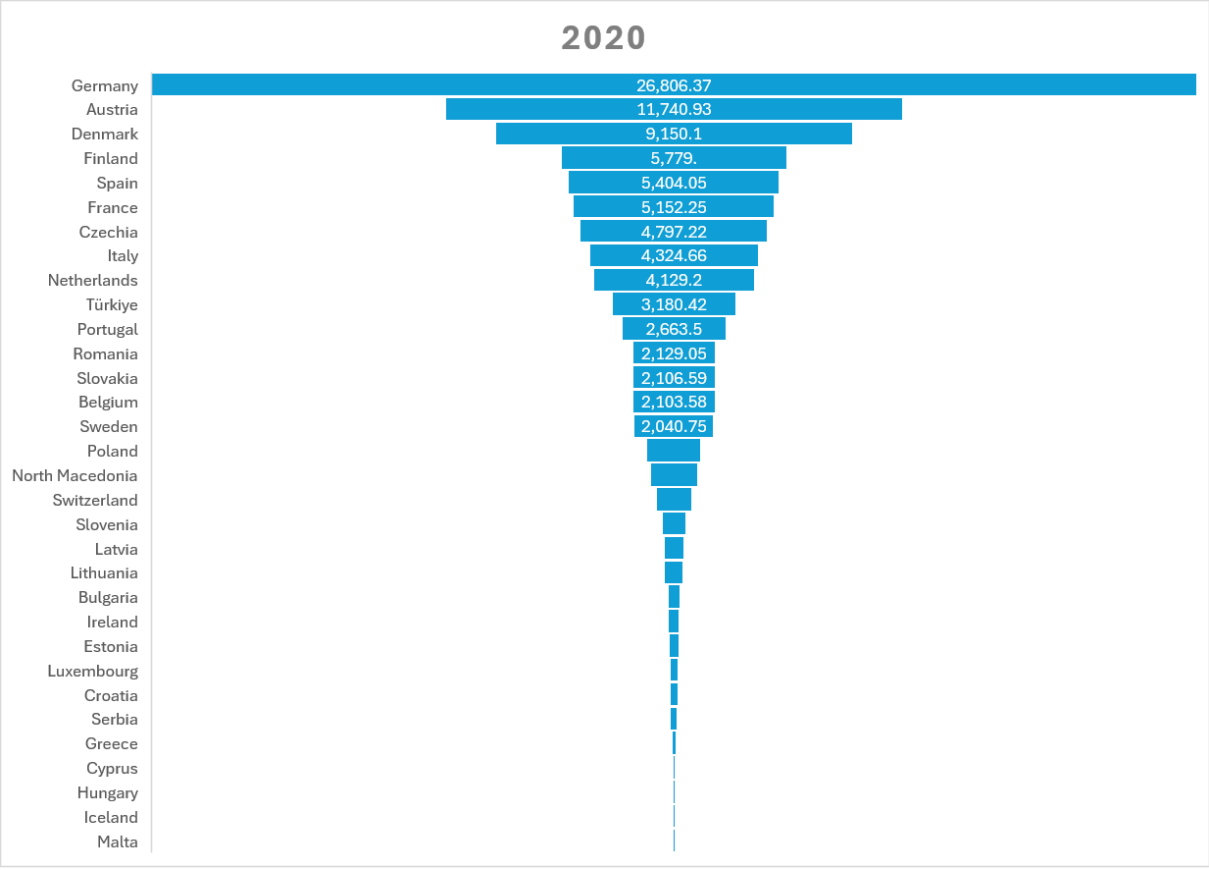

Figure 1: Exports values for the countries of EU area for the year 2020 (Source: Authors)

6.3. Variation Rates

In Figure 2 are displayed the variation rate of the export values for the environmental goods and services sector for the countries of EU area. The left side of this figure illustrates the variation in export values for all European countries between 2020 and 2022. To address the relevant variation rates observed for Hungary (+18,982.91%) and Malta (+8,833.33%), which may be considered extreme, the values have been transformed to a logarithmic scale previously. Therefore, these countries are excluded from the graph on the right side of the figure. This graph shows distinct growths: countries with high growth (>100%) includes Bulgaria (154.87%), the Netherlands (107.97%), and Czechia (104.38%); countries with moderate growth (30% to 90%) comprises 18 countries, ranging from Slovenia (30.00%) to Estonia (87.70%); with low growth (0% to 20%) features North Macedonia (19.98%), Denmark (19.56%), Slovakia (14.88%), Ireland (14.57%), Iceland (13.21%), and Croatia (9.87%); finally, countries with negative growth values that includes Luxembourg (-7.39%) and Türkiye (-48.24%). Particularly, Portugal present a variation rate of 45.4% in the period under analize.

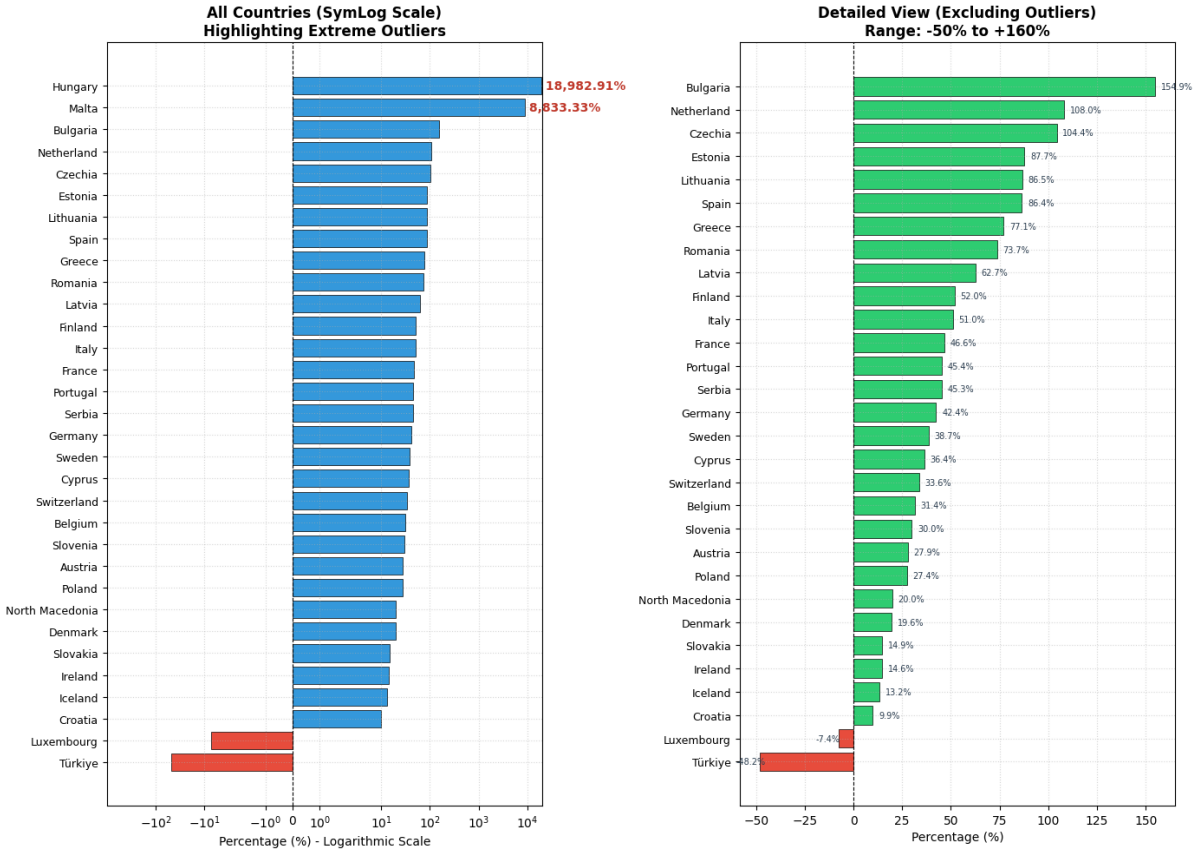

Figure 2: Exports values for the countries of EU area for the year 2020 (Source: Authors)

6.4. Country profiles from the cluster analysis

To identify distinct profiles for the European countries under analysis, the k-means clustering method is employed. This technique is an unsupervised machine learning approach that seeks to identify clusters within a dataset. The two methods typically used to determine the optimal number of clusters are the elbow plot and the silhouette score (Linoff & Berry, 2011). For the data under analysis an elbow plot indicate the existence of three clusters, with a silhoute score of 0.58, what means a reasonable quality of grouping.

Before the cluster analysis, the original data (export values) passed through a logarithmic transformation and standardization to account for the significant differences in absolute values among the countries considered and ensuring comparability. The obtained clusters are show in table 1. Cluster 0 comprises countries with high or intermediate export values from 2020 to 2022. This cluster represents the nation's most significantly involved in the analysed phenomenon. However, it is heterogeneous, as it includes countries with varying absolute values. Germany exhibits significantly higher values than the others. Nevertless, the use of logarithmic transformation and normalisation in the analysis mitigated Germany's extreme influence, preventing its isolation. The diversity within Cluster 0 is illustrated in Table 2. It is important to highlight that Türkiye experienced a negative trend from 2020 to 2022; however, its total export values allow its position in cluster 0. Portugal is classified within cluster 0, yet it does not belong to the subgroup of countries with high export values, such as Germany, Denmark, or Austria. Nonetheless, it surpasses countries with low export values, like Belgium or Poland, for example.

Cluster	General profile	Countries
Cluster 0	High and medium values	Germany, Austria, Denmark, Finland, Spain, France, Czechia, Italy, Netherlands, Türkiye, Portugal, Romania, Slovakia, Belgium, Sweden, Poland, North Macedonia
Cluster 1	Low values, but not negligible	Switzerland, Slovenia, Latvia, Lithuania, Bulgaria, Ireland, Estonia, Luxembourg, Croatia, Serbia, Greece, Hungary
Cluster 2	Residual or very low values	Cyprus, Iceland, Malta

Table 1: Clusters for European countries
(Source: Authors)

Subgroup within Cluster 0	Countries	Classification
Very High	Germany	Clearly leading (with huge values)
High	Austria, Denmark	Top countries
Medium-High	Finland, Spain, France, Czechia, Italy, Netherlands	Strong and growing countries
Intermediate	Portugal, Romania, Slovakia, Belgium, Sweden, Poland, North Macedonia, Türkiye	Countries with average values

Table 2: Subgroups within cluster 0, according their export values
(Source: Authors)

Cluster 1 comprises countries with low export values, though these are not negligible or residuals, unlike those in cluster 2. Additionally, this cluster includes countries with distinct rates of change. The exports values for Hungary should be seen with careful because the growth is enormous, what could signify wrong register of values. Cluster 2 comprises countries with residual values. Cyprus, Iceland and Malta are the countries with minimal values in the group of the 32 under analyse. Even for Malta that has a big evolution, the absolute values are small, when compared with other countries.

Country	Behaviour
Switzerland	low-mid value, close to the border with Cluster 1
Slovenia, Latvia, Lithuania	low values, but with positive growth
Bulgaria	strong growth, even though starting from a low base
Estonia	relevant growth
Luxembourg	low values, but negative growth
Greece and Croatia	low value, but positive growth
Hungary	special case, because it grows very quickly

Table 3: Countries within cluster 1
(Source: Authors)

Figure 3 displays box plots that compares the distribution of values over the three years (2020 to 2022) for the three identified clusters: Cluster 0, Cluster 1, and Cluster 2. All clusters demonstrate general growth from 2020 to 2022, while they show significant differences in scale. Cluster 0 likely represents a group with high-value observations, with some exceptional cases that strongly exceed the normal range. Cluster 1 reflects mid-tier growth with increasing variance. In this cluster, the median in 2022 is noticeably higher than in previous years. Cluster 2 comprises residual or low-value countries that began to show upward movement in 2022. In this time point, it becomes more dispersed and slightly stronger overall. In all the analysis performed it was clear that Germany and Hungary should be considered outliers, due to their very high volume and extremely sharp growth, respectively (see figure 1 and 2). Additionally, despite Malta experiencing a significant rate of change during this period, it is not classified as an outlier due to its relatively low export values. Considering the exclusion of these two countries and performing again a cluster analysis, three groups of countries are identified with a silhouette score of 0.61. This value indicates good clustering quality, suggesting that the clusters are relatively well defined. The previously defined identified profiles remains.

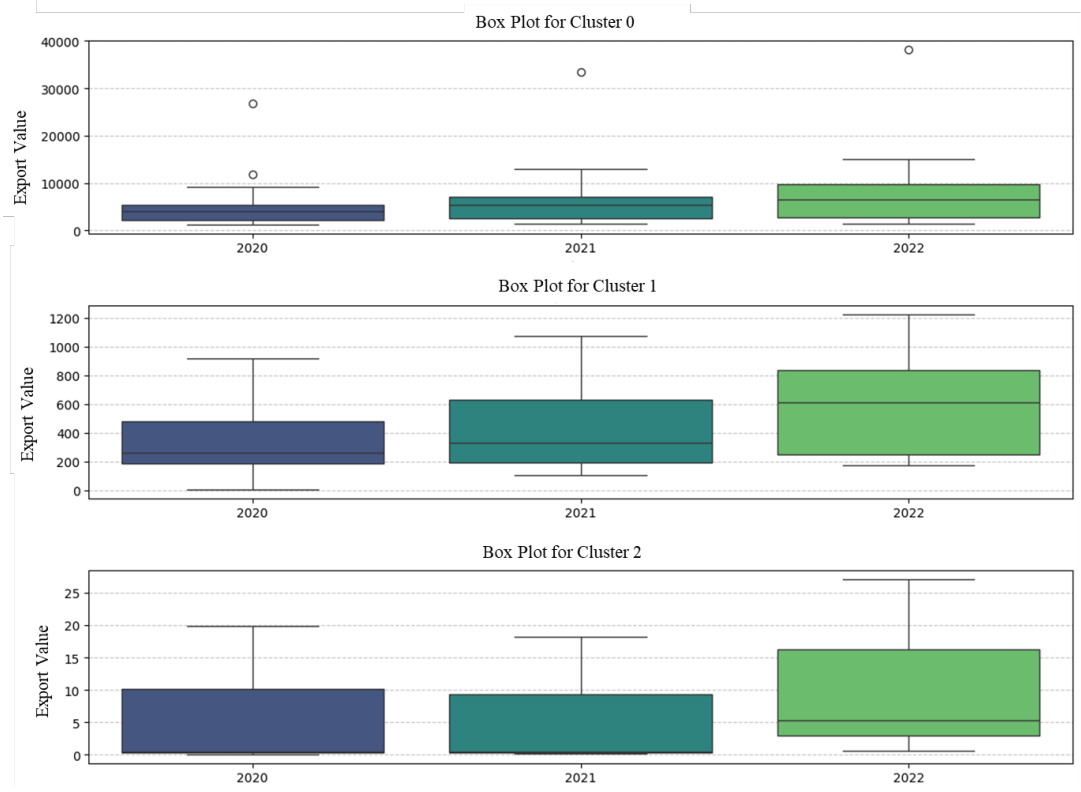

Figure 3: Exports values for the countries of EU area for the year 2020
(Source: Authors)

7. CONCLUSION

This study analysed the export performance of the Environmental Goods and Services Sector in the manufacturing industries of 32 European countries between 2020 and 2022, applying k-means cluster analysis to identify country profiles. Three profiles were identified. The cluster analysis with 3 groups allowed identifying a simple and interpretable structure of the countries. Cluster 0 brings together countries with higher or intermediate values. Cluster 1 includes smaller countries, but still with relevant values. Cluster 3 groups countries with residual expression. Thus, the segmentation obtained mainly distinguishes countries according to the level of values observed between 2020 and 2022, with Portugal being classified in the group with the highest relative expression. In the same cluster, Germany emerges as a clear outlier, exhibiting substantially higher export values than the other countries analysed, while Hungary, in cluster 1, presents an atypical trajectory, characterised by a marked increase in exports between 2020 and 2022. Also, with a big rate of change in the period of time under analyse Malta we not consider this country as outlier because the export values are very small (residual). The results point to differentiated policy priorities. Countries in the first profile are positioned to consolidate their advantage through strategic projects and non-price procurement criteria under the Net-Zero Industry Act. Countries in the second profile, which combine small volumes with rapid growth, are better served by niche specialisation and by participation in cross-border clean-technology value chains. Countries in the third profile face a prior constraint, namely the limited size of their industrial base, and their integration into European environmental value chains depends primarily on access to investment and technology transfer. Future research should extend the period as 2023 data and subsequent years become available, replicate the analysis on chained volumes, and incorporate relative indicators of environmental specialisation. A natural next step would be to move from typology to explanation, modelling the determinants of environmental export performance in a panel framework that includes environmental policy rigidity, eco-innovation and participation in European research networks.

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TECHNOLOGICAL INTENSIFICATION AND MITIGATING FACTORS FOR PSYCHOSOCIAL RISKS: PROPOSING A CONCEPTUAL FRAMEWORK

Lilian Faxina Girardi
Federal University of Technology – Paraná (UTFPR), Campus Ponta Grossa (Brazil)
lilianfaxina2@gmail.com

Cristina Rodrigues Piazer Turcato
Federal University of Technology – Paraná (UTFPR), Campus Ponta Grossa (Brazil)
piazercristina@gmail.com

Bruno Pedroso
State University of Ponta Grossa, Paraná (Brazil)
prof.brunopedroso@gmail.com

David Nunes Resende
University of Aveiro (Portugal), Researcher at GOVCOPP Research Unit – Governance, Competitiveness and Public Policy (CIS-GOVCOPP)
david@ua.pt

Claudia Tania Picinin
Federal University of Technology – Paraná (UTFPR), Campus Ponta Grossa (Brazil), Researcher at GOVCOPP Research Unit – Governance, Competitiveness and Public Policy (CIS-GOVCOPP)
claudiapicinin@utfpr.edu.br

ABSTRACT

This study aims to propose an integrative conceptual framework that explains the relationships among technological intensification, sociotechnical tensions, psychosocial risks, and human impacts arising from the transition from Industry 4.0 (I4.0) to Industry 5.0 (I5.0), while identifying mitigating factors that can alleviate the psychosocial demands associated with work. To achieve this objective, an integrative literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines. The literature search was performed on May 20, 2026, using the Scopus and Web of Science databases, with search terms related to Industry 4.0, psychosocial risks, burnout, stress, human sustainability, and quality of working life. An initial sample of 29 studies was identified and subsequently screened for eligibility. Studies focusing exclusively on engineering, ergonomics models, or strictly technological issues, as well as abstracts, editorials, book chapters, conference proceedings, and publications other than peer reviewed journal articles, were excluded. After the screening process, 13 articles were retained for analysis. The findings indicate that technological intensification contributes to improvements in productivity, operational efficiency, and organizational process control. However, when implemented without worker participation and without adequate consideration of human factors in the digital transformation process, it may increase exposure to psychosocial risks. The results further suggest that mitigating factors, including leadership, employee participation, training, and knowledge management, can reduce the adverse effects of technological intensification, facilitating a shift from technostress to techno stress.

As a theoretical contribution, this study proposes an integrative conceptual framework that connects technological intensification, sociotechnical tensions, psychosocial risks, human impacts, and mitigating factors within the context of the transition from Industry 4.0 to Industry 5.0.
Keywords: *conceptual framework; sociotechnical tensions; psychosocial risks; technostress; techno eustress*

1. INTRODUCTION

The dynamics of organizational management have been profoundly reshaped by the acceleration of digital technologies. The emergence of Industry 4.0 (I4.0), automation, digital transformation, and the Internet of Things (IoT) has progressively responded to organizational demands for greater efficiency and operational performance (Galanti et al., 2023). More recently, sustainability oriented policies have fostered the emergence of Industry 5.0 (I5.0), a paradigm that shifts the focus from technology driven automation toward sustainable human development. Within this new industrial landscape, human capital management becomes a central element of the transformation process (Laskowska & Laskowski, 2023; Vitrano & Micheli, 2025). Despite the human-centric discourse underlying Industry 5.0, the widespread adoption of advanced technologies has generated substantial debate regarding their implications for the quality of work. On the one hand, international evidence suggests that digital technologies can humanize industrial environments by enabling workers to participate in complex decision making processes (Adeniji et al., 2026). On the other hand, researchers have highlighted the risk of cognitive overload resulting from the continuous and rapid flow of information associated with digitally enabled workplaces (Passalacqua et al., 2025). Consequently, psychosocial risks such as technostress have become increasingly prominent in the literature (Farmanesh et al., 2025). The effects of this phenomenon are inherently dual. While the negative dimension of technostress is associated with exhaustion and psychological strain, workers' cognitive appraisal of technological demands may also foster technoeustress, a positive response that enhances motivation, engagement, and resilience (Fettahoglu & Yikilmaz, 2025). This duality creates an organizational paradox in which productivity gains must coexist with the preservation of workers' mental well-being. Accordingly, while manufacturing engineering research primarily emphasizes production system optimization through advanced algorithms and digital technologies (Calzavara et al., 2023; Boschetti et al., 2023), organizational behavior research seeks to understand and mitigate the psychosocial challenges generated by increasingly digital work environments (Galanti et al., 2023). Although the literature widely acknowledges both the benefits of digital transformation and its implications for employee well-being, existing studies remain fragmented, typically focusing on isolated dimensions such as productivity, technostress, ergonomics, or human resource management. Against this backdrop, the following research question emerges: How do technological factors and sociotechnical tensions arising from digital intensification influence the emergence of psychosocial risks among workers during the transition from Industry 4.0 to Industry 5.0, and how can these effects be mitigated within organizations?

To address this question, this study proposes an integrative conceptual framework designed to assess the psychosocial impacts of technological intensification by articulating technological, organizational, and human factors within the context of the transition toward Industry 5.0.

The study is justified by the growing concern over workers' mental health, particularly because stress consistently emerges as one of the most frequently reported consequences of digital transformation (Anshari & Hamdan, 2022; Galanti et al., 2023; Bastida et al., 2025; Adeniji et al., 2026). Although previous studies have independently examined digital transformation, technostress, ergonomics, and occupational well-being, there remains a lack of integrative models capable of simultaneously explaining the relationships among technological intensification, sociotechnical tensions, psychosocial risks, human impacts, and mitigating factors during the transition from Industry 4.0 to Industry 5.0. This theoretical gap limits a systemic understanding of the phenomenon and provides the rationale for the conceptual framework proposed in this study.

2. LITERATURE REVIEW

2.1. Industry 4.0, Digital Transformation, and Technological Intensification

The Fourth Industrial Revolution has been characterized by the widespread adoption and integration of disruptive technologies into production systems, including automation, robotics, the Internet of Things (IoT), Big Data, and tracking systems. This transition toward the digital era has enabled organizations to enhance profitability while developing new approaches to quality control and productivity improvement (Galanti et al., 2023; Boschetti et al., 2023). The COVID-19 pandemic accelerated the process of digital intensification that was already underway worldwide, expanding the use of digital technologies and increasing the need for adaptability among organizations and the labor market. The adoption of new technological solutions has provided workers with greater control over working time, workplace location, and the organization of work activities (Adeniji et al., 2026). Although digital transformation is frequently associated with gains in productivity, flexibility, and operational efficiency, its implications for workers are considerably more complex. Technological intensification may increase workers' exposure to psychosocial risk factors, suggesting that its effects depend largely on how organizations and employees adapt to the new demands imposed by digitally enabled work environments (Galanti et al., 2023; Farmanesh et al., 2025).

2.2. From Industry 4.0 to Industry 5.0: Human Centeredness in Production Systems

Beyond the pursuit of productivity gains, operational efficiency, and cost reduction, organizations must also address issues related to workers' well-being, including physical and mental workload, ergonomics, and occupational safety. Within this context, the transition from Industry 4.0 to Industry 5.0 has emerged as a new paradigm in which workers are no longer regarded merely as operators executing production tasks but instead assume a central role within production systems. From this perspective, algorithms increasingly incorporate human related variables, measuring factors such as posture, movement, physical exertion, attention, concentration, and cognitive fatigue (Boschetti et al., 2023). This approach reinforces the centrality of workers and highlights the growing concern for their well-being in contemporary industrial environments. Industry 5.0 represents an evolution of the principles established by Industry 4.0 by integrating the values of sustainability, resilience, and human-centricity. In this paradigm, technology is no longer viewed solely as a means of improving operational efficiency but also as an enabler of sustainable human development, fostering more inclusive, safer, and collaborative work environments (Laskowska & Laskowski, 2023; Vitrano & Micheli, 2025). This transformation is further reinforced by the gradual aging of the economically active population, which is expected to increase workers' exposure to physical limitations and chronic health conditions.

In this context, when implemented according to human-centric principles, technological intensification can contribute to the development of more inclusive, safer, and adaptive workplaces that accommodate the needs of workers across different age groups (Vitrano & Micheli, 2025).

2.3. Sociotechnical Tensions in Digital Transformation

The Sociotechnical Systems Theory posits that organizational performance depends on the joint optimization of social and technical systems. From this perspective, the adoption of new technologies requires not only technical adjustments but also changes in human relationships, organizational structures, and work processes. Accordingly, digital transformation should be understood as a complex sociotechnical phenomenon in which technological and human factors continuously interact. Within the sociotechnical perspective, organizational performance and transformation emerge from the interaction between technical and social systems. Consequently, the implementation of new technologies requires the simultaneous reconfiguration of human relationships, work processes, and organizational structures (Galanti et al., 2023). The literature highlights a dialectical tension regarding the effects of Industry 4.0. While one stream emphasizes improvements in productivity, quality, and operational efficiency, another points to risks such as reduced worker autonomy, job displacement, and diminished organizational learning. The central issue lies in how managers and employees interpret, adopt, and integrate technology into organizational practices. Consequently, industrial transformation constitutes a sociotechnical process that simultaneously reshapes technologies, work processes, and human interactions, giving rise to tensions between efficiency and wellbeing, automation and autonomy, monitoring and trust, as well as technological support and cognitive overload (Margherita & Braccini, 2024; Bastida et al., 2025). Because technology continues to evolve rapidly, organizations progress through different stages of technological adoption, each presenting distinct implications for workers and increasing the potential emergence of psychosocial risks (Passalacqua et al., 2025). Researchers argue that the adoption of Industry 4.0 affects workers in different ways, potentially reducing their participation in operational activities and replacing human labor in low-cost production systems. To mitigate these sociotechnical tensions, managers and organizations should invest in employee training, skill development, and preparedness for increasingly technology intensive work environments (Margherita & Braccini, 2024; Fettahoglu & Yikilmaz, 2025; Vitrano & Micheli, 2025; Anshari & Hamdan, 2022).

2.4. Psychosocial Risks and Technostress in the Context of Industry 4.0

Among the principal psychosocial risks associated with technological intensification, technostress has received particular attention. It is defined as an individual's difficulty in coping with the demands imposed by technology. The literature conceptualizes technostress through five dimensions: techno overload (work overload and accelerated work pace), techno complexity (difficulty in understanding and using technologies), techno insecurity (fear of professional obsolescence), and techno uncertainty (the continuous need to adapt to technological changes) (Galanti et al., 2023; Farmanesh et al., 2025), as well as techno invasion, which refers to the intrusion of work into employees' personal lives (Galanti et al., 2023). Previous research suggests that high levels of technostress resulting from technological overload tend to increase work related exhaustion and symptoms associated with burnout. However, these adverse effects can be mitigated when leadership plays a supportive and mediating role. In this regard, recent studies indicate that organizations investing in employee well-being report lower levels of demotivation, emotional exhaustion, and burnout (Farmanesh et al., 2025).

2.5. Mitigating Factors and the Transition from Technostress to Techno Eustress

Although part of the literature emphasizes the adverse effects of technological intensification, recent studies demonstrate that workers' perceptions of technology vary according to the level of organizational support they receive. In this context, factors such as participative leadership, training programs, knowledge management, psychological safety, continuous learning, and employee involvement in decisionmaking processes function as mitigating mechanisms that reduce sociotechnical tensions and the psychosocial risks associated with digital transformation (Farmanesh et al., 2025; Anshari & Hamdan, 2022; Haas & Cauda, 2022). When adequately supported, workers are more likely to perceive technological demands as opportunities for professional growth, learning, and competence development. This phenomenon is referred to as techno eustress, representing a positive response to technological demands that contributes to higher levels of motivation, work engagement, and occupational well-being (Fettahoglu & Yikilmaz, 2025). Accordingly, the presence of mitigating factors is essential for facilitating the transition from technostress to techno eustress, aligning organizational productivity objectives with the humancentric principles of Industry 5.0 while fostering more sustainable, resilient, and people centered organizational environments.

3. MATERIALS AND METHODS

This study adopts a qualitative research approach based on an integrative literature review with the objective of proposing a conceptual framework. This method was selected to synthesize and analyze the principal concepts and relationships among Industry 4.0, Industry 5.0, technological intensification, and psychosocial risks. An integrative literature review enables a comprehensive and holistic understanding of the different phenomena associated with the research topic by integrating evidence from diverse studies (Tavares de Souza et al., 2010). To ensure the transparency, reproducibility, and traceability of the literature search and selection process, the review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines (Page et al., 2021). The Scopus and Web of Science databases were selected because of their scientific relevance, international coverage, and multidisciplinary scope. To ensure the consistency of the review and the alignment of the selected studies with the research objective, predefined inclusion and exclusion criteria were established. The inclusion criteria comprised peer reviewed journal articles published between 2022 and 2026, written in English, and directly addressing topics related to Industry 4.0, Industry 5.0, digital transformation, technological intensification, psychosocial risks, technostress, worker wellbeing, mental health, quality of working life, or human sustainability within organizational contexts. The temporal scope was defined considering the recent emergence of Industry 4.0 technologies and the ongoing transition toward Industry 5.0 (Rojko, 2017).

The exclusion criteria comprised studies with a predominantly technical or engineering focus that did not address the human dimension of work, exclusively ergonometric models without consideration of psychosocial aspects, opinion papers, editorials, technical notes, extended abstracts, book chapters, conference proceedings, nonsystematic literature reviews, and publications whose content was not aligned with the objectives of this study.

Accordingly, the review sought to identify studies capable of contributing to the understanding of the relationships among technological intensification, sociotechnical tensions, psychosocial risks, human impacts, and mitigating factors associated with the transition from Industry 4.0 to Industry 5.0. The search strategies were developed using Boolean operators, as summarized in Table 1.

Database	Search String	Search Language	Search Field
Scopus	("Industry 4.0"OR "Fourth Industrial Revolution"OR "digital TITLE ABS KEY(("industry 4.0"OR "digital transformation"OR "industrial digitalization"OR "digital industrial transformation"OR "smart manufacturing"OR "industrial automation") AND ("sustainable human development"OR "human sustainability"OR "sustainable work"OR "decent work"OR "human centered"OR "worker well-being"OR "quality of working life") AND ("technological intensification"OR "work intensification"OR "psychosocial risks"OR "technostress"OR "mental workload"OR "digital labor"OR "occupational stress"))	EN	Article, title, Abstract, Keywork s
Web of Science	"Industry 4.0"OR "Industry 5.0"OR "smart manufacturing") AND ("psychosocial risks"OR technostress OR burnout OR work intensification"OR "worker well-being")	EN	Tópic

Tabela 1 – Boolean Search Strategy
Source: Prepared by the authors (2026).

The study selection process followed the stages recommended by the PRISMA 2020 guidelines (Figure 1), comprising the phases of identification, screening, eligibility, and inclusion. An initial total of 29 records was identified across the selected databases. After the removal of duplicate records and the screening of titles, keywords, and abstracts, the potentially relevant studies were selected. Subsequently, the full texts of the eligible articles were assessed, resulting in a final sample of 13 studies that served as the basis for the development of the proposed conceptual framework.

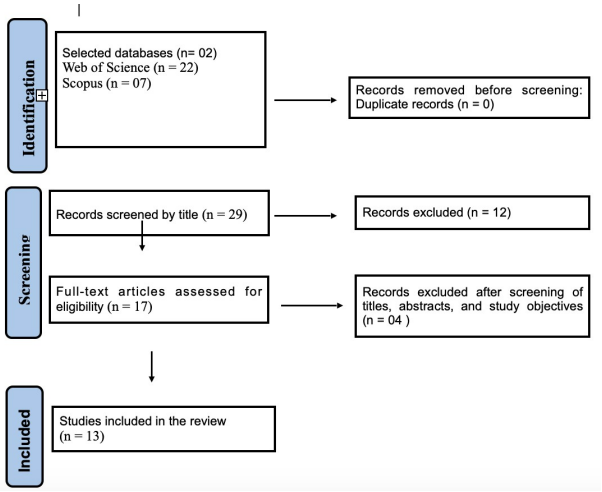

Figure 1: PRISMA 2020 flow diagram of the study selection process.
Source: Adapted by the authors (2026).

Following the study selection process, a qualitative content analysis was conducted to identify the principal theoretical concepts related to technological intensification, sociotechnical tensions, psychosocial risks, and the principles of Industry 4.0 and Industry 5.0. The findings were organized into thematic categories, enabling the identification of relationships among the investigated dimensions, as presented in Table 2.

Framework Category	Identified Dimensions	References
Technological Factors	Artificial Intelligence (AI); Internet of Things (IoT); Big Data; Automation; Cyber Physical Systems (CPS); Digital Monitoring; Digital Transformation; and Industrial Digitalization.	Galanti et al. (2023); Bastida et al. (2025); Adeniji et al. (2026); Passalacqua et al. (2025); Anshari & Hamdan (2022).
Sociotechnical Tensions	Efficiency × Well-being; Automation × Autonomy; Control × Participation; Monitoring × Trust; Technology × Competencies; and Human Adaptation to Technology.	Margherita & Braccini (2024); Bastida et al. (2025); Adeniji et al. (2026); Passalacqua et al. (2025); Anshari & Hamdan (2022); Haas & Cauda (2022).
Psychosocial Risks	Cognitive Overload; Anxiety; Job Insecurity; Resistance to Change; Fear of Monitoring; Mental Fatigue; Occupational Stress; Techno overload; Techno invasion; Techno complexity; Techno insecurity; Techno uncertainty; Digital Exhaustion; and Techno eustress.	Haas & Cauda (2022); Galanti et al. (2023); Farmanesh et al. (2025); Passalacqua et al. (2025); Bastida et al. (2025); Fettahoglu & Yikilmaz (2025); Anshari & Hamdan (2022).
Human Impacts	Well-being; Mental Health; Motivation; Work Engagement; Job Satisfaction; Quality of Work; Job Performance; Active Ageing; and Quality of Working Life.	Laskowska & Laskowski (2023); Calzavara et al. (2023); Farmanesh et al. (2025); Boschetti et al. (2023); Bastida et al. (2025); Adeniji et al. (2026); Fettahoglu & Yikilmaz (2025); Vitrano & Micheli (2025).
Mitigating Factors	Digital Leadership; Employee Participation; Training; Knowledge Management; Upskilling; Reskilling; Human Centered Design; Ergonomics; Organizational Transparency; and Human Machine Collaboration.	Laskowska & Laskowski (2023); Calzavara et al. (2023); Farmanesh et al. (2025); Boschetti et al. (2023); Bastida et al. (2025); Fettahoglu & Yikilmaz (2025); Vitrano & Micheli (2025); Anshari & Hamdan (2022); Haas & Cauda (2022).

Table 2 – Analysis of the Included Studies
Source: Prepared by the authors (2026).

Finally, based on the synthesis of the findings and the theoretical relationships identified in the literature, a conceptual framework was developed to represent the mechanisms through which technological, organizational, and human factors influence the psychosocial impacts associated with technological intensification in organizational settings. The framework was developed following the approach proposed by Jabareen (2009), which is based on the identification, categorization, and integration of the principal constructs identified in the literature, thereby providing a coherent theoretical articulation of the concepts examined.

4. RESULTS AND DISCUSSION: DEVELOPMENT OF AN INTEGRATIVE CONCEPTUAL FRAMEWORK

The analysis of the selected studies indicates that the transition from Industry 4.0 to Industry 5.0 represents an evolution in the principles underlying contemporary production systems. Whereas Industry 4.0 has been largely driven by automation, digitalization, and operational efficiency, Industry 5.0 extends this perspective by incorporating objectives related to human-centricity, sustainability, and organizational resilience (Laskowska & Laskowski, 2023; Vitrano & Micheli, 2025). From the Industry 4.0 perspective, technological intensification is primarily driven by the pursuit of productivity gains, process automation, cost reduction, and enhanced operational efficiency. In this context, technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Big Data, and cyberphysical systems are employed to optimize organizational performance, reduce waste, and strengthen business competitiveness (Galanti et al., 2023; Boschetti et al., 2023).

This perspective has been widely emphasized in the Industry 4.0 literature, which associates the digitalization of production systems with the maximization of productivity and operational efficiency (Margherita & Braccini, 2024). By contrast, Industry 5.0 advocates a human-centric approach in which technological development is expected to evolve in balance with human, social, and environmental needs. Within this paradigm, workers are no longer viewed merely as productive resources but instead occupy a central role in innovation and decision making processes. Furthermore, sustainability, occupational well-being, inclusion, human capital development, and quality of working life become strategic elements in the design of more sustainable and resilient production systems (Laskowska & Laskowski, 2023; Calzavara et al., 2023; Vitrano & Micheli, 2025). Organizational resilience constitutes another defining characteristic of Industry 5.0, as organizations increasingly seek to strengthen their capacity to adapt to technological, economic, and social transformations. According to Vitrano and Micheli (2025), production systems guided by the principles of Industry 5.0 should be capable of integrating technological advances with strategies that promote inclusion, active ageing of the workforce, and human sustainability. Similarly, Laskowska and Laskowski (2023) argue that the sustainable management of human capital is one of the key determinants of organizational resilience within the Industry 5.0 landscape. Consequently, the success of digital transformation no longer depends exclusively on the efficiency of technological systems but increasingly on organizations' ability to create work environments that reconcile productivity, innovation, and human well-being (Galanti et al., 2023; Farmanesh et al., 2025). This paradigm shift provides the conceptual foundation for the integrative framework proposed in this study, which brings together technological factors, sociotechnical tensions, psychosocial risks, human impacts, and mitigating factors within a perspective aligned with the principles of Industry 5.0. The identification and analysis of the studies retrieved from the Scopus and Web of Science databases through the PRISMA protocol (Figure 1) enabled the identification of the key dimensions underlying the transition to Industry 5.0 and supported the development of the integrative conceptual framework presented in Figure 2.



Figure 2: Integrative Conceptual Framework of Technological Intensification and Mitigating Factors (Source: Adapted by the authors with the assistance of AI.))

The proposed framework postulates that workers' mental well-being and operational performance are directly influenced by the quality of the interactions established between workers and technology. It further assumes that mitigating factors can shape the outcomes of this process. The framework begins with technological intensification, characterized by the widespread adoption of advanced technologies within production environments. Consistent with the principles of Industry 4.0, this process has been driven by the pursuit of higher productivity, greater operational efficiency, and enhanced process control, resulting in significant improvements in organizational quality and performance (Galanti et al., 2023; Boschetti et al., 2023). Although digital transformation has reduced part of the physical workload imposed on workers, it has simultaneously generated sociotechnical tensions arising from employees' adaptation to new technologies. This process highlights the tradeoffs between productivity and well-being, demonstrating that digital transformation extends beyond the implementation of technological tools to encompass changes in people, work processes, and organizational relationships (Margherita & Braccini, 2024). The need for workers to adapt to Industry 4.0 further reinforces the view that digital transformation constitutes a sociotechnical phenomenon whose effectiveness depends on employees' active participation and organizations' capacity to successfully manage change (Haas & Cauda, 2022). When these sociotechnical tensions are not adequately addressed through mitigating factors, they may evolve into psychosocial risks. Although technological innovation tends to reduce physical workload, it is frequently accompanied by an intensified flow of information that can increase cognitive overload (Passalacqua et al., 2025). Within this context, technostress emerges as a multidimensional phenomenon comprising techno overload, techno invasion, techno complexity, techno insecurity, and techno uncertainty. It is conceptualized as a form of work related strain associated with technological demands and may ultimately lead to stress, burnout, and occupational exhaustion (Galanti et al., 2023; Farmanesh et al., 2025). As illustrated in the proposed framework, mitigating factors can reduce or buffer the adverse consequences of technostress. Among the most prominent are effective leadership, employee well-being programs, worker participation, knowledge management, and occupational safety practices (Farmanesh et al., 2025; Anshari & Hamdan, 2022; Haas & Cauda, 2022). From this perspective, adequate organizational support can transform workers' perceptions of technological demands from sources of strain into opportunities for motivation and professional development, giving rise to techno eustress. In the literature, techno eustress refers to a positive psychological response in which technological challenges are perceived as opportunities for learning, greater autonomy, enhanced control over work, and higher levels of work engagement (Fettahoglu & Yikilmaz, 2025).

5. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCHERS

In summary, this study demonstrates that the literature on technological intensification and psychosocial risks remains fragmented, alternating between engineering oriented perspectives focused on production systems and organizational approaches centered on human resource management and organizational behavior. The findings indicate that the way technologies are implemented and the manner in which workers are integrated into this process directly influence the extent to which productivity gains can be achieved without compromising employee well-being. In this context, mitigating factors play a crucial role in reducing the adverse effects of technological intensification by facilitating the transition from technostress to techno eustress, a condition in which workers perceive technological challenges as opportunities for learning, professional development, and competence enhancement. From a theoretical perspective, this study contributes to the advancement of the literature by integrating constructs that have traditionally been examined in isolation.

The proposed conceptual framework articulates the relationships among technological intensification, sociotechnical tensions, psychosocial risks, human impacts, and mitigating factors, thereby providing a systemic understanding of the transition from Industry 4.0 to Industry 5.0 (Margherita & Braccini, 2024; Laskowska & Laskowski, 2023; Vitrano & Micheli, 2025). Furthermore, this research extends the literature on technostress by demonstrating that the effects of technological demands can be moderated by organizational factors, thereby fostering positive responses associated with techno eustress (Galanti et al., 2023; Farmanesh et al., 2025; Fettahoglu & Yikilmaz, 2025). From a managerial perspective, the findings highlight the importance of adopting strategies that place the human dimension at the center of digital transformation initiatives. Specifically, investments in continuous learning, professional development, upskilling and reskilling programs, knowledge management, and employee participation in organizational change processes can mitigate the sociotechnical tensions associated with the adoption of new technologies (Anshari & Hamdan, 2022; Haas & Cauda, 2022; Vitrano & Micheli, 2025). Likewise, effective digital leadership plays a pivotal role in fostering collaborative work environments, strengthening organizational trust, and supporting employees in coping with the demands imposed by increasing technological intensification (Farmanesh et al., 2025; Galanti et al., 2023). Despite its contributions, this study has several limitations. The proposed framework is based exclusively on evidence derived from the scientific literature and has not yet been empirically validated in real organizational settings. In addition, the review was limited to studies indexed in the Scopus and Web of Science databases, which may have excluded relevant contributions published in other databases or disciplinary contexts. Future research should focus on empirically validating the proposed framework across different industries and organizational contexts. Survey based studies are recommended to examine workers' and managers' perceptions of the psychosocial factors associated with technological intensification. Furthermore, the application of Partial Least Squares Structural Equation Modeling (PLSSEM) may provide a robust methodological approach for testing the causal relationships among the constructs identified in this study. Finally, in depth case studies of organizations undergoing the transition toward Industry 5.0 could enhance the understanding of the mechanisms through which mitigating factors reduce technostress and promote techno eustress in contemporary work environments.

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FINANCIAL PERFORMANCE ANALYSIS IN THE HOTEL INDUSTRY: THE CASE OF HOTEL BIOKOVO

Zoran Miletic
Faculty of Hospitality and Gastronomy, University of Split, Croatia
zmiletic@hig.unist.hr

Rebeka Vlaho Orsulic
Faculty of Hospitality and Gastronomy, University of Split, Croatia

ABSTRACT*

Financial performance analysis provides an important basis for assessing the financial position, operational efficiency and long-term sustainability of companies operating in the hotel industry. This paper examines the financial performance of Hotel Biokovo d.o.o., a hotel company operating in Makarska, Croatia, over the period from 2022 to 2024. The aim of the study is to assess changes in the company's financial position and business performance by analysing its financial statements and selected financial indicators. The analysis combines horizontal and vertical financial statement analysis with financial ratios related to liquidity, indebtedness, activity and profitability. The results indicate a continuous improvement in the company's financial performance during the observed period. Total revenues increased from EUR 1.22 million in 2022 to EUR 1.76 million in 2024, while profit increased from EUR 126,240 to EUR 306,570. At the same time, total liabilities decreased, indicating improved management of financial risk. Liquidity also strengthened, with the current ratio increasing from 1.63 in 2022 to 2.21 in 2024. Profitability indicators show a positive trend, with both return on assets and return on equity increasing over the analysed period. The findings suggest that Hotel Biokovo has strengthened its financial position through revenue growth, improved liquidity, reduced indebtedness and more efficient use of resources. The study demonstrates the importance of systematic financial analysis as a managerial tool for monitoring business performance and supporting strategic decision-making in the highly seasonal and competitive hotel industry.

Keywords: *Financial analysis, Financial performance, Financial ratios, Hotel industry, profitability*

1. INTRODUCTION

The hotel industry is characterised by a combination of high fixed costs, substantial investment in property and equipment, pronounced seasonality and strong sensitivity to changes in demand. These features make financial analysis particularly important for hotel managers, owners, creditors and other stakeholders. Revenue growth alone does not necessarily indicate improved performance: growth may be accompanied by rising operating costs, greater indebtedness, weaker liquidity or inefficient use of assets. A meaningful assessment therefore requires the simultaneous examination of the income statement, balance sheet and key financial ratios. The period following the COVID-19 pandemic is especially relevant for the analysis of hospitality companies. Hotels faced an abrupt collapse in travel demand during the pandemic, followed by a recovery shaped by renewed tourist flows, inflationary pressures, labour shortages and higher input costs. In such an environment, the ability to convert revenue recovery into sustainable profitability while preserving liquidity and a sound capital structure became a central managerial issue. This paper examines the financial performance of Hotel Biokovo d.o.o. in Makarska during the 2022–2024 period. The company operates in accommodation and hospitality services and Hotel Biokovo has 52 rooms and provides accommodation, restaurant and related hotel services.

The selected period makes it possible to observe the company during a phase of post-pandemic tourism recovery and to assess whether the increase in business volume was accompanied by an improvement in financial quality. The objective is not merely to reproduce accounting changes but to interpret the relationships among growth, cost dynamics, liquidity, leverage, operating efficiency and profitability. The central analytical question is whether Hotel Biokovo achieved financially sustainable growth. In this context, sustainable growth is understood as growth that improves earnings and operating efficiency without creating excessive short-term liquidity pressure or increasing dependence on debt. The paper is structured as follows: following the introduction and literature review, the methodology is presented, followed by the results and analysis of Hotel Biokovo's financial performance, discussion of the findings and managerial implications, while the final sections address the study's limitations, future research directions, and conclusions.

2. FINANCIAL PERFORMANCE ANALYSIS IN THE HOTEL INDUSTRY

Financial statement analysis transforms accounting information into indicators that can support evaluation, comparison and decision-making. In a hotel context, the most informative approach is multidimensional. Liquidity indicates the ability to meet short-term obligations; indebtedness reflects financial risk and the structure of financing; activity ratios show how efficiently assets and working capital are used; and profitability measures the company's capacity to generate returns from revenues, assets and equity. Horizontal and vertical analyses provide the structural context necessary for interpreting these ratios.

2.1. Horizontal and vertical analysis

Horizontal analysis evaluates changes in individual financial-statement items over time. It is particularly useful for identifying growth rates and detecting whether revenues, costs, assets and liabilities move in the same direction. In the present case, horizontal analysis reveals whether the recovery of hotel revenues was accompanied by proportional expense growth or whether operating leverage allowed profit to grow more rapidly than sales. Vertical analysis expresses individual balance-sheet or income-statement items as a percentage of a common base. For the balance sheet, total assets are typically used as the denominator. This approach is useful in hotels because the industry is generally asset intensive. A high proportion of non-current assets is expected, but changes in the share of current assets may signal increasing financial flexibility or changes in working-capital management.

2.2. Liquidity

Liquidity is a fundamental dimension of short-term financial stability. The current ratio compares current assets with current liabilities, whereas the quick ratio excludes inventories and therefore provides a more conservative assessment. For hotels, liquidity should be interpreted carefully because cash flows can be seasonal and year-end balance-sheet positions may not fully represent liquidity during peak or off-peak months. Nevertheless, a sustained increase in both ratios over several years normally indicates a strengthening short-term position.

2.3. Indebtedness and capital structure

Capital structure decisions are important in hospitality because hotels require significant long-term investment. Tang and Jang (2007), in their analysis of lodging firms, demonstrate that capital-structure determinants in lodging differ from those in less asset-intensive industries. Debt can support investment and growth, but excessive leverage increases fixed financial commitments and vulnerability to demand shocks. The debt ratio and financing ratio therefore provide useful evidence on the balance between external and internal sources of financing.

2.4. Activity and asset utilisation

Activity ratios connect balance-sheet positions with revenue generation. Receivables turnover indicates how quickly amounts due from customers and business partners are converted into cash, while inventory turnover measures how efficiently inventory is used. Improvements in these ratios can release working capital and support liquidity. For a hotel, inventory is usually less dominant than property and equipment, but food and beverage operations can still make inventory management financially relevant.

2.5. Profitability

Profitability is the ultimate outcome of the interaction among pricing, occupancy, operating costs, asset utilisation and financing decisions. Return on assets (ROA) measures profit relative to the asset base, while return on equity (ROE) measures the return generated for owners. Croatian hotel-sector research has shown that profitability is related to firm-specific financial and operating characteristics, including capital structure and working-capital dynamics (Škuflić & Mlinarić, 2015; Karanović, Štambuk, & Jagodić, 2020; Korent, Bubanić, & Golubić, 2023). For this reason, profitability should be analysed jointly with leverage and liquidity rather than as an isolated outcome.

3. METHODOLOGY

The study adopts a single-company case-study approach and relies on secondary financial data reported in the graduate thesis on Hotel Biokovo d.o.o. The observation period covers 2022, 2023 and 2024. The original thesis applies deductive, mathematical, descriptive, synthesis, classification and compilation methods. The present paper retains the same empirical basis but places greater emphasis on integrated interpretation of the results. Four analytical layers are used.

First, horizontal analysis identifies absolute and relative changes in revenues, expenses, profit, assets and liabilities. Second, vertical analysis examines changes in the composition of assets. Third, ratio analysis evaluates liquidity, indebtedness, activity and profitability. Fourth, the indicators are interpreted jointly in order to assess whether the observed growth represents financial strengthening or merely an increase in scale.

The analysis is descriptive and does not establish causal relationships. For example, higher revenues may reflect stronger tourism demand, improved pricing, occupancy, service quality or other factors, but the available financial statements do not allow these mechanisms to be separated. Accordingly, such explanations are treated as possible interpretations rather than empirically demonstrated causes.

4. RESULTS

4.1. Overall financial development

The overall development is strongly positive. Total revenues increased from EUR 1,224,670 in 2022 to EUR 1,759,480 in 2024, representing cumulative growth of approximately 43.7%. Total expenses also increased, but at a slower cumulative rate of approximately 32.3%. The difference between revenue and expense growth is reflected in a much faster increase in profit, from EUR 126,240 to EUR 306,570, or approximately 143% over the two-year period.

Indicator	2022	2023	2024	2023/2022	2024/2023
Total revenues (EUR)	1,224,670	1,468,320	1,759,480	+19.9%	+19.8%
Total expenses (EUR)	1,098,430	1,259,880	1,452,910	+14.7%	+15.3%
Profit (EUR)	126,240	208,440	306,570	+65.1%	+47.1%
Total assets (EUR)	2,814,150	2,973,780	3,162,540	+5.7%	+6.3%
Total liabilities (EUR)	1,102,900	1,051,460	998,310	-4.7%	-5.1%

Table 1: Key Financial Performance Indicators of Hotel Biokovo, 2022–2024 (Source: Authors' analysis based on the available financial data)

This pattern is analytically more important than revenue growth alone. If expenses had increased at the same or a faster rate than revenues, the expansion in sales would not necessarily have improved financial performance. Instead, Hotel Biokovo appears to have converted additional revenue into profit with increasing efficiency. The widening gap between revenues and expenses suggests positive operating leverage and improved capacity to absorb fixed and semi-fixed costs. At the same time, total assets increased by approximately 12.4%, while total liabilities declined by approximately 9.5%. This combination is particularly favourable: the company expanded its asset base without relying on additional liabilities. The financial position therefore strengthened not only through higher earnings but also through a gradual reduction in leverage.

4.2. Revenue growth and cost dynamics

Revenue increased by almost 20% in both 2023 and 2024. The stability of this growth rate suggests that the improvement was not limited to a single rebound year. Expenses increased by 14.7% and 15.3%, respectively, which means that the company maintained a persistent growth differential of roughly four to five percentage points in favour of revenues. This differential is a key driver of the rise in profit. The underlying thesis identifies material and personnel costs as the most important expense categories and notes that their relative shares declined. In an industry exposed to wage pressures and higher food, energy and service costs, the ability to keep total expense growth below revenue growth is financially significant. However, the available data do not permit a precise decomposition of the improvement into price, volume, occupancy and productivity effects. A useful additional analytical measure can be obtained by relating the reported profit directly to total revenue. On this basis, profit represented approximately 10.3% of revenue in 2022, 14.2% in 2023 and 17.4% in 2024. This calculation is not intended to replace the margin definitions used in the original thesis; rather, it illustrates the increasing proportion of revenue retained as profit according to the reported aggregate figures.

4.3. Asset structure

The balance-sheet structure confirms the asset-intensive nature of hotel operations. Non-current assets represented almost three quarters of total assets in 2022, although their share declined to 71.50% by 2024. Tangible assets remained the dominant component, accounting for 63.49% of total assets in 2024. This is consistent with the economic characteristics of a hotel business, where buildings, equipment and other physical assets form the operational infrastructure.

Asset category	2022	2023	2024
Non-current assets	74.56%	73.23%	71.50%
Tangible assets	66.98%	65.32%	63.49%
Intangible assets	3.39%	3.66%	3.79%
Financial assets	4.19%	4.26%	4.25%
Current assets	25.44%	26.77%	28.50%

Table 2: Changes in the Asset Structure of Hotel Biokovo, 2022–2024
(Source: Authors' analysis based on the available financial data)

The gradual increase in the share of current assets, from 25.44% to 28.50%, is noteworthy. It indicates that a larger proportion of the asset base became available in more liquid or short-term forms. When interpreted together with improving liquidity ratios and declining liabilities, this shift supports the conclusion that the company increased its financial flexibility. The source thesis contains minor differences between current-asset and inventory figures used in the vertical-analysis table and those used in the liquidity-ratio table. These differences do not change the overall direction of the findings, but they should be reconciled with the original statements before the paper is submitted for publication.

4.4.

Liquidity improved continuously throughout the observed period. The current ratio increased from 1.63 in 2022 to 1.79 in 2023 and 2.21 in 2024. The quick ratio followed the same direction, rising from 1.21 to 1.71. These movements show that current assets increasingly exceeded short-term obligations and that the improvement was not dependent solely on inventories.

Liquidity indicator	2022	2023	2024
Current assets (EUR)	715,880	798,420	900,090
Current liabilities (EUR)	439,570	445,090	407,290
Current ratio	1.63	1.79	2.21
Quick ratio	1.21	1.37	1.71

Table 2: Development of Liquidity Indicators of Hotel Biokovo, 2022–2024
(Source: Authors' analysis based on the available financial data)

The 2024 current ratio above 2.0 indicates a substantial short-term liquidity buffer at the reporting date. At the same time, very high liquidity is not automatically optimal because excessive current assets may imply idle resources. In the present case, however, the improvement coincides with strong profit growth and faster turnover ratios, so there is little evidence in the reported data that liquidity was accumulated at the expense of operating efficiency.For a seasonal hotel company, annual balance-sheet ratios should nevertheless be interpreted with caution. Liquidity can vary considerably across the year as reservations, receivables, supplier payments and staffing costs fluctuate. Monthly or quarterly cash-flow data would therefore provide a stronger test of liquidity resilience.

4.5. Indebtedness and financial risk

The debt ratio decreased from 0.39 in 2022 to 0.32 in 2024. Conversely, the financing ratio increased from 0.61 to 0.68. These changes indicate a clear strengthening of the capital structure. By 2024, a smaller proportion of assets was financed through liabilities and a larger proportion through own sources of financing.

Indebtedness indicator	2022	2023	2024
Total liabilities (EUR)	1,102,900	1,051,460	998,310
Total assets (EUR)	2,814,150	2,973,780	3,162,540
Debt ratio	0.39	0.35	0.32
Financing ratio	0.61	0.65	0.68

Table 4: Changes in Indebtedness and Capital Structure of Hotel Biokovo, 2022–2024 (Source: Authors' analysis based on the available financial data)

The debt ratio decreased from 0.39 in 2022 to 0.32 in 2024. Conversely, the financing ratio increased from 0.61 to 0.68. These changes indicate a clear strengthening of the capital structure. By 2024, a smaller proportion of assets was financed through liabilities and a larger proportion through own sources of financing. The decline in liabilities is particularly relevant because it occurred while assets and revenues were increasing. In other words, Hotel Biokovo did not need to increase leverage to support its growth during the analysed period. This reduces exposure to interest-rate and refinancing risk and may improve the company's capacity to absorb future demand shocks. The interaction between profitability and deleveraging is important. Higher retained earnings can strengthen equity and reduce the need for external financing. Although the available data do not provide a detailed financing-flow analysis, the simultaneous increase in profit and decline in liabilities is consistent with a process of internally financed balance-sheet strengthening.

4.6. Activity ratios and working-capital efficiency

The formal activity-ratio table shows an increase in both receivables and inventory turnover. Receivables turnover improved from 5.76 to 6.44, suggesting faster conversion of receivables into revenue and, indirectly, cash. Inventory turnover increased even more strongly, from 6.68 to 8.61, indicating more intensive use of inventory relative to business volume.

Activity indicator	2022	2023	2024
Receivables turnover	5.76	6.12	6.44
Inventory turnover	6.68	7.84	8.61

Table 5: Development of Activity and Working Capital Efficiency Indicators of Hotel Biokovo, 2022–2024 (Source: Authors' analysis based on the available financial data)

These trends reinforce the liquidity findings. Improved working-capital turnover can reduce the amount of cash tied up in operating assets and support the company's ability to meet obligations without additional borrowing. In a hotel with food and beverage operations, faster inventory turnover may also indicate more disciplined purchasing and stock management, although operational data would be required to confirm this interpretation. The narrative section of the underlying thesis reports different activity-ratio values, including receivables turnover increasing from 6.72 to 7.60 and inventory turnover from 5.46 to 6.15. Because these figures conflict with the formal table, this paper relies on the table values. The discrepancy should be resolved by recalculating the ratios directly from the original financial statements.

4.7. Profitability

Profitability improved substantially. According to the formal profitability table, ROA increased from 0.04 in 2022 to 0.10 in 2024, while ROE increased from 0.07 to 0.14. These changes suggest that the company generated progressively more profit from both its asset base and owners' capital.

Profitability indicator	2022	2023	2024

Profit (EUR)	126,240	208,440	306,570
ROA	0.04	0.07	0.10
ROE	0.07	0.11	0.14

Table 6: Development of Profitability Indicators of Hotel Biokovo, 2022–2024 (Source: Authors' analysis based on the available financial data)

The rise in ROA is consistent with the fact that profit grew much faster than total assets. Assets increased by approximately 12.4% between 2022 and 2024, while profit increased by about 143%. This means that the additional asset base was associated with a disproportionate increase in earnings. The rise in ROE is also notable because it occurred while leverage declined. The improvement in owners' returns therefore cannot be attributed simply to greater use of debt. A significant source inconsistency must be highlighted. Elsewhere in the thesis narrative, lower values are reported for ROA and ROE, including ROA increasing from 3.04% to 4.11% and ROE from 6.39% to 8.56%. These values do not correspond to Table 8. Before publication, the profitability indicators should be recalculated from the audited or officially filed statements and one consistent definition should be used throughout.

5. DISCUSSION

The most important conclusion from the integrated analysis is that Hotel Biokovo experienced financial strengthening rather than simple revenue expansion. The company combined four favourable developments: rapid revenue growth, slower expense growth, declining leverage and stronger liquidity. These developments were accompanied by improved turnover and profitability indicators. The pattern can therefore be described as profitable growth with deleveraging. This distinction matters in hospitality finance. A hotel can report strong sales while simultaneously weakening its balance sheet if growth requires excessive borrowing, if receivables expand too rapidly or if operating costs absorb the additional revenue. Hotel Biokovo shows the opposite pattern in the analysed data. Liabilities fell, current assets increased, working-capital turnover improved and profit grew considerably faster than sales.

The findings are broadly consistent with the hospitality-finance literature, which emphasises the interaction between capital structure, liquidity and profitability. Tang and Jang (2007) show that lodging firms have sector-specific capital-structure characteristics, while Croatian studies indicate that firm characteristics and financing choices are associated with profitability in the hotel sector. The Hotel Biokovo case adds a company-level illustration of how improved profitability can coincide with lower indebtedness rather than being driven by leverage. The results also have a post-pandemic interpretation. Radivojević, Dimovski and Mitić (2023) document the substantial financial effects of COVID-19 on major hotel companies. Against this background, the 2022–2024 improvement at Hotel Biokovo can be understood as part of a recovery phase. However, the available evidence is insufficient to attribute the improvement solely to post-pandemic demand. Changes in prices, occupancy, market mix, cost control and investment may all have contributed. From a strategic perspective, the most encouraging feature is the quality of earnings growth. Revenue rose by 43.7% over two years, but profit rose by approximately 143%. This suggests that the company captured a progressively larger economic benefit from each additional euro of revenue. The reduction in the debt ratio further implies that this improvement was not purchased through greater financial risk. Nevertheless, a strong three-year trend should not be interpreted as proof of long-term resilience. Hotels remain exposed to tourism cycles, geopolitical uncertainty, climate-related disruptions, labour availability and input-price volatility. A financially stronger balance sheet creates a buffer against these risks, but future performance will depend on the company's ability to preserve margins and liquidity when demand conditions are less favourable.

6. MANAGERIAL IMPLICATIONS

The analysis suggests several implications for management. First, the company should protect the favourable relationship between revenue and expense growth. The strongest driver of improved profitability was not merely higher revenue but the fact that expenses grew more slowly. Management should therefore monitor labour, food and beverage, energy, maintenance and external-service costs in relation to revenue rather than focusing only on nominal cost increases. Second, the improved liquidity position provides financial flexibility, but liquidity should be actively managed. A current ratio of 2.21 offers a strong buffer, yet management should distinguish between necessary liquidity reserves and potentially underutilised current assets. Rolling cash-flow forecasts would be especially useful because annual ratios can conceal seasonal shortages. Third, the declining debt ratio creates additional borrowing capacity. This should not automatically lead to higher debt, but it gives the company strategic room to finance renovation, digitalisation, energy efficiency or service improvements if projects have attractive expected returns. Investment decisions should be evaluated against the company's strengthened internal financing capacity. Fourth, working-capital indicators should be incorporated into routine performance monitoring. Faster receivables and inventory turnover supported the overall financial improvement. Management should continue to monitor payment terms with intermediaries and business customers, purchasing cycles and inventory levels, particularly in food and beverage operations. Finally, financial performance should increasingly be connected with hotel-specific operational indicators. Occupancy rate, average daily rate, revenue per available room, labour cost per occupied room and departmental profitability would allow management to identify the operational mechanisms behind the financial ratios. This would transform the current accounting analysis into a more complete hotel performance-management system.

7. LIMITATIONS AND FUTURE RESEARCH

The study has several limitations. The first is the single-case design. Hotel Biokovo provides a useful illustration, but the results cannot be generalised to the entire Croatian hotel industry. A future study could compare the company with hotels of similar size, category, location and ownership structure.

The second limitation is the short observation period. Three years are sufficient to identify a clear direction but not to distinguish a temporary recovery from a stable long-term trend. Extending the analysis to a longer pre- and post-pandemic period would make it possible to evaluate structural change and resilience more convincingly.

The third limitation concerns the exclusive reliance on annual financial data. Hotel performance is highly seasonal. Monthly or quarterly data would permit analysis of within-year liquidity pressure, cash conversion and cost behaviour. Incorporating cash-flow statements would also strengthen the assessment of financial sustainability.

The fourth limitation is the absence of hotel-specific operating indicators. Financial ratios reveal outcomes but do not explain whether revenue growth was driven by higher occupancy, room rates, restaurant activity or other services. Future research should combine accounting data with occupancy, ADR, RevPAR and capacity-utilisation indicators.

Finally, the source thesis contains inconsistencies between several tables and narrative interpretations. These are particularly visible in the activity and profitability ratios. A publication-ready version should therefore recalculate all ratios directly from the original financial statements and document the formulas used. This verification is essential for reproducibility and academic credibility.

8. CONCLUSION

The financial analysis of Hotel Biokovo d.o.o. for 2022–2024 indicates a substantial improvement in financial performance. Revenues increased from EUR 1.22 million to EUR 1.76 million, while profit increased from EUR 126,240 to EUR 306,570. Expenses increased more slowly than revenues, enabling a strong expansion in earnings. The balance sheet strengthened simultaneously. Total assets increased, total liabilities declined, the debt ratio fell from 0.39 to 0.32 and the current ratio increased from 1.63 to 2.21. Receivables and inventory turnover improved according to the formal ratio table, while reported ROA and ROE increased substantially. These movements point to stronger liquidity, lower financial risk, more efficient working-capital use and higher returns.

The central finding is therefore not simply that Hotel Biokovo grew, but that the quality of its financial position improved while it grew. The company generated more revenue and profit while reducing leverage and strengthening short-term solvency. This combination provides a stronger basis for future investment and resilience than revenue growth alone. At the same time, the analysis demonstrates the importance of consistency in financial-ratio reporting. Conflicting values in the underlying source material should be resolved before the study is submitted for academic publication. Once the indicators are verified against the original financial statements, the Hotel Biokovo case can provide a useful contribution to the literature on financial performance and post-pandemic recovery in the hotel industry.

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INDUSTRIAL POLICY AND ECONOMIC DIVERSIFICATION: A COMPARATIVE ANALYSIS FOR ALGERIA

Benmouhoub Thiziri
Department of Economic Sciences, University of Bejaia, Algeria
thiziri.benmouhoub@univ-bejaia.dz

Boukhezer Nacira
Department of Economic Sciences, University of Bejaia, Algeria
nacira.boukhezer@univ-bejaia.dz

Boudemagh Mohamed Lamine
Department of Economic Sciences, Mouloud Mammeri University of Tizi Ouzou, Algeria
mohamedlamine.boudemagh@ummto.dz

Humberto Nuno Rito Ribeiro
GOVCOPP; ESTGA, University of Aveiro, OSEAN, Portugal
hnr@ua.pt

ABSTRACT

This paper evaluates industrial revival policies as a critical mechanism for sustainable economic diversification in the context of rentier economies, focusing on the Algerian trajectory. The research employed a vis-à-vis comparative methodology to benchmark Algeria versus countries with successful industrial transformations (South Korea, Japan, Germany, and Malaysia); together with those that experienced failed diversification (Nigeria, Venezuela, and Brazil). Four primary quantitative indicators guided this evaluation: the share of manufactured exports in Gross Domestic Product (GDP), the proportion of high-technology products within manufactured exports, research and development (R&D) expenditure as a percentage of GDP, and the ease of doing business index. Additionally, the research incorporates the theoretical dimensions of technology transfer via foreign direct investment (FDI) and total factor productivity (TFP), to understand the role of absorptive capacity. The findings demonstrate that successful policies form a distinct paradigm characterized by selective state support strictly conditioned on verifiable performance, deliberate and sustained accumulation of technological capabilities, and stable institutional governance. Conversely, failed experiences typically involve unconditional market protection, macroeconomic instability, and rent-seeking behaviors. The study suggests that sustainable diversification requires more than capital accumulation or import substitution, as shown by the relevance of existing robust R&D investment, high domestic absorptive capacity, and continuous policy coordination. For Algeria, escaping the rentier trap demands a transition towards performance-conditioned interventions, aggressive human capital development, and institutional mechanisms capable of shielding strategic industrial objectives from political and resource volatility.

Keywords*: Algeria, economic diversification, industrial economies, industrial policy, resource curse, technology transfer*

1. INTRODUCTION

The dynamics of industrialization and economic growth have long underscored the necessity of robust policy frameworks, particularly in an era characterized by the rapid globalization of production and the growing interdependence of national economies.

This accelerated pace of global integration has been primarily stimulated by the expansive diffusion of technological progress, notably in information and communication technologies, the precipitous decline in transport costs, and the widespread deregulation, privatization, and liberalization of global markets. Within this complex global architecture, the interaction between the New Economic Geography, the New Theory of International Trade, and Endogenous Growth Theory indicates that economic integration is far more than a simple reduction in trade frictions; it is a profound process of diffusing innovations, research and development (R&D), ideas, and specialized know-how. Consequently, industrial revival policies are no longer evaluated solely on their capacity to accumulate physical capital or substitute imports, but on their ability to act as conduits for global technological diffusion (Aiginger & Rodrik, 2020). The initial phases of this research established the conceptual and theoretical parameters of this process, examining the historical experiences of nations that successfully managed their industrial transformation and tracing the specific trajectory of Algeria's industrial revival. This Algerian trajectory provides a fascinating and often contradictory case study, evolving from the highly centralized, planned industrialization of the 1960s and 1970s, moving through the chaotic policy fluctuations of the 2000s, and culminating in the swift, destabilizing abandonment of the comprehensive 2007 industrial strategy. The present analysis seeks to transition from historical description to rigorous critical evaluation, aiming to provide an argued, empirically grounded judgment on the efficacy of these industrial revival policies in fostering genuine, sustainable economic diversification. Evaluating industrial policy is an inherently complex academic exercise for several intertwined reasons. First, the impacts of such structural interventions unfold over extremely long horizons, often manifesting their true economic consequences long after the political mandates of the teams that designed them have expired. Second, industrial policy operates within a highly volatile global environment where external shocks (such as wild fluctuations in the commodity prices of raw materials, global economic downturns, or sudden geopolitical shifts) simultaneously exert massive pressure on the exact same macroeconomic variables the policies intend to manage. Finally, the publicly stated objectives formulated by public authorities are rarely articulated in precise, measurable terms that lend themselves to standard econometric evaluation. Consequently, this study adopts a robust comparative approach: rather than judging a policy in a theoretical absolute vacuum, we benchmark it against international experiences whose long-term results are unequivocally established, mobilizing a restricted, highly targeted set of common quantitative indicators. This comparative benchmarking is significantly enriched by incorporating theoretical models of Technology Transfer and Foreign Direct Investment (FDI), recognizing that economic catch-up for imitator countries in the Global South is largely driven by their capacity to absorb and internalize foreign innovations. This research addresses a central, overarching question: What specific configurations of industrial revival policies are capable of fostering sustainable diversification of the Algerian economy, rigorously taking into account the profound structural constraints inherent to a rentier economy and the absolute imperative of technological absorption? To systematically address this complex problem, the study formulates and tests three primary hypotheses. Hypothesis 1 posits that contemporary revival policies constitute a distinct paradigm in which public support is highly selective and rigorously conditioned on verifiable performance outcomes, whereas policy failure is almost universally characterized by unconditional protectionism. Hypothesis 2 argues that the sustainability of economic diversification is fundamentally linked to the deliberate accumulation of technological capabilities, robust R&D efforts, and the formation of the human capital required to actively absorb foreign technology. Hypothesis 3 asserts that institutional factors (particularly the stability of the regulatory environment, the efficacy of coordination mechanisms, and the strict mitigation of rent-seeking behaviors) are critical, overriding determinants of policy effectiveness in resource-abundant economies.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The theoretical foundation of this study is situated precisely at the intersection of modern industrial policy theory, endogenous growth models, and the complex economics of international technology transfer. Classical models of industrial policy often focused almost exclusively on the sheer volume of capital accumulation and the rigid protection of infant industries through Import Substitution Industrialization strategies. However, modern economic history has repeatedly demonstrated that static protection alone is entirely insufficient and frequently leads to severe allocative inefficiencies and long-term technological stagnation. The technological capability literature adds that catching up requires a deliberate and costly effort to assimilate, adapt, and eventually create technology, rather than the mere accumulation of capital (Kim, 1997; Lall, 1992). The endogenous growth theory, popularized by Romer (1990) and Lucas (1988), fundamentally altered this perspective by positing that economic growth is primarily the result of endogenous forces rather than external shocks. In this framework, deliberate investment in human capital, continuous innovation, and the generation of knowledge are the most significant contributors to long-term economic growth. Furthermore, the New Theory of International Trade and the New Economic Geography indicate that the process of economic integration extends far beyond the mere reduction of transport costs; it is fundamentally a dynamic process of diffusing innovations, R&D capabilities, and specialized know-how from the technological center to the periphery. In this specific sense, Technology Transfer via FDI has been highlighted in economic theory through several distinct channels of diffusion. These vital channels include labor turnover from multinational firms to domestic firms, demonstration and imitation effects, vertical linkages and sub-contracting relationships, direct technical assistance, and the insertion of domestic firms into a highly competitive market characterized by strong incentives to invest in research and to learn by doing. According to Blomström and Kokko (1998), technology transfer is a dynamic process where advanced foreign technology is conveyed by multinational corporations through positive externalities, frequently referred to in the literature as technological spillovers. However, the expansive literature on this subject clearly distinguishes between exogenous and endogenous models of technology transfer, a distinction that is crucial for understanding policy failures in developing nations. Early models, such as those building upon Findlay's (1978) application of the backwardness effect described by Veblen (1915) and Gerschenkron (1962), assumed that technology transfer was a somewhat automatic, exogenous process. In these models, the transfer was stimulated merely by the technological lag between multinational firms and domestic firms, functioning almost like a contagious disease, as proposed by Mansfield (1961). In stark contrast, more recent and nuanced models, particularly the one developed by Wang and Blomström (1992), emphasize that technology transfer is a highly endogenous process. It is actively stimulated by the strategic interaction between the profit-maximizing motives of foreign firms and the explicit absorptive capacity of domestic firms. The stationarity of this process is often determined by a Nash equilibrium where the costs of technology transfer for the multinational are balanced against the learning costs and human capital investments of the domestic firm. Empirical studies present a highly mixed picture regarding the automaticity of these spillovers, highlighting the danger of passive industrial policies. While Driffield (2001), Liu (2008), and Javorcik (2004) have shown positive, significant correlations between FDI and total factor productivity (TFP) in host countries, Aitken and Harrison (1999) found negative correlations in specific contexts, such as the manufacturing sector in Venezuela. The prevailing consensus in the contemporary literature is that FDI only contributes to improving the productivity of domestic firms when the technological gap is not excessively wide and, crucially, when the absorptive capacity of domestic firms (measured by human capital and local R&D) is highly developed. This theoretical backdrop is absolutely vital for evaluating Algeria's trajectory.

As a classic rentier state, Algeria faces the severe symptoms of the Dutch Disease, where massive resource booms lead to real exchange rate appreciation and a massive shift of resources toward non-tradable, rent-seeking sectors (Corden & Neary, 1982). Yet the resource curse is not deterministic: its effects depend on institutional quality (Mehlum et al., 2006), and oil rents shape the very structure of rentier states (Karl, 1997). Overcoming this structural trap requires an industrial policy that does not merely invite foreign capital, but explicitly forces technological upgrading, mandates export performance, and actively constructs the domestic absorptive capacity necessary to capture and internalize global technological spillovers.

3. METHODOLOGICAL FRAMEWORK OF THE COMPARATIVE REVIEW

This section meticulously delineates the construction of the comparative review, establishing the strict criteria for selecting the sample countries, defining the precise evaluation indicators, and addressing the inherent methodological limitations of cross-country macroeconomic comparisons. The intrinsic value of an international comparison depends far less on the sheer number of countries examined than on the rigorous theoretical logic with which they are chosen, the specific metrics used to describe their trajectories, and the analytical prudence applied to interpreting the observed variances. The primary objective of this methodological architecture is to provide a highly robust empirical reference point to evaluate Algerian industrial choices. By systematically identifying the shared characteristics of policies that have successfully driven structural diversification and contrasting them with those that have unequivocally failed, the methodology directly aligns with and tests the research hypotheses. For the first hypothesis regarding conditionality, the review assesses whether successful countries subordinated state support to strict performance requirements (such as non-negotiable export targets) and whether failing countries relied on unconditional, permanent market protection. For the second hypothesis regarding technological accumulation, specific indicators regarding the technological content of exports and aggregate R&D expenditures are scrutinized as proxies for absorptive capacity. For the third hypothesis regarding institutional stability, the ease of doing business and qualitative governance assessments provide a robust proxy for the overall quality of the institutional environment. Furthermore, the analysis is guided by the evaluation criteria defined by the Organisation for Economic Co-operation and Development (OECD, 2021): relevance, coherence, effectiveness, efficiency, impact, and sustainability. These criteria serve as a qualitative reading grid, with particular emphasis on effectiveness, impact, and sustainability. This emphasis is essential because it prevents the analytical error of conflating genuine structural success with temporary, price-driven export surges, ensuring that the true structural integrity and resilience of the industrial base are evaluated rather than fleeting macroeconomic mirages. The sample for this comparative analysis consists of seven carefully selected countries divided into two distinct groups to explicitly avoid the selection bias documented by Geddes (1990) in comparative politics. Selecting only cases where the studied phenomenon (success) occurred inevitably leads to skewed, inaccurate conclusions, as the observed characteristics might also exist in failed cases without causing success. The first group comprises four countries whose industrial transformations are universally held as successful archetypes: South Korea and Japan, which vividly illustrate state-led catch-up coordinated by highly competent bureaucracies; Germany, which illustrates the maintenance of industrial leadership founded on deep, long-term institutions; and Malaysia, which presents the highly relevant case of a resource-rich economy successfully transitioning from primary commodity dependence to high-volume manufactured exports. The second group includes three countries whose industrial policies demonstrably failed to produce the expected diversification: Nigeria and Venezuela, two hyper-dependent oil economies that share profound structural constraints and rentier dynamics with Algeria; and Brazil, which serves as a crucial counter-example of a massive, heavily protected

industrialization drive that ultimately culminated in severe premature deindustrialization due to a lack of export discipline. Table 1 summarizes the sample and the rationale for each selection. The observation period for this analysis ranges from the historical inception of these policy trajectories in the mid-twentieth century to the most recent data available (2022–2023), except for the Doing Business index, which refers to its last edition (2020). To anchor this qualitative comparison in hard data, four specific quantitative indicators are utilized. First, manufactured exports as a percentage of Gross Domestic Product (GDP) measures the integration and massive scale of the outward-looking industrial base, effectively neutralizing the distorting effect of raw material price variations. Second, high-technology products as a percentage of manufactured exports precisely evaluates the technological sophistication of the productive apparatus, in line with the idea that what a country exports matters for its growth (Hausmann et al., 2007), relying on standard classifications of research intensity. Third, total R&D expenditure as a percentage of GDP reflects the absolute national effort in accumulating technological capabilities, serving as a direct test of the second hypothesis. Finally, the Ease of Doing Business index (World Bank, 2020) broadly indicates the quality of the institutional environment and regulatory complexity, directly aligning with the third hypothesis regarding institutional stability and the mitigation of bureaucratic rent-seeking. This edition is the last published before the World Bank discontinued the series in 2021, which constitutes a limitation of this indicator.

Table 1: Sample Selection and Justification

Country	**Group**	**Trajectory Type**	**Rationale for Selection**
South Korea	Success	State-led catch-up, export orientation	Demonstrates support strictly conditioned on performance and rapid tech upgrading
Japan	Success	Ministry-coordinated catch-up	Shows public-private coordination and continuous, massive R&D effort
Germany	Success	Maintained industrial leadership	Illustrates the power of long-term institutions for training and applied innovation
Malaysia	Success	Resource economy to manufactured export	Closest match to Algeria's resource endowments with a successful industrial transition
Nigeria	Failure	Oil economy, import substitution	Shared structural constraints, high hydrocarbon dependence, and institutional weakness
Venezuela	Failure	Oil economy, high interventionism	Illustrates extreme policy instability, rentier collapse, and the ultimate resource curse
Brazil	Failure	Protected industrialization, decline	Used Asian-style tools but fatally lacked export conditionality and market discipline

Source: Elaborated by the authors based on Geddes (1990) and comparative literature.

4. EXPERIENCES OF SUCCESSFUL INDUSTRIAL TRANSFORMATION

This section deeply examines the four countries whose industrial transformations are universally recognized as successful, analyzing their initial objectives, the specific policy instruments deployed, their governance structures, and the resulting macroeconomic indicators. South Korea's trajectory exemplifies an industrialization heavily guided by the state but strictly disciplined by the global market. In the early 1960s, the nation was deeply impoverished and devoid of significant natural resources, surviving largely on external aid. The decisive turning point occurred when macroeconomic policy resolutely shifted toward export orientation.

The government unified and devalued the exchange rate, provided massive financial incentives to exporters, and set strict export targets monitored at the highest political levels. Crucially, as extensively highlighted by Amsden (1989), this state support was coupled with severe, uncompromising discipline. The massive conglomerates, known as chaebols, received subsidized directed credit, temporary tariff protection, and exclusive manufacturing licenses entirely in exchange for meeting rigorous, verifiable performance commitments on international markets. The failure to meet these export targets resulted in the immediate withdrawal of state backing. This logic of reciprocal control between the state and private enterprises effectively short-circuited the rent-seeking behaviors that typically plague massive interventionist policies. During the Heavy and Chemical Industry drive of the 1970s, the state aggressively targeted steel, shipbuilding, and petrochemicals. While financially costly and initially generating overcapacity, it successfully endowed the country with a globally competitive industrial base capable of absorbing advanced technology. Furthermore, South Korea's rapid technological ascent relied on early, sustained investments in domestic absorptive capacity, transitioning from simple imitation to frontier innovation. The state created advanced public research institutes in the 1960s and gradually incentivized private firms to establish massive internal laboratories. Today, South Korea's manufactured exports represent roughly 30 percent of its GDP. High-technology goods constitute an impressive 30 percent of these exports, structurally supported by a massive, world-leading R&D expenditure approaching 5.0 percent of its GDP. Japan's post-war model stands as the historical archetype of highly coordinated, rapid industrial catch-up without the heavy reliance on state-owned conglomerates seen in other developing nations. The Ministry of International Trade and Industry functioned as the unquestioned pivot of a developmental state, orienting national resource allocation toward long-term competitiveness while preserving private property and intense domestic market competition (Johnson, 1982). The policy instruments utilized included strict control over foreign exchange and the importation of technology, targeted development bank loans, and a highly effective system of administrative guidance. Unlike purely directive, Soviet-style regimes, the Japanese government expertly coordinated collaborative research programs to overcome the immense costs of technological catch-up. The Very Large Scale Integrated circuit project in the 1970s is a prime example, uniting fiercely competing domestic manufacturers around shared, state-subsidized research laboratories to leapfrog foreign competitors. While the administration sometimes failed in its explicit sector-picking efforts (famously attempting to limit the number of automobile manufacturers against market forces) the intense internal competition and massive private investment in process innovation ensured overall systemic success. Japan currently exports primarily highly complex medium-high technology products like vehicles, advanced machinery, and precision components. Its national R&D effort remains highly consistent, hovering around 3.4 percent of GDP, ensuring its unshakeable position at the global technological frontier and demonstrating that effective state coordination must be fundamentally anchored in intense market competition. Germany distinguishes itself significantly from the other countries in the sample because it did not have to catch up to a technological frontier in the contemporary period; its primary macroeconomic challenge was maintaining an existing, dominant position of industrial leadership in the face of rapid globalization. Consequently, the German model relies less on an explicit, directive sectoral industrial policy and much more on a dense, highly stable network of long-term institutions that make directive policy unnecessary. The post-war ordoliberal tradition favored a highly stable regulatory framework, a protected competitive environment, and independent monetary policy over the active targeting of specific sectors. Several key institutions act effectively as an implicit, highly efficient industrial policy. The state-owned KfW development bank finances the continuous modernization and innovation of small and medium enterprises at highly favorable conditions.

The Fraunhofer Society ensures the seamless, rapid transfer of applied research from academic laboratories directly to private manufacturing companies. Perhaps most importantly, the globally renowned dual vocational training system provides an immense pool of highly certified technical competencies, acting as a massive, continuous investment in human capital and domestic absorptive capacity. This robust institutional ecosystem supports the Mittelstand, an incredibly dense fabric of medium-sized, highly specialized exporting firms that often operate as hidden champions in global niche markets. With overall R&D spending steadily at 3.1 percent of GDP and manufactured exports nearing an astonishing 31 percent of GDP, Germany unequivocally proves that continuous institutional stability, patient financing, and cooperative labor relations are vital for long-term technological resilience. Malaysia provides the most structurally pertinent comparison for Algeria within this sample. Initially structured almost entirely around primary resources like tin, rubber, palm oil, and subsequently petroleum and natural gas, Malaysia successfully executed a massive pivot toward export-oriented manufacturing, avoiding the classic traps of the resource curse. Following a brief, unsatisfactory period of import substitution, the country radically shifted strategies in the late 1960s and early 1970s. It established massive free trade zones, particularly in Penang, to aggressively attract FDI, primarily targeting American and Japanese multinational corporations in the burgeoning electronics sector. The Malaysian state utilized highly structured five-year plans and specific Industrial Master Plans to continuously consolidate its export orientation, later attempting to deepen domestic value chains through heavy industry projects like the national car initiative, Proton. The relative continuity of this impressive trajectory was structurally supported by effective coordination between federal and state levels, continuous institutionalized dialogue with the private sector, and a steadfast openness to foreign investors even during economic downturns. Consequently, manufactured exports today represent approximately 58 percent of Malaysia's GDP, a remarkably high level of structural openness and integration into global markets. Furthermore, high-technology products comprise approximately 59.4 percent of these exports, placing Malaysia among the top global exporters in this category. However, this apparent massive success harbors a significant structural vulnerability that aligns perfectly with the theories of technology transfer. Malaysia's aggregate R&D expenditure remains exceedingly modest, approximating only 1.0 percent of its GDP, a weakness that Rasiah (2011) associates with the risk of negative deindustrialization. This vast discrepancy between the exceptionally high technological content of its exports and its remarkably low domestic research effort indicates an insertion into global value chains based primarily on assembly, testing, and packaging rather than indigenous design and deep innovation. It perfectly illustrates the theoretical premise that aggressively attracting FDI without simultaneously forcing the development of deep domestic absorptive capacity severely limits the extent of genuine, sustainable technological transfer, leaving the economy vulnerable to shifts in multinational corporate strategy. Table 2 summarizes the main indicators for the four successful economies.

Table 2: Performance Indicators of Successful Economies (Latest Available Data)

Country	**Mfg. Exports (% GDP)**	**High-Tech (% of Mfg)**	**R&D (% GDP)**	**Doing Business (2020)**
Malaysia	≈ 58%	59.4%	≈ 1.0%	Rank 12
Germany	≈ 31%	17.9%	3.1%	Rank 22
South Korea	≈ 30%	30.0%	≈ 5.0%	Rank 5
Japan	≈ 15%	17.0%	≈ 3.4%	Rank 29

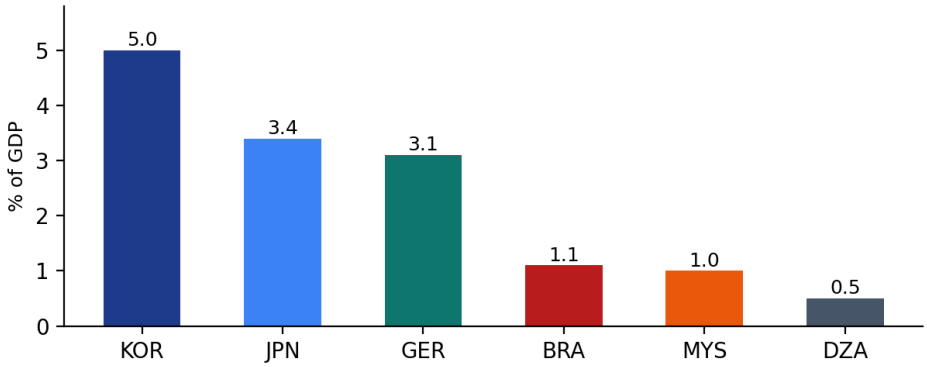
Source: Elaborated by the authors based on World Bank (2026) and World Bank (2020).

5. EXPERIENCES OF FAILED DIVERSIFICATION

This section investigates the sobering cases of countries where massive industrial policies fundamentally failed to produce the expected economic diversification. The explicit objective is to identify the root structural and institutional causes of these failures, verifying that they represent the exact inverse of the success conditions previously identified in the Asian and European models. Failure is defined here strictly in the macroeconomic sense as the non-attainment of sustainable economic diversification and the failure to build a competitive outward-looking manufacturing base, regardless of any potential achievements in other domestic public policy domains. Nigeria offers a classic, tragic example of an economy whose productive structure dramatically simplified as petroleum exploitation expanded. Before the massive oil booms of the 1970s, the country exported a highly diverse array of agricultural products. However, following the mechanics of the Dutch Disease described by Corden and Neary (1982), the massive influx of oil revenues led to a severely overvalued currency, inexorably drawing capital and labor resources away from tradable agricultural and industrial sectors and heavily into non-tradable sectors. The state built its entire political legitimacy upon the massive redistribution of these oil rents rather than the collection of taxes from a productive base. Nigeria's industrial policy relied heavily on aggressive import substitution, utilizing astronomically high tariffs, severe quantitative restrictions, and massive, poorly planned public projects. The indigenization decrees of the 1970s forced national participation in foreign enterprises but completely failed to spur actual technology transfer because domestic partners acted as passive rent-collectors rather than active technological learners. Emblematic mega-projects, such as the Ajaokuta steel complex and the sprawling public refineries, absorbed billions but never sustainably reached their planned capacities. The fatal, underlying flaw was the total absence of conditionality; massive state protections were granted to local elites without any corresponding export requirements or strict timelines for the withdrawal of support. Consequently, Nigeria's manufactured exports currently linger around an abysmal 1 percent of GDP, high-technology exports are virtually non-existent, and aggregate R&D stands at an insignificant 0.2 percent of GDP, representing a total failure of technological accumulation. Venezuela presents an even more extreme case of rent interventionism leading to total productive collapse. The nation recognized the dire need for diversification very early, adopting the famous slogan "sow the oil" in the 1930s. Successive governments heavily promoted import substitution and created massive, state-owned heavy industry poles in the Guayana region, focusing on steel and aluminum. However, as Karl (1997) documented, the extreme structural dependence on oil rent fundamentally shaped Venezuelan institutions in a way that inherently amplified macroeconomic volatility. Massive boom cycles triggered explosive external debt and unrestrained public spending, which were inevitably followed by severe, destabilizing socio-economic adjustments when global oil prices fell. Starting in 1999, state interventionism in the micro-economy intensified dramatically. The government instituted paralyzingly strict currency controls, rigid price ceilings that destroyed profit margins, and widespread, arbitrary expropriations across the steel, cement, and agricultural sectors. Crucially, the extreme politicization of the national oil company, PDVSA, following strikes drastically reduced the nation's core technical competence. These aggressive measures systematically destroyed the fundamental incentive to invest, innovate, or produce within the formal economy. When global oil prices predictably collapsed in 2014, the profound, underlying structural fragility of this heavily subsidized system was fully exposed, leading to unprecedented hyperinflation and the near-total evaporation of the non-oil productive fabric. Venezuela currently ranks at the absolute bottom of global business environment indices, providing a stark, undeniable warning about the destructive potential of unconditional rent distribution coupled with extreme, unpredictable policy instability and the destruction of market signals.

Brazil provides a highly crucial counter-example in this comparative analysis because it is not a pure, oil-dependent rentier economy like Nigeria or Venezuela, yet it experienced severe, debilitating premature deindustrialization. During the mid-twentieth century, Brazil aggressively utilized state development banks, massive state-owned enterprises, and heavy protectionist barriers to successfully build a broad, diverse industrial base. However, a glaring, fatal omission separated Brazil's import substitution strategy from the highly successful export-led growth of the Asian Tigers: a profound lack of export discipline and performance conditionality. Amsden (2001) documented how massive Brazilian state protections and subsidized credits were rarely, if ever, conditioned on stringent, verifiable export commitments. The infamous informatics policy of the 1980s perfectly illustrates this structural failure. A strict market reserve totally prohibited the importation of microcomputers in an attempt to foster a purely national industry from scratch. Without the ruthless discipline of global competition to force efficiency and innovation, this policy produced equipment that was technologically obsolete, heavily dependent on smuggled components, and excessively expensive for downstream domestic industries. When the Brazilian economy was finally subjected to sudden, poorly planned trade liberalization in the 1990s, the deeply uncompetitive industrial base contracted sharply, a pattern that Rodrik (2016) describes as premature deindustrialization. Despite massive contemporary subsidy programs aimed at creating national champions, Brazil's manufactured exports remain structurally low at roughly 4 percent of GDP. The Brazilian experience unequivocally proves that merely utilizing the outward instruments of industrial policy (such as development banks and tariffs) without building the necessary disciplinary architecture of conditionality leads to inevitable technological decline and re-primarization of the export basket.

Figure 1: R&D Expenditure as % of GDP (Latest Available Data)



Source: Elaborated by the authors based on UNESCO Institute for Statistics (2026) and World Bank (2026).

6. THE ALGERIAN TRAJECTORY AND ECONOMETRIC EVIDENCE

The quantitative macroeconomic indicators unequivocally place Algeria deep within the group of economies that have structurally failed to diversify. Between 2016 and 2022, the hydrocarbon sector maintained an overwhelming stranglehold on the economy, accounting for 93 percent of total merchandise exports and 41 percent of fiscal revenues (World Bank, 2026). Non-hydrocarbon exports remain severely limited, completely dominated by low-transformation products or direct hydrocarbon derivatives like ammonia and fertilizers, which simply represent another form of resource extraction. Manufactured exports, the true engine of technological catch-up, represent a statistically marginal 1.5 percent of GDP. Furthermore, the technological sophistication of the Algerian economy is critically low. High-technology products account for approximately 1 percent of manufactured exports, and total R&D expenditure stagnates at around an unacceptable 0.5 percent of GDP.

The institutional environment has also severely degraded, with the country falling from 136th in 2010 to 157th in 2020 in the Doing Business ranking (World Bank, 2020), reflecting a labyrinthine regulatory framework that stifles private initiative. This precarious, deeply vulnerable position is the direct result of chronic policy instability, flawed regulatory frameworks, and a fundamental misunderstanding of how technology is actually transferred. The rapid, politically motivated abandonment of the comprehensive 2007 industrial strategy under the intense pressure of rent-seeking interest groups completely shattered policy continuity. Furthermore, the rigid imposition of the 51/49 ownership rule in 2009 for all foreign investments acted as a severe, structural deterrent to high-quality FDI. Instead of fostering genuine technology transfer through forced partnerships, it isolated Algerian firms from the most advanced global value chains and the associated technological spillovers, as multinational corporations refused to transfer their most valuable proprietary technologies to entities they did not control. Subsequent import restrictions implemented in the mid-2010s functioned exactly as unconditional protections, completely removing the vital competitive pressures required to stimulate productivity improvements and innovation among domestic firms, recreating the exact conditions that led to Brazil's failure. To deepen this analysis beyond comparative benchmarking, it is crucial to integrate recent empirical econometric evidence specific to the Algerian case, notably Vector Autoregression (VAR) and Vector Error Correction Models (VECM) applied to TFP. The findings from these robust empirical analyses are highly revealing and validate the theoretical concerns regarding absorptive capacity. Estimations reveal that FDI in Algeria actually has a negative and statistically significant short-term impact on TFP. This counter-intuitive result can be explained by severe competition effects where highly efficient multinational corporations crowd out domestic firms, combined with an immense technological gap that prevents local firms from absorbing the introduced technologies. Furthermore, the weak nature of industrial cooperation, driven by restrictive ownership laws rather than strategic alignment, stifles the positive externalities typically associated with foreign capital. Conversely, the VECM analysis demonstrates that economic openness and the accumulation of human capital (measured by secondary and tertiary enrollment) have a significantly positive long-term impact on the dynamics of Technology Transfer. However, when introducing interactive terms to test the synergy between foreign capital and local capabilities, the data reveals a critical bottleneck: the current level of human capital in Algeria is insufficiently developed to effectively absorb the specific foreign technologies conveyed by multinational corporations. In essence, Algeria is importing machinery without having cultivated the dense network of engineers, technicians, and applied researchers necessary to reverse-engineer, adapt, and ultimately improve upon those technologies. This econometric evidence proves that the process of catching up is not merely about accumulating capital equipment; it is a complex, long-term process of learning by doing that requires a highly specific, aggressively funded educational and research infrastructure that is currently absent in the Algerian rentier model.

7. HYPOTHESIS TESTING AND DISCUSSION

The convergence of the qualitative comparative data and the robust econometric evidence allows for a definitive confrontation of the three central research hypotheses formulated at the inception of this study, providing a clear roadmap for future policy design. Testing Hypothesis 1, which posits that successful revival policies constitute a paradigm of selective support rigorously conditioned on performance, yields strong support. The successful Asian nations invariably tied every ounce of tariff protection and subsidized credit to strict, verifiable export performance, forcing domestic firms to achieve global efficiency. Conversely, the failing nations, including Nigeria, Venezuela, Brazil, and Algeria, universally granted unconditional rents and permanent protections without any mandate for export competitiveness.

This suggests that the policy instruments themselves (such as state development banks or import tariffs) are fundamentally neutral; the presence of strict conditionality appears to be the deciding factor between structural success and rentier failure. Testing Hypothesis 2, which argues that the sustainability of economic diversification is fundamentally linked to the accumulation of technological capabilities and research efforts, also receives strong support, albeit with a crucial nuance. Robust, massive expenditures in R&D in South Korea, Germany, and Japan directly correlate with their sustained economic complexity and high-technology exports. However, Malaysia's case provides a critical warning. Brazil's case adds a further nuance: with R&D of about 1.1 percent of GDP (Figure 1), it spends marginally more than Malaysia (1.0 percent) yet is classified as a failure, which suggests that the level of R&D alone is insufficient and must be accompanied by conditionality and institutional stability (Hypotheses 1 and 3). While it achieved massive high-technology export volumes via the aggressive attraction of FDI for electronics assembly, its persistently low domestic R&D expenditure highlights a severe vulnerability in indigenous value addition. Algeria's negligible research expenditure of 0.5 percent of GDP aligns with its failure to diversify, suggesting that a lack of deliberate, state-funded technological accumulation prevents any meaningful industrial transition, regardless of the amount of physical capital imported. Testing Hypothesis 3, regarding the overriding importance of institutional stability and the mitigation of rent-seeking, suggests that policy continuity and competent, politically insulated bureaucracies are the hallmarks of successful industrial transitions. In stark contrast, regulatory volatility, rampant rent capture by entrenched elites, and a total lack of macroeconomic coordination are the defining characteristics of the failed petro-states. Institutions ultimately dictate whether resource wealth is utilized for long-term productive investments or squandered on short-term clientelism. The comprehensive findings of this study bear massive implications for the architectural redesign of industrial policy in Algeria. While the direct, unaltered transposition of foreign models is impossible due to vastly different geopolitical, historical, and cultural contexts, the fundamental economic principles underlying successful diversification are universal and entirely applicable. The foremost, non-negotiable lesson is the absolute necessity of integrating strict performance conditionality into all forms of state aid. Whether the Algerian state is providing highly subsidized energy, extended tax holidays, or targeted credit from public banks, it must require verifiable, measurable reciprocation from both private and public enterprises. This conditionality must be tied directly to global market tests, specifically export competitiveness targets, which force domestic firms to continuously upgrade their quality and efficiency to survive. When firms fail to meet these stringent targets, state support must be predictably, transparently, and ruthlessly withdrawn to prevent the calcification of rent-seeking elites that have historically paralyzed the Algerian economy. Secondly, Algeria must radically and immediately rethink its approach to FDI and the mechanics of technology transfer. The theoretical framework of endogenous growth and the supporting econometric data dictate that technology transfer is never an automatic phenomenon. It requires a dynamic, highly open environment and, critically, massive local absorptive capacity. By restricting foreign capital through arbitrary ownership rules and maintaining a critically weak applied research infrastructure, Algeria actively prevents the technological spillovers necessary for industrial catch-up. The state must foster a competitive, open environment while concurrently investing massively in human capital, particularly in advanced science, technology, engineering, and mathematics, pushing aggregate research expenditure well beyond the current 0.5 percent toward a target of 2 to 3 percent of GDP, comparable to the levels observed in Germany and Japan (Table 2). Finally, the institutional environment matters significantly more than the specific sectoral targets selected by central planners. The rapid turnover of industrial strategies in Algeria signals an institutional volatility that actively deters long-term, sunk-cost investments in advanced manufacturing.

Shielding economic planning agencies from short-term political cycles, establishing truly independent evaluation mechanisms, and maintaining absolute macroeconomic stability are strict, unavoidable prerequisites for overcoming the institutional channels of the resource curse. This study has several limitations. First, the sample is purposive and limited to seven countries, which prevents statistical generalization. Second, the indicators are descriptive and do not allow causal inference; the findings should be read as consistent patterns rather than identified effects. Third, the Doing Business index was discontinued in 2021 and has been criticized for data irregularities, so institutional quality is only roughly approximated. Future research could extend the sample and rely on panel econometric methods and alternative governance indicators.

8. CONCLUSION

This comparative evaluation strongly suggests that the mere existence of a stated industrial policy, regardless of the volume of financial resources mobilized by a wealthy rentier state, is insufficient to guarantee sustainable economic diversification. The stark, undeniable divergence between successful late-industrializers in Asia and stagnant, resource-dependent economies in Africa and South America lies almost entirely in the underlying governance, the rigorous discipline, and the strict conditionality of the policy itself. Algeria currently shares deep, troubling structural and institutional similarities with the world's most prominent failed industrializers. An extreme reliance on hydrocarbon exports, negligible and stagnant investment in R&D, a level of human capital insufficient to absorb foreign technology, and a highly volatile, unconditionally protectionist regulatory environment has trapped the economy in a state of persistent technological stagnation. To break this historical trajectory and escape the rentier trap, Algeria must orchestrate a complete, uncompromising paradigm shift. The state must transition away from a historical logic of unconditional protectionism and mandated local ownership, moving forcefully towards a rigorous framework of conditional support, deep global integration, and the aggressive, deliberate accumulation of technological absorptive capabilities. The resource rent, despite its historical association with economic distortion, is not an inescapable curse. It is a massive influx of capital that simply amplifies the pre-existing institutional characteristics of the state. Transforming this natural resource wealth into sustainable, globally competitive industrial capacity requires an uncompromising political commitment to institutional quality, massive, targeted educational investment in STEM fields, and the strict, unwavering enforcement of market discipline upon both public and private enterprises. Only by adopting these empirically validated principles, shifting from passive import substitution to aggressive, performance-based technological accumulation, can Algeria hope to achieve the profound structural transformation required for long-term economic diversification and resilience in the twenty-first century.

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KNOWN BUT NOT SHORTLISTED: FAVOURABLE BRAND ASSOCIATIONS, NEEDS FIT AND THE SHORTLISTING OF RETAIL BANKS IN ALBANIA

Edmond Cera
Tirana Business University, Tirana, Albania
edmond.cera@tbu.edu.al

Gentjan Cera
Faculty of Economics and Agribusiness, Agricultural University of Tirana; Albania
gcera@ubt.edu.al

Sandra Raquel Pinto Alves
OSEAN, CEOS.PP, ESTG, University of Leiria and Oeste, Portugal
raquel.alves@ulo.pt

ABSTRACT

Retail banks invest heavily in staying present in consumers' memories, yet a bank that is remembered is not necessarily a bank that is shortlisted. This paper examines whether the depth of brand recall still separates the banks that Albanian consumers would seriously consider once the favourable associations attached to each bank and its perceived fit with personal needs are held constant. The analysis uses a 2023 survey of 1,000 banked adults in Albania, each of whom evaluated several of seven competing banks, producing 5,983 respondent–bank evaluations. A bank is treated as shortlisted when the respondent names it as first choice or as a bank they would seriously consider. The method combines cross-tabulations with a survey-weighted binary logistic regression, with standard errors clustered by respondent and results reported as odds ratios and predicted probabilities. Before adjustment, the contrast is stark: 80.3% of top-of-mind banks were shortlisted, against 7.3% of banks recognised only when prompted. After adjustment, the predicted shortlisting probability is almost flat across recall levels (25.5% to 26.6%), and neither spontaneous nor top-of-mind recall is statistically significant. Favourable association breadth, perceived needs fit and existing customer relationships account for the difference. Recall therefore behaves as a condition of entry rather than a reason for selection, and recall-based tracking alone overstates a bank's competitive position.

Keywords: *brand recall, brand associations, consideration set, retail banking, logistic regression, Albania*

1. INTRODUCTION

Albanian retail banking is concentrated. In the survey analysed here, three banks (banks A, B and C) together account for 72.3% of the respondents who named a main bank. Core products are broadly comparable across providers, and consumers who think about switching or opening a second account rarely examine every option on the market. They screen. Electronic channels have spread quickly in the Albanian system, yet customers still voice doubts about the reliability of e-banking and know relatively little about what it offers (Çera & Khan, 2024; Çera et al., 2020; Lila and Tanushev, 2024), so judgements about a bank's dependability carry real weight. Which banks pass that screen, and why, is a practical question for every bank outside the leading group and a defensive one for the banks inside it. Marketing practice has a ready answer: be remembered. Awareness metrics, and top-of-mind recall above all, are standard items in bank brand-tracking studies, and they are frequently read as a proxy for competitive strength.

The position has respectable theoretical support. David Aaker (1991) treated awareness as one of the core assets of brand equity, and Sharp (2010) has argued forcefully that growth depends on mental availability, the likelihood that a brand comes to mind in buying situations, and Romaniuk (2023) has argued that brand-health trackers should be redesigned around this evidence. Keller (1993), however, drew a sharper line between knowing a brand and what that knowledge contains. In his account, awareness makes a brand retrievable, while brand image, the set of associations linked to it, governs how consumers respond once it is retrieved. This distinction raises a question that tracking data seldom answer. When a consumer already knows several banks, does it matter whether a bank was recalled first, recalled later, or merely recognised from a logo? Or is the apparent advantage of top-of-mind banks explained by the fact that these banks also carry more favourable associations, fit the consumer's needs better and are often the consumer's own bank? The answer changes how recall figures should be read. If recall depth retains its own association with shortlisting, investment in salience is justified on its own terms. If it does not, recall is better understood as a gate that a bank must pass, with the decisive work done by what the bank is believed to offer. The paper addresses this question with survey data from 1,000 banked consumers in Albania who each assessed several of seven competing banks. The approach is deliberately simple. Shortlisting is coded as a yes-or-no outcome, observed differences are first described in cross-tabulations, and a single survey-weighted logistic regression then compares banks at different recall levels that are otherwise alike in their favourable associations, needs fit and relationship with the respondent. Three research questions guide the analysis. RQ1 asks how shortlisting rates differ by recall depth, relationship status and bank. RQ2 asks whether recall depth remains associated with shortlisting once favourable associations, needs fit and existing relationships are held constant. RQ3 asks which of these evaluative and relational factors carries the association that recall shows in the raw data. Section 2 sets out the conceptual background. Section 3 describes the data, measures and estimation. Section 4 reports the results, Section 5 discusses them, and Section 6 concludes with the limitations of the study.

2. CONCEPTUAL BACKGROUND

2.1. Recall depth and the route to the shortlist

Consumers choose from a consideration set, a reduced group of alternatives they are prepared to evaluate seriously. Roberts and Lattin (1991) modelled entry into this set as a trade-off: a brand is included when the benefit expected from evaluating it exceeds the cost of doing so. Two implications follow. Brands that come to mind easily lower the cost side of the trade-off, and brands that are believed to offer more raise the benefit side. Recall and evaluation are therefore separate routes into the set, even if they often travel together. Recent funnel evidence shows how selective the passage is: across several categories, the number of brands narrows markedly from recognition to consideration and again from consideration to purchase (Mecredy et al., 2024). Nedungadi (1990) showed experimentally that this separation is real. Making a brand easier to retrieve raised its chance of being considered without changing how it was evaluated. Romaniuk and Sharp (2004) developed the idea of brand salience as the propensity of a brand to be noticed or thought of in buying situations, and they distinguished it from attitude. Awareness, in this view, is graded rather than binary.

A bank recognised only when its logo is shown sits at the shallow end; a bank recalled without help sits deeper; a bank mentioned first sits deepest. If depth of recall matters for its own sake, shortlisting should rise across these three levels even among banks that consumers evaluate equally favourably.

2.2. Favourable associations, needs fit and existing relationships

Recall does not tell a consumer why a bank deserves consideration. That information comes from the associations stored with the brand: that it is stable, reliable, accessible, good value or helpful. Keller (1993) argued that the favourability, strength and uniqueness of such associations drive differential consumer response. In financial services the argument has particular force, because the product is intangible, its quality is hard to judge before use, and the cost of a poor choice can be high. Erdem and Swait (2004) found that brand credibility raised the probability that a brand entered the consideration set, and the effect was stronger where consumers faced more uncertainty. Recent banking studies point in the same direction. Jannat et al. (2024) found that trust mediates the link between banks' social responsibility and their brand equity, and Tosun and Gürce (2024) showed that favourable social-responsibility and personnel images make bank customers more forgiving after a service failure. General favourability is not the same as personal relevance. A consumer may regard a bank as solid and modern and still doubt that it suits a salary account, a mortgage or a small business. Devlin and Gerrard (2004) showed that retail banking customers weigh several choice criteria and that their relative importance shifts over time. In a Polish survey, Schmidt-Jessa (2023) found that the cost of service and mobile and online banking ranked highest, and that the weight given to each criterion differed most by age, then by income and gender. Perceived needs fit captures this personal match directly. Finally, a respondent's own bank occupies a special position. Existing customers know the provider from experience, and the basis of their trust differs: among familiar non-customers, trust in financial providers rests mainly on reputation, whereas customers attach more weight to shared values, protection of their interests and personalised service (Pattit and Pattit, 2024), so relationship status must be held constant before the role of recall or image can be judged. Taken together, these arguments suggest a testable contrast. If recall depth contributes something of its own, it should remain associated with shortlisting after favourable associations, needs fit and relationship status are controlled. If its raw advantage reflects the evaluative content and experience that travel with salient banks, the association should shrink towards zero.

3. DATA AND METHOD

3.1. Data

The data come from the Albanian wave of a 2023 regional survey on brand equity and customer experience in retail banking. Eligible respondents were aged 18 to 59, held a current account in their own name and had used it for at least one transaction in the preceding three months. Quotas were set by gender, age group, urban or rural settlement and region, and 1,000 interviews were completed across all twelve Albanian regions. The achieved sample was 76.7% urban, and 49.2% of respondents lived in Tirana. Calibration weights were built by iterative proportional fitting so that the weighted sample reproduces the design margins for gender, five age groups, settlement type and region; after weighting, 46.1% of respondents are male. Each respondent evaluated several banks. The data were therefore reshaped so that one record represents one respondent's evaluation of one bank. Seven banks with sufficient coverage were retained. After excluding evaluations without a valid consideration answer, 5,983 respondent–bank evaluations remained, an average of almost six per respondent.

3.2. Measures

Shortlisting. Respondents rated how likely they were to consider each bank the next time they chose a bank, on a five-point scale from "definitely would not consider" to "first choice". A bank is coded as shortlisted (1) when it was rated "first choice" or "would seriously consider", and as not shortlisted (0) otherwise. The binary form matches the managerial notion of a shortlist and keeps the model easy to interpret. In total, 24.4% of evaluations were shortlisted.

Recall depth. The awareness sequence asked first for the bank that came to mind first, then for other banks recalled without help, and finally for banks recognised from their logos. Because banks mentioned at one stage were not asked about again, each evaluation falls into exactly one of three levels: prompted awareness only (43.0% of evaluations), spontaneous recall (41.1%) and top-of-mind recall (15.9%). Prompted awareness is the reference category.

Favourable association breadth. Respondents indicated which of a list of attributes they associated with each bank. Eighteen favourable functional and relational attributes were counted, including financial stability, reliability, accessibility, range of services, value for money, innovation, staff competence, fast lending and favourable fees. The count was divided by 18, giving a share between 0 and 1 (mean 0.225, or about four attributes). The measure records breadth, not intensity, and is treated as an index rather than a latent scale.

Needs fit. Respondents rated how well each bank delivers the main things they need from a bank, on a scale from 1 to 10 (mean 4.39). A brand-closeness item was also available, but it correlates at $r = 0.87$ with needs fit and was not entered. Favourable association breadth and needs fit correlate at $r = 0.65$, which is substantial but leaves room to estimate both.

Relationship and controls. Relationship status distinguishes non-customers (81.5% of evaluations), customers for whom the bank is not their main bank (2.7%) and main-bank customers (15.8%). All models also include indicators for the seven banks (bank A as reference), gender, age in years, rural residence and the twelve regions.

3.3. Analytical approach

The analysis has two steps. The first describes shortlisting rates across recall levels, relationship categories and banks, which answers RQ1 and shows the size of the raw gaps. The second estimates a binary logistic regression of the form

$$\text{logit Pr}(S_{ib} = 1) = \alpha + \beta_1 \text{Spont}_{ib} + \beta_2 \text{TOM}_{ib} + \beta_3 \text{Assoc}_{ib} + \beta_4 \text{Fit}_{ib} + \gamma' R_{ib} + \delta' X_{ib}$$

where S_{ib} indicates that respondent i shortlisted bank b; Spont and TOM are the two recall indicators; Assoc is favourable association breadth; Fit is perceived needs fit; R holds the relationship indicators; and X holds the bank, demographic and regional controls. RQ2 is answered by β_1 and β_2, and RQ3 by β_3, β_4 and γ.

Three choices keep the estimation simple but sound. First, the model is estimated as a survey design with the respondent as the primary sampling unit, so standard errors are linearised and clustered on the 1,000 respondents, which allows for the fact that evaluations from the same person are not independent. Second, each respondent's calibration weight is divided by the number of banks they evaluated, so that people who rated more banks do not carry more total weight. Third, coefficients are reported as odds ratios and translated into average predicted probabilities, because odds ratios alone are easily misread and are not directly comparable with the raw percentages; Carina Mood (2010) sets out why probability-scale summaries are the safer basis for interpretation, and current guidance on reporting predictions and marginal effects for non-linear models follows the same logic (Arel-Bundock et al., 2024). An auxiliary linear model was used to check collinearity. The variance inflation factors of the focal variables were 1.52 (spontaneous recall), 4.25 (top-of-mind recall), 4.05 (association breadth) and 2.55 (needs fit), all below the conventional threshold of 5.

4. RESULTS

4.1. Shortlisting rates before adjustment

Table 1 answers RQ1. The gradient by recall depth is steep. Only 7.3% of banks recognised from a logo were shortlisted, compared with 20.7% of banks recalled spontaneously and 80.3% of banks mentioned first. A top-of-mind bank was therefore about eleven times more likely to be shortlisted than a bank known only when prompted. Relationship status shows an equally sharp gradient: 10.9% of evaluations by non-customers ended in a shortlist, against 68.5% for secondary customers and 86.7% for main-bank customers.

Table 1: Shortlisting rates by recall depth, relationship status and bank

Group	Evaluations (n)	Share of evaluations (%)	Shortlisted (%)
Recall depth			
Prompted awareness only	2,575	43.0	7.3
Spontaneous recall	2,456	41.1	20.7
Top-of-mind recall	952	15.9	80.3
Relationship status			
Not a customer	4,877	81.5	10.9
Customer, not main bank	162	2.7	68.5
Main bank	944	15.8	86.7
Bank evaluated			
Bank A	992	16.6	39.7
Bank B	982	16.4	38.2
Bank C	926	15.5	30.1
Bank D	787	13.2	20.8
Bank E	852	14.2	13.9
Bank F	849	14.2	11.3
Bank G	595	9.9	5.9
All evaluations	**5,983**	**100.0**	**24.4**

(Source: Authors' calculations from the 2023 Albanian retail banking survey; unweighted respondent–bank evaluations)

The two gradients are hard to separate in raw data. The first bank a person names is often the bank they already use, and the two groups are almost the same size (952 top-of-mind evaluations and 944 main-bank evaluations). Banks also differ widely. Bank A and bank B were shortlisted in close to four of every ten evaluations, while bank G was shortlisted in fewer than one in sixteen. The raw percentages therefore mix memory, experience and brand differences, and they cannot by themselves show what recall depth contributes.

4.2. Shortlisting after adjustment

Table 2 reports the logistic regression. The answer to RQ2 is negative. Once favourable associations, needs fit, relationship status and the controls are held constant, spontaneous recall (OR = 0.90, p = 0.388) and top-of-mind recall (OR = 0.85, p = 0.577) are not associated with higher odds of shortlisting. Both point estimates are slightly below one, and their confidence intervals comfortably include it.

Figure 1 places the two sets of numbers side by side. The observed shortlisting rate climbs from 7.3% to 80.3% across recall levels. The predicted probabilities from the model, which hold every other variable at its observed value, are 26.6% for prompted banks, 25.8% for spontaneously recalled banks and 25.5% for top-of-mind banks. The steep raw gradient becomes a flat line.

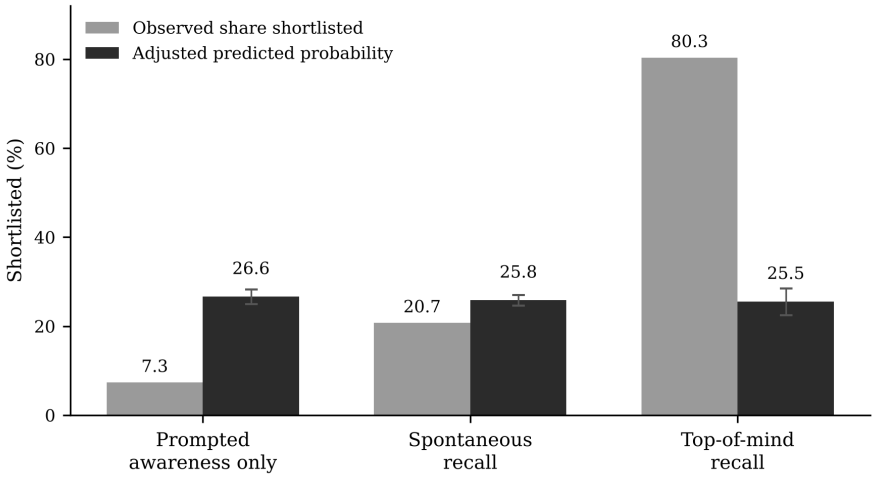

Figure 1: Observed and adjusted shortlisting by recall depth
(Source: Authors' calculations. Adjusted values are average predicted probabilities from the model in Table 2, with 95% confidence intervals)

Table 2: Survey-weighted logistic regression of bank shortlisting (odds ratios)

Predictor	Odds ratio	95% CI	p
Recall depth (ref.: prompted awareness only)			
Spontaneous recall	0.90	0.70 – 1.15	0.388
Top-of-mind recall	0.85	0.49 – 1.48	0.577
Evaluation			
Favourable association breadth (0–1)	24.32	14.63 – 40.42	<0.001
Needs fit (1–10, per point)	1.40	1.32 – 1.49	<0.001
Relationship (ref.: not a customer)			
Customer, not main bank	2.51	1.43 – 4.40	0.001
Main bank	3.74	2.24 – 6.24	<0.001
Bank (ref.: bank A)			
Bank B	1.00	0.76 – 1.31	0.988
Bank C	0.87	0.65 – 1.17	0.373
Bank D	1.13	0.80 – 1.59	0.493
Bank E	0.54	0.38 – 0.78	0.001
Bank F	0.65	0.46 – 0.91	0.012
Bank G	0.41	0.25 – 0.67	<0.001
Respondent controls			
Female	1.07	0.81 – 1.41	0.643
Age (years)	0.99	0.98 – 1.00	0.178
Rural residence	1.24	0.90 – 1.72	0.191
Region indicators (11)	Included		
Evaluations / respondents	5,982 / 1,000		
Model test	F(26, 974) = 47.22		<0.001

(Source: Authors' estimates. Linearised standard errors clustered by respondent; calibration weights divided by the number of banks each respondent evaluated)

RQ3 concerns what carries the raw association. The odds ratio for favourable association breadth refers to a move across the full range of the index, from no favourable attributes to all eighteen, so it is better read in smaller steps. Each additional favourable attribute raises the odds of shortlisting by about 19%, and an increase of 0.10 in the index, close to two attributes, raises them by about 38%.

Needs fit has a comparable weight: each point on the ten-point scale raises the odds by 40%, so a bank rated 7 rather than 4 has roughly 2.7 times the odds of being shortlisted. Relationship status remains important after these variables are included. Secondary customers have 2.5 times and main-bank customers 3.7 times the odds of non-customers, which reflects first-hand experience that associations and fit do not fully capture. The bank indicators add a further result. Bank B, C and D are statistically indistinguishable from bank A once evaluations are controlled, so their raw gaps are explained by how they are perceived. Bank E, F and G, by contrast, retain a disadvantage, with odds 35% to 59% lower than bank A at equal recall, associations, fit and relationship status. Part of their weaker position therefore lies outside the measured attributes. Among the demographic controls, gender, age and settlement type are not significant, while some regions differ markedly from the reference region, notably Korçë (OR = 4.31) and Lezhë (OR = 0.17). Two supplementary results support this reading. First, in the 4,876 evaluations made by non-customers, where existing relationships cannot play any part, the predicted probability of naming a bank as first choice was 0.97% whether the bank had been recalled unprompted or only recognised. Second, a specification on the full five-point scale added four positioning associations that are not part of the favourable index: local roots, international presence, tradition, and visibility through television advertising or sponsorship. The three heritage associations were not significant. Advertising and sponsorship visibility had a negative coefficient ($b = -0.26$, $p < 0.001$) once favourable association breadth was controlled, and recall depth remained non-significant. Being seen in the media, in other words, adds nothing to shortlisting unless it comes with substantive reasons to choose the bank.

5. DISCUSSION

The central finding is the contrast in Figure 1. In raw data, recall depth looks like the strongest single predictor of whether a bank makes a consumer's shortlist. Once the content of the consumer's knowledge is taken into account, the advantage disappears. Banks that come to mind first are shortlisted far more often because they are also the banks to which consumers attach more favourable attributes, the banks they judge to fit their needs, and frequently the banks they already use. Among banks that are equal on those counts, being recalled first or recalled at all brings no further gain. This result fits the two-route view of consideration more closely than a simple awareness-to-choice account. Nedungadi (1990) and Roberts and Lattin (1991) both treat accessibility and evaluation as distinct contributors to consideration. The Albanian data suggest that, among banks consumers already know, evaluation does almost all of the work. Recall still matters, but in a different place in the process: it determines which banks enter the field of comparison at all. The sample contains only banks of which respondents were aware, so the findings say nothing against the role of awareness in getting a bank noticed. They say that, within the known field, depth of recall is a weak guide to which banks will be selected. The finding also clarifies the debate between mental availability and differentiation. Sharp (2010) argues that brands grow mainly by being easy to think of and easy to buy. The present evidence does not contradict this at the level of entry into the market, but it does qualify it at the point of comparison. In a category where products are intangible and the stakes of a wrong choice are high, consumers appear to need reasons. The weight of favourable associations and needs fit is consistent with the claim of Erdem and Swait (2004) that brand information reduces perceived risk and thereby raises the probability of consideration. The negative result for advertising and sponsorship visibility points the same way: exposure without substance does not help a bank onto the shortlist. Three implications follow for bank marketers. First, recall scores should not be reported as a stand-alone measure of brand strength. A top-of-mind score that rises while favourable associations and needs fit stay flat signals greater visibility, not a stronger competitive position.

Tracking studies should report recall, association breadth, needs fit and shortlisting together, and should read them as stages rather than substitutes. Second, communication should be judged by the associations it builds. Each additional favourable attribute is linked to roughly a fifth higher odds of shortlisting, which gives a concrete metric for campaigns: how many consumers now connect the bank with reliability, value, accessibility or helpful staff. Third, the residual disadvantage of three banks is a warning that some barriers lie outside the measured image. For these banks, gains in recall and even in image may convert less readily into shortlisting until the unmeasured factors, possibly perceived size, branch reach or past service experiences, are understood. For customer acquisition, the non-customer result is the most direct. Among people who do not bank with a provider, being recalled unprompted did not raise the chance of becoming a first choice at all. Campaigns aimed at winning new customers therefore need to supply reasons, not only reminders. The point carries weight because most of a brand's growth potential lies with people who buy it rarely or not at all (Trinh et al., 2024), and because familiar non-customers of financial providers build trust mainly through reputation (Pattit and Pattit, 2024).

6. CONCLUSION

This paper asked whether the depth of brand recall distinguishes the retail banks that Albanian consumers would seriously consider. In raw data it does so dramatically: top-of-mind banks were shortlisted eleven times as often as banks recognised only from a logo. After favourable associations, perceived needs fit and existing relationships are held constant, the difference vanishes, and the predicted shortlisting probability is almost the same at every level of recall. Favourable association breadth and needs fit carry the association, alongside the experience that comes with being a customer. Being remembered is the condition for entering the comparison; being believed to offer something relevant is what decides it. Several limitations apply. The data are cross-sectional, so the analysis shows associations, not causes. Consideration may itself strengthen recall and favourable associations, as consumers learn more about banks they already lean towards. The sample covers banked adults aged 18 to 59 in a single, concentrated market, and the results may differ elsewhere. The association index counts favourable attributes with equal weight and cannot show which associations matter most. The analysis is conditional on awareness and cannot trace the move from complete unfamiliarity to consideration. Finally, the single-level model with clustered standard errors was chosen for transparency. It corrects inference for repeated evaluations but does not separate stable differences between respondents from differences between banks. Panel data following the same consumers over time, and weighted or attribute-specific association measures, would allow a stronger test of the sequence proposed here.

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