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A jump start to open innovation: A multidimensional competence profile in an international setting

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A B S T R A C T
Objective: This study investigates open innovation (OI) competence development through a dynamic capabilities lens, offering a systematic understanding of how OI competencies are distributed across higher education contexts in mature and post-transition economies.
Research Design & Methods: We conceptualised and measured OI competencies among 397 engineering students from three European countries – Denmark, Latvia, and Poland – representing both mature and post-transition economies. Using multigroup latent profile analysis (LPA), we identified empirically determined patterns of competence distribution. This methodological approach enables robust cross-cultural comparison while accounting for national contextual variations.
Findings: Results revealed three distinct OI competence profiles with significant cross-national variations. Latvian students demonstrated higher entrepreneurship and risk-taking competencies, Danish students excelled in digital skills, while Polish students showed moderate levels across dimensions. Gender analyses uncovered unexpected patterns: women students were significantly more represented in high OI profiles in Poland and Latvia, while men dominated high profiles in Denmark.
Implications & Recommendations: For higher education institutions, our findings emphasise the need for contextually sensitive OI learning environments. For practitioners, our OI Competence Profile provides a framework for recruitment and team development across different national contexts.
Contribution & Value Added: This study advances OI theory by validating a comprehensive competence profile that functions as a first-order dynamic capability. Our multi-country, gender-inclusive approach reveals how educational, cultural, and economic factors shape innovation competency development across different national contexts.
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INTRODUCTION

The paradigm of open innovation (OI) has fundamentally transformed how organisations develop and commercialise innovative products, services, and processes. Chesbrough's (2003) foundational framework highlights how organisations could benefit from both 'outside-in' knowledge flows, where external knowledge is brought into the organisation, and 'inside-out' flows, where internal ideas are commercialised through external channels. Numerous studies have investigated the advantages, limitations, and challenges associated with both inbound and outbound open innovation practices (Carmona-Lavado *et al.*, 2021). To fully capitalise on external knowledge flows, organisations must cultivate distinct open innovation competencies at the employee level (Mahdad *et al.*, 2020; Podmetina *et al.*, 2018).

We developed an OI Competence Profile that integrates six essential competencies and examined the critical learning contexts that support their development in individuals (El Maalouf *et al.*, 2022). Previous OI literature has conceptualised innovation skills in a broad and often ambiguous manner (Bogers *et al.*, 2018), with varying definitions of competencies related to successful open innovation implementation (Teece, 2020). This conceptual uncertainty has resulted in defining OI competence through separate, isolated competencies such as creativity, communication skills, and problem-solving (Podmetina *et al.*, 2018). From a practical perspective, organisations face significant challenges in identifying the optimal configuration of competencies required for recruiting employees best suited for OI implementation.

Relatively few studies have explored the learning contexts – particularly higher education – that foster OI competencies, which subsequently support diverse portfolios of OI activities in industrial settings. Limited research exists regarding the significance of higher education institutions (HEIs) in OI development and how university education could systematically cultivate these competencies (Carayannis & Morawska-Jancelewicz, 2022; Ovbiagbonhia *et al.*, 2023). Furthermore, while OI is gaining importance in post-transition economies, empirical investigations in these contexts remain scarce. Existing studies suggest that OI practices might be less developed in post-transition economies compared to mature economies, with companies in transitional contexts relying more heavily on internal R&D and less on external partnerships for innovation (McPhillips, 2020; Stojčić, 2021).

Post-transition economies face unique innovation challenges, including insufficient infrastructure, limited access to qualified personnel, and underdeveloped regulatory frameworks to support collaborative innovation (Stojčić, 2021). Despite these constraints, OI presents significant opportunities for economic development in these regions. Developing robust OI competencies could enable companies in post-transition economies to access new technologies, markets, and resources that enhance their global competitiveness (Akhmadi & Tsakalerou, 2022).

Based on these research gaps, our study contributes to the literature by exploring OI competencies exhibited by students in higher education institutions that can later be leveraged in organisational contexts. Grounded in dynamic capabilities theory (Teece, 2020; Bogers *et al.*, 2019), we analyse the role of HEIs in facilitating OI capability development. Dynamic capabilities refer to an organisation's capacity to assimilate, develop, and revise both indigenous and exogenous competencies in response to rapidly changing environments (Teece, 2020). Our research objective is to explore students' OI competencies as potential dynamic capabilities that will ultimately support organisations in achieving competitive advantages through open innovation strategies.

We gathered data from three European countries – Denmark, Poland, and Latvia – to enhance understanding of OI in both mature and post-transition economies. This cross-cultural comparative approach builds on work by Zhang *et al.* (2023), which suggests that while specific OI outcomes may vary across countries, fundamental competencies that drive innovation remain consistent across diverse contexts. The unique cultural and institutional characteristics of each country provide valuable insights into the development of OI competencies within different educational frameworks.

Most studies defining various OI competencies have not empirically measured competence levels in individuals. We addressed this gap by examining both the prevalence of different OI competencies and measuring their levels among university students before they enter organisational contexts. This timing is methodologically significant, as subsequent organisational factors – such as firm-specific OI training and innovation climate – may influence individual OI competence levels (Burcharth & Fosfuri, 2015). Therefore, we focused on students in their final years before graduation to establish baseline competence levels before organisational socialisation.

This article illuminates critical factors, namely university education efforts, national context, and gender, that significantly influence the development of OI competence profiles. Previous research on OI competence has typically conceptualised it in general terms (Bogers *et al.*, 2018) or through qualitative case studies (Chatenier *et al.*, 2010), often examining single countries without consideration of gender dimensions. Our multi-country, gender-inclusive approach addresses these limitations and contributes to a more comprehensive understanding of OI competence development (Krieger *et al.*, 2022; Zuraik *et al.*, 2020).

To develop our competence profile, we integrated the European Skills, Competences, Qualifications, and Occupations (ESCO) framework with a comprehensive analysis of OI competence literature.

We specifically focused on competencies demanded by companies implementing OI activities (McPhillips *et al.*, 2022). Drawing from primary interviews with OI team managers and preceding empirical studies, we identified, selected, and aggregated key competencies into an OI Competence Profile representing antecedents to successful OI performance (El Maalouf *et al.*, 2022).

Based on OI competence profiles of university students across three European countries, our findings support the significant role of HEIs in developing OI competence. The focus on higher education represents a substantial contribution to OI literature and highlights the necessity of creating effective OI learning contexts during tertiary education (Leskinen *et al.*, 2023). By developing and acquiring OI competencies, future employees can more productively assimilate and redistribute knowledge relevant to innovation processes.

This article is structured as follows. We begin with this introduction and continue with a comprehensive literature review on the development of the OI Competence Profile and the role of HEIs in cultivating OI competence. We then present our methodological framework and operationalisation, followed by empirical findings. The final section offers conclusions, theoretical and practical contributions, limitations, and future research directions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Open innovation (OI) represents a paradigm shift in how organisations develop and commercialise new products, services, and processes. Rather than relying exclusively on internal R&D capabilities, OI involves engaging with external partners and leveraging diverse knowledge sources, including research institutions, customers, suppliers, and broader innovation ecosystems (Bogers *et al.*, 2019; Chesbrough, 2003). The fundamental objective of OI is to accelerate innovation processes, enhance creativity, and increase effectiveness by harnessing the collective intelligence of a diverse array of stakeholders (Bertello *et al.*, 2022). In the high-tech sector, firms embracing OI approaches demonstrate superior innovation outcomes, including higher patent output, compared to those relying solely on internal R&D capabilities (Holgersson & Granstrand, 2022).

OI activities encompass processes of actively seeking, assimilating, and integrating external knowledge, ideas, and resources into an organisation's innovation framework. These activities include scientific collaborations, crowdsourcing, co-creation initiatives, OI competitions, open sourcing, and corporate venturing (Rauter *et al.*, 2019). While numerous studies have identified isolated determinants of effective OI implementation, such as absorptive capacity, strategic orientation, and partner composition (Greco *et al.*, 2017), research highlights that complementary resources like human capital, partnership-building abilities, and multi-partner learning capabilities are critical for successful OI outcomes (Carmona-Lavado, 2021).

Organisations increasingly depend on arrays of complementary competencies to support OI teams and effectively manage employee-centred challenges in OI implementation (Bogers *et al.*, 2018). Individual competencies encompass skills, knowledge, and personal attributes necessary for successful engagement in OI activities (McPhillips *et al.*, 2022).

By aggregating clusters of key competencies essential for individuals involved in OI processes, we have identified the most frequently referenced competencies in the literature: creativity, communication, networking, entrepreneurship, open-minded thinking, risk-taking attitude, and self-efficacy in digital skills. Creativity, *i.e.*, the ability to generate novel ideas, is crucial for OI as it enables individuals to contribute innovative solutions (Engelsberger *et al.*, 2022; Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018). Effective communication competencies are essential for OI success, as individuals must convey ideas and information to both external partners and internal stakeholders. Networking capabilities, *i.e.*, the ability to build and sustain relationships with external partners, allow individuals to access new ideas and resources beyond organisational boundaries (Behnam *et al.*, 2018; Podmetina *et al.*, 2018; Du Chatenier *et al.*, 2010). Entrepreneurship encompasses the competencies required for managing innovation processes and implementing ideas. Studies demonstrate that individuals with entrepreneurial mindsets more readily identify and pursue OI opportunities and successfully implement OI initiatives (Bogers *et al.*, 2018; Du Chatenier *et al.*, 2010). Beyond these 'classic' OI competencies, recent em-

pirical studies underscore the importance of open-minded thinking (Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018). Since OI often involves collaborating with partners from diverse cultural backgrounds, cultural awareness and adaptability to different norms constitute important competencies for individuals in OI contexts (Podmetina *et al.*, 2018). Another key capability emphasised in the literature is a risk-taking attitude and adaptability to uncertain situations. Individuals engaged in OI must demonstrate resilience and flexibility in responding to changing conditions and potential failure (Engelsberger *et al.*, 2022). Emotional responses to tensions significantly influence OI practice effectiveness (Stefan *et al.*, 2022). Finally, self-efficacy in digital skills represents an emerging essential competence for individuals involved in OI, as proficiency with digital technologies becomes increasingly critical for innovation in contemporary business environments (Marion & Fixson, 2020; Enkel *et al.*, 2020). Digital technologies substantially impact the composition and performance of OI teams (Bogers *et al.*, 2018), and self-efficacy in digital skills correlates positively with individual innovation performance and innovative behaviour (Urbinati *et al.*, 2020). Table 1 explains how each competency cluster corresponds to specific OI activities, based on the ESCO framework.

Table 1. OI competence clusters and related OI activities

Competence type	Relevance for OI activity (based on the ESCO framework)
Creativity (Engelsberger *et al.*, 2022; Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018)	Creating new ideas, integrating existing ones, and carrying out activities in innovative and creative ways.
Communication and Networking (Podmetina *et al.*, 2018; Behnam *et al.*, 2018; Du Chatenier *et al.*, 2010)	Communicating, knowledge sharing, cooperating, mutual learning, integrating information from different sources, and using external knowledge for problem-solving.
Entrepreneurship (Du Chatenier *et al.*, 2010; Bogers *et al.*, 2018; Hafkesbrink & Schroll, 2014)	Organising tasks, leading other people, taking responsibility, anticipating future problems, actively managing them, spotting opportunities, and implementing plans.
Open-minded thinking (Hafkesbrink & Schroll, 2014; Matricano, 2018; Podmetina *et al.*, 2018)	Being flexible in thinking; the ability to work in cross-functional, cross-disciplinary, and cross-cultural teams.
Risk-taking attitude (Engelsberger *et al.*, 2022; Stefan *et al.*, 2022)	The ability to cope with uncertainty and ambiguity; the ability to accept risk and failure.
Self-efficacy in digital skills (Marion & Fixson,2020; Enkel *et al.*, 2020; Bogers *et al.*, 2018; Urbinati *et al.*, 2020; Tomczak *et al.*, 2023)	Using digital tools needed by the organisation; communicating and sharing resources online; data proficiency and data security abilities; interacting with different interfaces; understanding industrial application of digital technologies.

Source: own elaboration based on literature review, pilot study, and ESCO framework.

OI literature suggests that for organisations to effectively absorb knowledge through OI partnerships, they must develop specific competencies (Bogers *et al.*, 2018). Human capital theory (Becker, 1964; Deming, 2022) distinguishes between organisation-specific and general human capital. While organisation-specific human capital relates to particular positions or organisational contexts, general human capital encompasses transversal competencies applicable across different settings. Higher education represents a primary source of general human capital in innovative organisations and constitutes a significant learning environment supporting the development of OI competencies.

A substantial distribution of OI competencies through higher education exposure enhances individuals' awareness of and readiness for OI practice. Moreover, tertiary education may help overcome not-invented-here and not-shared-here syndromes (Marzi *et al.*, 2023). Education focused on OI competencies could reduce individuals' tension and uncertainty regarding inter-organisational partnerships (El Maalouf *et al.*, 2022), and well-designed curricula may better prepare students for work in external collaborative contexts. Moreover, education in OI cooperation competencies could minimise students' prejudgments and enhance their abilities to function effectively in OI teams. A climate of openness could subsequently foster improved OI competencies, encouraging trial-and-error ap-

proaches to OI practice in future organisational settings. Consequently, education promoting OI competencies may influence the level of implementation success while reducing associated challenges.

Conversely, empirical studies reveal that OI practitioners report misalignment between needed and actual OI competencies among individuals recruited for effective collaboration in OI teams (McPhillips *et al.*, 2022). Although prior studies (Table 1) address the significance of specific OI competencies, they have not examined the competency levels necessary to determine the role of HEIs in preparing future employees with essential OI capabilities. To bridge this gap, we developed and tested an OI Competence Profile to capture the general level and distribution of OI competencies among students at universities in Denmark, Poland, and Latvia. We focused on engineering students in their final year before graduation to measure baseline competency levels before the inevitable influence of organisational culture and training (Burcharth & Fosfuri, 2015), providing a comparative foundation for analysing the role of HEIs in developing OI competencies.

European HEIs have actively promoted open innovation within entrepreneurship education and encouraged exchange programs among students, which helps foster similar OI competencies across different countries. The established European Entrepreneurship Competence Framework offers a standardised approach to competency development across educational systems, potentially reducing variation in OI competencies across national borders. Zhang *et al.* (2023) suggest that while specific OI outcomes may vary across countries, fundamental competencies that drive innovation remain consistent across diverse contexts. The unique cultural and institutional characteristics of each country provide valuable insights into the development of OI competencies within different educational frameworks. However, the underlying competencies themselves should show consistency in their patterns. Moreover, business culture in developed countries is characterised by collaboration and networking, key OI competencies, which may contribute to consistent levels of OI competencies throughout Europe. HEIs face similar challenges and opportunities globally, including increased competition, evolving consumer demands, and rapid digital technology adoption. These shared contextual factors, combined with the globalising nature of knowledge exchange and educational frameworks, suggest commonalities in how OI competencies develop across different national contexts. Therefore, we hypothesised that:

H1: The levels of competencies in OI profiles is similar among engineering students across the three countries, *i.e.*, Denmark, Poland, and Latvia.

Regarding gender distribution, the relationship between OI competencies and entrepreneurship competencies is complementary. Literature suggests significant differences in entrepreneurship skills and tendencies between male and female students in Europe (Petrović & Radukić, 2018). Studies have found that male students generally demonstrate higher levels of self-efficacy, risk-taking propensity, and proactive behaviours related to entrepreneurship (Krieger *et al.*, 2022, while female students often exhibit greater networking abilities and social capital development. Gender differences in innovation competencies appear to manifest in various ways, influenced by socialisation processes, gender stereotypes, access to resources and mentorship, and disparities in confidence and self-efficacy (Zuraik *et al.*, 2020).

Traditional gender roles and socialisation patterns often encourage behaviours in male students, such as assertiveness, competitiveness, and risk-taking, that align closely with competencies valued in innovation contexts (Ehrtmann *et al.*, 2019). These socialised behaviours may lead to greater confidence in dynamic, collaborative environments typically associated with OI. Moreover, male students often benefit from greater access to mentorship opportunities and industry networks, particularly in fields where innovation activities are prominent (Leka *et al.*, 2024; Shah & Krishnan, 2023). Research also indicates that male students generally express higher confidence in their innovation capabilities, even when actual competency levels are comparable (Shinnar *et al.*, 2014).

However, these differences stem from societal factors, including gender stereotypes and discriminatory practices, rather than inherent differences in abilities or potential. Based on this literature, we hypothesised:

H2: Male students have a higher probability of being classified into higher OI profiles than female students across the countries.

By examining these hypotheses, we aimed to contribute to a deeper understanding of how OI competencies develop in educational contexts and how they may be influenced by factors such as national setting and gender. This knowledge can inform both educational practices and organisational strategies for fostering effective OI implementation.

RESEARCH METHODOLOGY

Before full-scale deployment of questionnaires across universities in the three countries, we conducted a preliminary pilot study comprising 12 in-depth semi-structured interviews with OI practitioners from innovative companies. This methodological approach aligns with recommendations by Podmetina et al. (2018) for developing robust competency models in OI contexts. The fundamental objective of the pilot study was to confirm the significance of each OI competence examined in our research and to establish the content validity of our measurement framework (Spurk et al., 2020). Moreover, this introductory phase ensured that participants unambiguously understood all determinants employed in the study. Each interview began with a brief introduction explaining the study's purpose, followed by asking OI practitioners to identify and classify competencies that support OI activities in their projects. Based on these interviews, we selected six competencies for inclusion in the survey. 'Self-efficacy in digital technologies' was the only competence not initially included in our literature review, but emerged as significant during the pilot interviews.

Following the pilot study, we distributed an online questionnaire to students at three universities, namely the University of Southern Denmark (Denmark), Riga Technical University (Latvia), and Gdansk University of Technology (Poland). The respondents were master-level students in production engineering (management studies with an industry context), a program typical for technological universities and particularly relevant for future employees in OI teams.

We strategically selected Denmark, Latvia, and Poland as study settings to capture nuances in OI competency development across diverse economic and educational landscapes. This cross-cultural comparative approach followed methodological guidance by Buil et al. (2012) for ensuring meaningful comparisons between distinct national contexts. Denmark represents a mature economy with an established reputation for innovation and a robust educational system that actively integrates OI principles. Latvia and Poland, as post-transition economies where OI practices are still evolving, offer a unique opportunity to explore how emerging educational practices influence OI competencies.

We designed the survey to examine different OI competence profiles, specifically, the quantity and attributes of distinctive clusters of OI competencies across university students in the three countries, and to understand determinants connected to these clusters, particularly how gender may influence the probability of students being classified into each of the developed profiles. This focus on profiles rather than individual competencies represents a methodological advancement in understanding OI competence development, as it recognises the multidimensional and interconnected nature of these skills (Spurk et al., 2020). Morin et al. (2015) demonstrate that the profiles derived from such analyses can offer tailored insights into group-specific characteristics, linking them to distinct response patterns observed in different populations.

We gathered data through individual online questionnaires distributed to engineering students at the three respective universities in 2022. Our sample consisted of engineering students in their final semester of master's level education, shortly before graduation. This timing is methodologically significant, as it allowed us to measure OI competency levels after full exposure to the university's educational influence but before the inevitable impact of organisational culture and training that would occur in workplace settings (Burcharth & Fosfuri, 2015). By focusing on students at the conclusion of their academic programs, we captured the cumulative effect of higher education on OI competence development, providing a more accurate assessment of HEIs' contribution to preparing future employees with essential OI capabilities. Our final sample consisted of 397 students who completed the survey, with the following distribution: Gdansk University of Technology, Poland (n=200), Riga Technical University, Latvia (n=100), and University of Southern Denmark, Denmark (n=97). The sample comprised 54.7% male students, 44.8% female students, and 0.5% who did not indicate gender. This sample size

and distribution align with recommendations for conducting Latent Profile Analysis with sufficient statistical power (Spurk *et al.*, 2020).

The survey examined students' positioning regarding OI in reference to their self-perceived abilities and dispositions associated with OI competencies. This self-assessment approach has been validated in previous studies of innovation competencies (Ovbiagbonhia *et al.*, 2023) and provides valuable insights into individuals' confidence and readiness to engage in innovative activities. We established the OI Competence Profile based on six aggregated competence constructs, supported by previous OI literature, the pilot study findings, and the ESCO framework (Table 1). We assessed the general OI Competence level through six constructs: Creativity, Communication and Networking, Entrepreneurship, Open-minded thinking, Risk-taking attitude, and Self-efficacy in Digital skills. While these skills and attitudes would individually benefit anyone participating in innovation projects, their combined profile consolidates key aspects of competence supporting effective OI performance. Each construct comprised 4-7 items, totalling 36 items. We adapted established, psychometrically validated scales to measure each construct, enhancing the reliability of our measur2ement approach. Before administering the survey, we conducted comprehensive assessments of the internal consistency reliability for all construct items by examining their Cronbach's alpha coefficients. We performed exploratory factor analysis to evaluate construct reliability and validity (see Table 2). One item was reverse-coded, which contributed to a lower Cronbach's alpha for that construct. We assessed common method bias through Harman's single-factor test, which indicated no significant bias in our data collection approach.

Table 2. Measurements of constructs

OI Competence Profile constructs	Factor loadings α
Creativity (Adopted from Liñán & Fernández-Serrano, 2018)	0.673
Entrepreneurship (Adopted from Liñán & Fernández-Serrano, 2018)	0.715
Communication and knowledge sharing (Adopted from Bereznoy *et al.*, 2021)	0.818
Open-minded thinking (Adopted from Lavrynenko *et al.*, 2018)	0.780
Risk-taking (Adopted from Zhang *et al.*, 2018)	0.937
Self-efficacy in digital skills (Adopted from Tierney & Farmer, 2002)	0.849

Source: own study.

To develop the OI competence Profiles and test our research hypotheses, we employed Latent Profile Analysis (LPA), a sophisticated person-centred analytical approach that identifies unobserved subgroups within a population based on response patterns across multiple indicators (Spurk *et al.*, 2020). LPA was particularly appropriate for our research objectives as it categorises individuals into profiles based on their responses to the OI competencies derived from the ESCO framework. This method excels at identifying underlying patterns in data that are not immediately apparent, allowing for the classification of competencies into empirically robust profiles. We selected a multigroup approach to account for variations across different national contexts, ensuring that the profiles reflect the specific socio-economic and educational dynamics of each country while maintaining cross-cultural comparability (Demir *et al.*, 2023).

RESULTS AND DISCUSSION

To determine the optimal number of OI profiles within each sample, we conducted several separate LPA models with two to five profile solutions. Based on multiple fit indices (AIC, BIC, AWE, CLC, and KIC), the three-profile model emerged as the best solution (see Table 3). This selection aligns with recommendations by Spurk *et al.* (2020) for balancing statistical fit with theoretical interpretability when determining profile solutions. The entropy values (ranging from 0.737 to 0.852) further indicated good classification quality across all samples, providing statistical validation for our three-profile approach. This approach allowed us to identify meaningful groupings.

We named the resultant profiles based on the mean scores of the six OI components after determining the optimal three-profile solution across all countries. Following methodological guidance from

Spurk *et al.* (2020), we designated the profiles as 'Low OI,' 'Moderate OI,' and 'High OI' since higher scores consistently correlated with higher OI competence levels across all dimensions. Table 4 presents the LPA results. Figure 1 displays the differences in measured levels of OI competencies.

Table 3. Latent Profile Analysis, fitting measures, 3 profiles

Country	AIC	BIC	AWE	CLC	KIC	Entropy
DK	383.429	428.608	602.083	333.134	412.429	0.852
LV	874.832	940.114	1133.731	824.498	903.832	0.833
PL	2657.822	2750.698	2972.099	2607.297	2686.822	0.737
ALL	3688.707	3792.223	4024.221	3638.226	3717.707	0.760

Source: own study.

Table 4. Latent class marginal means, ALL countries: DK, PL, LV; (n = 397)

Variable	Low OI (n = 49) 12.3%		Medium OI (n = 223) 56.3%		High OI (n = 125) 31.4%	
	M	SD	M	SD	M	SD
Creativity	2.741	0.087	3.302	0.048	3.857	0.063
Entrepreneurship	3.282	0.061	3.688	0.0403	4.147	0.044
Communication and knowledge sharing	2.942	0.083	3.695	0.043	4.299	0.060
Risk taking	2.750	0.118	3.148	0.056	3.576	0.074
Open-minded thinking	3.493	0.076	4.018	0.035	4.432	0.046
Self-efficacy in digital skills	3.067	0.087	3.754	0.055	4.381	0.053

Source: own study.
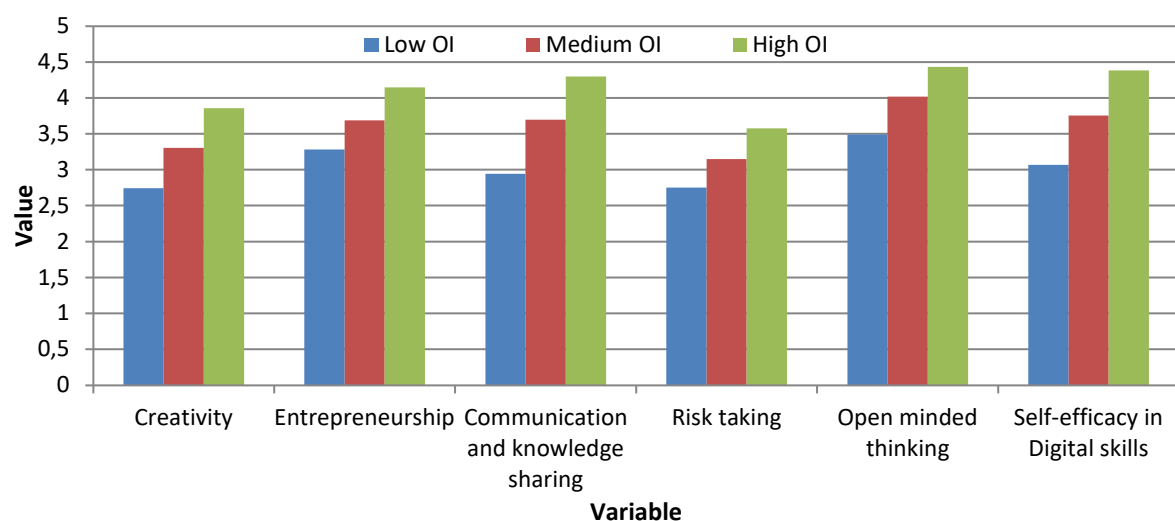
Figure 1. The differences in measured levels of OI competencies in the three profiles (High OI, Medium OI and Low OI)
Source: own elaboration, n=397.

Our findings revealed that, contrary to our first hypothesis (H1), the levels of OI competence varied significantly among the three countries. The substantial disparities in profile sizes and composition across the three sets of observations indicate that OI competencies are not uniformly distributed across different national contexts, despite shared European educational frameworks. This finding aligns with research by Akhmadi and Tsakalerou (2022), who identified persistent cultural divides in innovation practices across different European regions. As Tables 5, 6, and 7 show, there are notable variations in both profile distributions and competency patterns among Denmark, Latvia, and Poland. Tables 5, 6, and 7 (n = 397; survey data) show the profile means and profile size variations for the three countries.

Table 5. Differences in profiles: Low OI

Variable	DK (n = 12)	LV (n = 36)	PL (n = 39)	K-W p-value	Differences
Creativity	2.965	3.295	2.677	0.001	LV > DK = PL
Entrepreneurship	3.108	3.276	3.137	0.001	LV > PL = DK
Communication and knowledge sharing	3.575	3.470	2.953	0.001	DK > LV > PL
Risk taking	2.729	3.113	2.749	0.001	LV > PL = DK
Open-minded thinking	3.746	3.791	3.487	0.001	LV > DK > PL
Self-efficacy in digital skills	4.024	3.386	3.085	0.001	DK > LV > PL

Source: own study.

Table 6. Differences in profiles: Medium OI

Variable	DK (n = 16)	LV (n = 47)	PL (n = 142)	K-W p-value	Differences
Creativity	3.397	3.439	3.321	0.0167	DK = LV > PL
Entrepreneurship	3.613	3.827	3.535	0.0411	LV > DK > PL
Communication and knowledge sharing	3.566	4.065	3.676	0.0061	LV > PL > DK
Risk taking	3.254	3.653	3.135	0.0231	LV > DK > PL
Open-minded thinking	4.155	4.249	4.008	0.0490	LV > DK > PL
Self-efficacy in digital skills	3.638	4.110	3.772	0.0241	LV > PL > DK

Source: own study.

Table 7. Differences in profiles: High OI

Variable	DK (n = 14)	LV (n = 8)	PL (n = 83)	K-W p-value	Differences
Creativity	3.840	4.348	3.904	0.0008	LV > PL > DK
Entrepreneurship	4.214	4.664	4.084	0.0001	LV > DK > PL
Communication and knowledge sharing	4.606	4.543	4.244	0.0001	DK > LV > PL
Risk taking	3.872	4.297	3.339	0.0472	LV > DK > PL
Open-minded thinking	4.607	4.849	4.407	0.0001	LV > DK > PL
Self-efficacy in digital skills	4.589	4.396	4.332	0.0001	DK > LV > PL

Source: own study.

Upon examining individual competencies, we found that Latvian students demonstrated significantly higher levels of 'Entrepreneurship,' 'Risk taking,' and 'Open-minded thinking' competencies across all profiles compared to Danish and Polish students. This pattern may reflect Latvia's educational emphasis on entrepreneurial mindsets and risk-taking as essential components for economic development in post-transition contexts (Kubiv *et al.*, 2020). Conversely, Danish students exhibited notably higher competence in digital skills compared to their Polish and Latvian counterparts, particularly in the Low and High OI profiles. This digital competency advantage aligns with Denmark's advanced digital infrastructure and educational focus on technological integration (van Kessel *et al.*, 2022). Polish students displayed relatively consistent, moderate levels of competencies across all profiles, suggesting a more standardised approach to education that may not emphasise the extremes of either high or low competence development in specific areas.

Noteworthy, despite differences in individual levels of specific competencies, the advantage of the OI Competence Profile is to evaluate these elements as an aggregated index, reflecting OI managers' need for recruiting employees with a full range of OI competences, each presented at a significant level.

We may attribute the observed differences in OI competencies among students across the three countries to several factors. Educational systems significantly impact competency development, with some systems placing stronger emphasis on OI-related skills than others (Spada *et al.*, 2022). Curriculum variations across universities and countries substantially influence competency development, with

certain national educational contexts focusing more intensively on sectors requiring higher OI competencies (Gürdür Broo *et al.*, 2022).

Furthermore, governmental support for innovation varies considerably across countries. Mature economies like Denmark typically provide more substantial funding and resources for innovation projects (Markovic *et al.*, 2021), creating more fertile environments for OI competency development. Some differences may also stem from varying levels of systemic digitalisation across the three countries. While Industry 4.0 implementation is widespread in Denmark, it remains more limited in Poland and Latvia (Honti *et al.*, 2020), affecting the development of digital competencies essential for OI practices. Overall, the level of OI competencies among students is influenced by multiple interacting factors that collectively shape competency development within each national context.

We also examined gender as a predictor of OI Competence levels. Contrary to our second hypothesis (H2), which proposed that male students would have a higher probability of being classified into higher OI profiles, our findings revealed a more complex gender landscape across the three countries. While male students were indeed more likely to appear in the High OI profile when considering the overall sample (66.4% men vs. 33.6% women), country-specific analyses revealed significant variations in this pattern (Tables 8-11).

Table 8. Profile differences by gender (percentages), all countries: DK, PL, LV

Variable	Low OI (n = 49)	Medium OI (n = 223)	High OI (n = 125)
Female	59.18	47.98	33.60
Male	40.78	52.02	66.40
Prefer not to say	0.04	0.004	0.00

Source: own study.

Table 9. Profile differences by gender (percentages): DK

Variable	Low OI (n = 12)	Medium OI (n = 16)	High OI (n = 14)
Female	41.60	62.50	28.57
Male	58.40	37.50	71.42

Source: own study.

Table 10. Profile differences by gender (percentages): PL

Variable	Low OI (n = 39)	Medium OI (n = 142)	High OI (n = 83)
Female	53.85	55.63	68.67
Male	46.40	44.36	31.33
Prefer not to say	0.05	0.01	0.00

Source: own study.

Table 11. Profile differences by gender (percentages): LV

Variable	Low OI (n = 36)	Medium OI (n = 47)	High OI (n = 8)
Female	55.50	57.44	62.50
Male	44.50	42.56	37.50

Source: own study.

In Denmark, our findings aligned with H2, showing a strong male representation (71.42%) in the High OI Profile. This suggests potential gender disparities in encouragement or confidence among Danish students within high-stakes innovation environments. This pattern aligns with research by Krieger *et al.* (2022) on gendered educational outcomes in Nordic countries. However, contrary to our hypothesis (H2), Poland showed predominant female representation in the High OI Profile (68.67%), with this trend persisting in the Medium OI Profile (55.63%). This unexpected finding indicates robust engagement of

women in high-level innovation activities in the Polish educational context. Similarly, Latvian female students demonstrated higher OI competencies than male students, with increasing female representation as profile levels increased (55.5% in Low OI, 57.44% in Medium OI, and 62.5% in High OI).

These contrasting gender patterns across countries led us to reject H2 in its generalised form, suggesting that cultural context plays a significant moderating role in the relationship between gender and OI competencies. This finding highlights the importance of contextually sensitive approaches when examining gender dynamics in innovation contexts.

We may explain these contrasting gender patterns across countries through several theoretical lenses. As suggested by Antonelli *et al.* (2023), educational systems in post-transition economies like Poland and Latvia may emphasise collaborative and community-oriented projects that more effectively engage female students in innovative practices. The pedagogical approaches in these countries might better integrate gender-specific experiences and challenges into learning environments, yielding higher OI competency profiles among women.

Conversely, Denmark's highly egalitarian but well-established educational system may present a different landscape where different factors influence gender distinctions in competencies. As Lapuente and Suzuki (2020) suggest, in contexts with well-established gender equality, the pressures and incentives for female students to demonstrate higher innovation competencies may differ from those in countries still actively addressing gender disparities.

These gender-related findings highlight the complex interplay of cultural factors, educational systems, leadership opportunities, and societal expectations in shaping OI competence development across different national contexts. This complexity underscores the need for contextually sensitive approaches when developing educational strategies aimed at fostering OI competencies among diverse student populations.

CONCLUSIONS

This study provides a comprehensive analysis of open innovation competence among university students, employing dynamic capabilities theory to categorise and understand the varying distributions of OI competencies across higher education contexts in Denmark, Latvia, and Poland.

From the perspective of dynamic capabilities theory (Teece, 2020), our study makes several significant contributions to OI research. Firstly, the development of an OI Competence Profile represents a first-order dynamic capability that contributes to competitive advantage by enabling organisations to better identify and develop essential innovation skills (El Maalouf *et al.*, 2022). By adopting a profile approach that integrates distinct yet complementary competencies, we provide a more holistic framework for understanding how these capabilities collectively enhance innovation practices.

Secondly, our cross-national comparison reveals important insights into how educational, cultural, and economic contexts shape OI competency development. Contrary to our first hypothesis, we found significant variations in OI competence profiles across the three countries, suggesting that despite shared European educational frameworks, national contexts substantially influence innovation competency development. Latvian students demonstrated notably higher levels of entrepreneurship, risk-taking, and open-minded thinking, while Danish students excelled in digital competencies, and Polish students showed consistent moderate levels across all dimensions.

Thirdly, our gender analysis uncovered unexpected patterns that challenge conventional assumptions about gender and innovation. While our aggregate data showed male students were more likely to appear in high OI profiles overall, country-specific analyses revealed that female students in Poland and Latvia were significantly more represented in high OI profiles than their male counterparts. Only in Denmark did we observe the expected male predominance in high OI profiles. These findings highlight the complex interaction between gender, educational systems, and cultural contexts in shaping innovation competencies (Krieger *et al.,* 2022; Zuraik *et al.*, 2020).

Our research contributes to the OI literature by conceptualising and measuring OI competencies at the individual level before organisational influence, providing an important baseline for under-

standing how these capabilities develop through educational experiences. The multi-country, gender-inclusive approach offers nuanced insights into how national educational systems and cultural factors influence OI competency development, addressing significant gaps in existing literature that has typically examined these issues in isolated contexts.

From a practical perspective, our findings provide valuable insights for both educational institutions and industry practitioners. For higher education institutions, our results emphasise the need to create targeted OI learning contexts during tertiary education that account for specific national and cultural factors. Universities should consider integrating practical experiences, collaborative projects, and digital skill development into their curricula, while remaining attentive to potential gender disparities in innovation education (Ovbiagbonhia *et al.*, 2023).

For practitioners, our OI Competence Profile offers a framework for identifying and developing key competencies in potential and current employees. Organisations can use this profile to guide recruitment strategies and professional development initiatives, particularly when assembling diverse teams for OI projects (Podmetina *et al.*, 2018). The country and gender variations we observed suggest that organisations should adopt contextually sensitive approaches to talent development and avoid one-size-fits-all strategies when operating across different national contexts.

Our study has several limitations that present opportunities for future research. First, while our sample provides meaningful insights into three European countries, expanding this research to include a broader range of countries, including non-European contexts, would enhance the understanding of how cultural and economic factors influence OI competency development globally. Secondly, longitudinal studies tracking how OI competencies evolve from university into professional settings would provide valuable insights into the long-term impact of educational interventions. Thirdly, a deeper investigation into the specific educational practices and cultural factors that contribute to the observed gender differences could yield important insights for designing more inclusive innovation education.

Future research could also explore how specific pedagogical approaches, such as project-based learning, industry collaborations, and experiential learning environments, influence the development of OI competencies. Moreover, examining how digital transformation in education affects OI competency development represents an important avenue for further investigation.

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Use of Artificial Intelligence

This text is free of AI/GAI usage except for grammar and spell-checking performed with Grammarly.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Exploring the macro conditions for national entrepreneurship: A panel data-based analysis in developing countries

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A B S T R A C T
Objective: The article aims to analyse the impacts of macro factors on national entrepreneurship, providing insights for policymakers to promote entrepreneurial activities in developing countries.
Research Design & Methods: We employed the panel data analysis method and identified the robust fixed-effects model as the most appropriate for our research sample, which we obtained from the open databases of Global Entrepreneurship Monitor (GEM) and the World Bank. Given the unbalanced panel structure, the dataset comprised 37 developing countries, with 173 year-observations over the period 2003 to 2019.
Findings: Our findings indicate that economic growth, consumer price index (CPI), government expenditure on education, and Research and Development (R&D) investment positively impact national entrepreneurship of developing countries, whereas unemployment exhibits a negative impact. However, other macro factors such as Gross Domestic Product (GDP) per capita, Foreign Direct Investment (FDI) inflows, import, export, gross national expenditure, labour force quality and entrepreneurial institutions do not show a significant impact on national entrepreneurship of developing countries.
Implications & Recommendations: Governments of developing countries should prioritise national entrepreneurship by investing in education, R&D, and controlling inflation at an appropriate level. It is also crucial for these countries to enhance economic growth and address unemployment through entrepreneurship programs and labour market reforms.
Contribution & Value Added: This study contributes to the literature by enriching the resource-based view (RBV) and institutional theory on national entrepreneurship and its macro conditions, which governments in developing countries can influence to promote entrepreneurial activities at the macro level. Methodologically, our empirical study strengthens the field by employing panel data analysis on a sample of developing countries. The findings provide policymakers with a clearer perspective for planning strategies and policies to enhance positive factors and mitigate negative ones, fostering an environment conducive to entrepreneurship and sustainable economic development in developing countries.

INTRODUCTION

With its direct outcome of newly established businesses, entrepreneurship has been considered one of the most important drivers of a country's socio-economic development. Newly established firms are often more efficient and create competitive pressures for other firms, by contributing to national productivity enhancement and economic growth (Klapper *et al.*, 2006). Newly established businesses have higher job creation rates than mature firms, thereby reducing unemployment rates and increase-

ing individual incomes (Ayyagari *et al.*, 2014). Particularly in developing countries, scholars agree that entrepreneurship contributes positively to economic growth, job creation, poverty, and unemployment reduction, as well as to improvements in national and firm competitiveness (Acs & Amorós, 2008; Alvarez & Barney, 2014; Ayyagari *et al.*, 2014; Urbano & Aparicio, 2016). Therefore, clarifying the conditions for entrepreneurship at the country level constitutes an important research interest that continues to attract the attention of both researchers and policymakers.

In the literature, entrepreneurship has been extensively studied in recent decades, but research at the country level remains underexplored. Previous studies have predominantly focused on the individual level, specifically on favourite factors such as demographic and psychological characteristics, entrepreneurship skills, managerial competences, financial resources, and social relations (De Clercq & Dakhli, 2009; Lim *et al.*, 2016); as well as macro determinants, including economic, political, business environment, technological, and cultural factors, that encourage individuals to start a business (Lim *et al.*, 2016; Pathak & Muralidharan, 2016). Furthermore, as highlighted by Pfeifer *et al.* (2021) and Hamdan *et al.* (2022) in their literature reviews, there is a growing interest among researchers and policymakers in investigating and analysing the determinants of national entrepreneurship or entrepreneurship at the country level.

Addressing the research gaps mentioned above, our study focuses on the context of developing countries, where entrepreneurs face distinct challenges when initiating new business ventures. Starting a new business in developing countries often encounters more difficulties compared to developed countries due to underdeveloped or inadequately established infrastructure and institutions. These limitations restrict entrepreneurs in terms of necessary resources and result in high transaction costs when capitalising on new market opportunities. Moreover, existing studies have rarely conducted a comprehensive empirical analysis that simultaneously considers an extensive set of macro variables, specifically in developing countries, making this context both important and underrepresented in the literature. Hence, researching macro conditions to foster national entrepreneurship in developing countries is both pressing and tailored to the needs of these countries. It also contributes to global economic development (Hamdan *et al.*, 2022; Pfeifer *et al.*, 2021; Urbano *et al.*, 2019).

In the aforementioned perspective, this study focuses on analysing the macro conditions for national entrepreneurship in developing countries. The research question posed is: Which macro factors influence national entrepreneurship in developing countries and how do they do it? Our objective is to identify macro factors shaping the business environment for entrepreneurs, and analyse their impact on the national entrepreneurship in developing countries. The novelty of this research lies in its comprehensive and simultaneous examination of macro variables, using a large unbalanced panel dataset focused exclusively on developing countries. Unlike the existing research that predominantly examines entrepreneurship at the individual level, focusing on entrepreneurs and their characteristics, this study adopts a national level perspective, emphasising the economic, social, and institutional conditions that facilitate or hinder entrepreneurship in developing economies. Moreover, the study applies a robust fixed-effects model to address data heterogeneity across countries and years – an approach that enhances the reliability and validity of the findings. By applying both institutional theory and the resource-based view (RBV), this study provides a more comprehensive framework for analysing national entrepreneurship, offering insights into how macro conditions interact to shape entrepreneurial activity in developing countries. The findings of our research will provide valuable insights for public management, enabling governments of developing countries to formulate and implement targeted regulatory policies that address both favourable and constraining macro conditions to promote entrepreneurship at the national level.

The following parts of the article consist of four key sections. In the first one, we develop the theoretical framework for exploring how macro factors influence national entrepreneurship in developing countries and formulate hypotheses based on the literature review. Next, the research methodology section details the data collection and research sample, as well as the study variables and the panel data analysis method. Following this, the results and discussions section presents the empirical findings, analysing how these align with the formulated hypotheses and discussing the

impact of macro factors for understanding national entrepreneurship dynamics in developing countries. Particularly, we highlight how macro conditions influence national entrepreneurship, addressing the concern that entrepreneurship development varies significantly across developing countries. Lastly, the conclusions section summarises the main findings, research contributions, policy implications, and suggests future research directions in the national entrepreneurship area.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Theoretical Framework

Concept of National Entrepreneurship

From an individual perspective, entrepreneurship is the career choice between self-employment and work as a salaried employee. Therefore, an individual can become an entrepreneur if the profits and non-monetary benefits gained from self-employment exceed the wages and additional benefits obtained from wage employment (Evans & Jovanovic, 1989; Murphy *et al.*, 1991). Hence, entrepreneurship, defined as an individual's discovery and exploitation of opportunities (Shane & Venkataraman, 2000), equates to self-employment or being a business owner.

From a macro perspective, the concept of 'national entrepreneurship' (or entrepreneurship at the country level) refers to the proportion of adults or the labour force within a country who have initiated a business and currently own new businesses (Wennekers, 2006). The nature of national entrepreneurship lies in the management and regulation of macro-level factors towards creating a favourable environment and conditions to promote the development of entrepreneurship within the country. National entrepreneurship is intricately connected with individual-level entrepreneurship and firm-level entrepreneurship, but, in general, individual-level and firm-level entrepreneurship serve as the foundation for national entrepreneurship (Hamdan *et al.*, 2022; Pfeifer *et al.*, 2021). Specifically, the percentage of new business ownership among the national labour force depends on individual career decisions within that country; conversely, these decisions are influenced by macro conditions.

National Entrepreneurship and Resource-based View (RBV)

At the firm level, the resource-based view (RBV) explains the differences in performance among companies operating in similar conditions and business environments. Accordingly, a firm's competitive advantage primarily lies in its effective utilisation of a set of valuable tangibles and/or intangible resources. Firms are differentiated by their possession of distinct resources (Barney, 1991; Grant, 1991). Resources are everything that a firm possesses, specifically tangible and intangible assets associated with the business (Wernerfelt, 1984, p. 172). They include all assets, capabilities, organisational processes, information attributes, or knowledge that the firm holds control over (Barney, 1991, p. 101). Resources which are valuable, rare, inimitable, and non-substitutable are considered as sources of sustainable competitive advantage of the firm (Barney, 1991).

At the macro level, the RBV is also significant in studying national entrepreneurship. Accordingly, the favourable economic, social, and institutional conditions of a country provide the necessary resources for its national entrepreneurship. The provision of these resources influences the supply-side of entrepreneurship, as the availability of resources determines the inputs of entrepreneurship, such as capital, human skills, technology, etc. (Sarasvathy, 2009). In other words, the establishment of new businesses requires appropriate resource conditions; a lack of resources can negatively impact the decision to start a business, resulting in a decline in the rate of new business formation and reducing national entrepreneurship subsequently. According to Alvarez and Busenitz (2001), if potential entrepreneurs have all the necessary resources to exploit a market opportunity, they do not need to organise but only to coordinate and execute. Conversely, if they lack one or more key resources, they need to organise more business activities to exploit price differentials.

By their nature, developing countries – often marked by a scarcity of essential resources – face significant challenges in fostering national entrepreneurship. These challenges stem from adverse economic and social conditions, underdevelopment, burdensome regulatory frameworks, administrative

complexities, and a range of other restrictive factors. Moreover, the extant resources within developing countries are inadequate to supplement, supplant, or mobilise additional resources needed for entrepreneurial endeavours. Consequently, this deficiency hampers the growth of entrepreneurial ventures and acts as a deterrent to the overall advancement of national entrepreneurship.

National Entrepreneurship and Institutional Theory

Institutional theory focuses on analysing the institutionalisation process, as well as the role of institutions issued by governments and provincial authorities in shaping the behaviours of individuals and organisations. By definition, institutions are models implementing rules and regulations, in which 'departures from the pattern are counteracted in a regulated fashion, by repetitively activated, socially constructed, controls – that is, by some set of rewards and sanctions' (Jepperson & Meyer, 2021, p. 39). This definition emphasises the role of state power in the form of control. Accordingly, the current institutions directly influence behaviours of individuals, organisations and society, including entrepreneurship. Institutions, including formal ones (such as policies, regulations, and government variables) and informal ones (such as attitudes, values, social norms, religion, and other factors), impose what individuals and organisations are allowed, not allowed to do or should do.

Consequently, institutions exert a significant influence on the supply of entrepreneurship and new businesses' activities by shaping the temporal, financial, and resource-related requirements associated with entrepreneurial endeavours. Entrepreneurial regulations impact the time and cost of initiating a business, while economic and social ones determine the economic and social conditions that in turn, influence the availability of essential resources for new business ventures, such as financial resources, skilled labour, and market opportunities (Castaño *et al.*, 2015; Harraf *et al.*, 2021). This means that having necessary resources, in the absence of efficient institutions to leverage them, does not suffice to create sustainable competitive advantages. In this regard, institutions are essential for entrepreneurs to efficiently exploit and utilise resources to support business entrepreneurship and contribute to the success of newly established businesses.

In developing countries, characterised by uncertainty and high risk, small and medium-sized enterprises often gain an advantage over larger corporations. Moreover, most developing countries may have underdeveloped economic and political institutions, lacking transparency (Nafziger, 2012). Consequently, the establishment of a suitable, effective, and transparent institutional environment becomes imperative to optimise resource mobilisation and utilisation, thereby fostering the development of national entrepreneurship (Lim *et al.*, 2016; Urbano *et al.*, 2019). Moreover, establishing regulations and policies (formal institutions) also serves to mitigate transactional risks and reduce associated costs, thereby incentivising and nurturing national entrepreneurship. Therefore, institutions play a central role in explaining the positive and negative conditions of national entrepreneurship, particularly individuals' decisions to start a business or not, as well as the industries favoured for entrepreneurial activity through related rules and legal procedures (Hamdan *et al.*, 2022).

Hypotheses Development

Economic Conditions for National Entrepreneurship

Economic development is also crucial for entrepreneurship in developing countries, as larger economic activities create positive economic expectations, provide financial and physical resources, and improve perceptions of opportunities, thereby encouraging individuals to engage in business activities (Acs *et al.*, 2018; Awoa Awoa *et al.*, 2022; Castaño *et al.*, 2015; Prieger *et al.*, 2016). Therefore, initiatives that promote economic activities and establish a stable macroeconomic environment stimulate national entrepreneurship in developing countries. Some scholars suggest that economic conditions, such as economic growth, GDP per capita (McMullen *et al.*, 2008), trade (Solomon *et al.*, 2021), and FDI (Hong *et al.*, 2021; Slesman *et al.*, 2021) may lead to market saturation and increased competition, potentially hindering or having negligible or negative effects on new business creation. Thus, examining the nuanced impacts of economic conditions in developing economies provides a more balanced understanding of their role in shaping national entrepreneurship.

The economic conditions within a country may exert a strong impact on the demand-centric dimension of entrepreneurship. Empirical evidence highlights that higher income is a driving force behind the increasing demand for entrepreneurship (Awoa Awoa *et al.*, 2022). It means that higher income levels can engender and distinct consumer demands, creating opportunities for business ventures with new or specialised products and consequently fostering the emergence of potential niche markets. Moreover, higher available income also contributes to capital accumulation and national reserves, providing favourable financial resources for entrepreneurship (Albert *et al.*, 2023; Tleuberdinova *et al.*, 2021). Li (2025) and Cervelló-Royo *et al.* (2024) support and affirm that there is a positive relationship between financial capital and entrepreneurship.

Moreover, moderate inflation can have a stimulative effect on entrepreneurship by increasing nominal revenues for businesses, thereby enhancing profitability and incentivising new business creation. In developing countries where access to financial markets is limited, inflation can push individuals to shift capital from stagnant savings to investment in business ventures as a means of preserving wealth (Baltar, 2015; Gillman & Kejak, 2011). As Izuchukwu (2023), Khan *et al.* (2023), and Cervelló-Royo *et al.* (2024) highlight the positive impact of inflation, we believe that a controlled level of inflation may encourage borrowing for entrepreneurial activities, as the real cost of debt decreases over time, making credit more accessible for aspiring entrepreneurs in developing countries.

Furthermore, international trade activities also positively influence national entrepreneurship. International trade, specifically exports and imports, facilitates the expansion of economic relations between countries and the rest of the world, thereby creating new business opportunities (Purkayastha *et al.*, 2021; Shane & Venkataraman, 2000). Rahman *et al.* (2023) observed that trade openness contributes significantly to the development of global entrepreneurship in Brazil, India, China, and South Africa. Both imports and exports have significant positive effects on the economic growth of countries, especially those in the developing phase. Imports of production materials, machinery, and technology enhance domestic production capacity and product quality. On the other hand, exports help in expanding consumer markets and boosting domestic production activities. Exports also increase the value of goods and services, resulting in higher revenues for businesses and export-oriented countries, providing attractive financial rewards that encourage individuals to engage in entrepreneurship. Nguyen *et al.* (2022) highlight that, in low and middle-income economies, export diversification may play a more significant role in fostering entrepreneurship compared to high-income economies.

By promoting economic growth, international trade also contributes to the creation of financial resources for entrepreneurial endeavours at the country level. Furthermore, entrepreneurs involved in export businesses have privileged access to market knowledge and foreign technology (Purkayastha *et al.*, 2021). This knowledge can help them discover untapped opportunities in the domestic market, thus driving them to undertake further entrepreneurial activities (Shane & Venkataraman, 2000).

Moreover, foreign direct investment (FDI) also contributes to increasing a developing country's income, creating conditions for improving the state budget, and thus enabling financial accumulation and net savings, which in turn provide more resources for entrepreneurship (Zhao, 2023). Moreover, FDI brings in modern scientific and high-specialisation technology, advanced management practices, and expertise, which help enhance domestic technological and managerial capabilities through learning and imitation processes (Afi *et al.*, 2022). These are crucial factors that support entrepreneurship in developing countries.

In summary, economic conditions have a strong influence on both the supply and demand sides of entrepreneurship, providing favourable conditions for mobilising and accumulating the necessary resources while opening up new business opportunities that make entrepreneurial endeavours more attractive to individuals. Therefore, developing economic conditions is a necessary task to provide sufficient inputs and opportunities for initiating new business activities. Based on these prior empirical results, we assumed the first research hypothesis:

H1: Economic conditions significantly influence the national entrepreneurship of developing countries.

Social Conditions for National Entrepreneurship

Although some studies have found contrasting results (Dheer, 2017; Solomon *et al.*, 2021), scholars agree that social conditions contribute intangible resources (such as skills, knowledge, and capabilities) as well as informal institutions (such as attitudes, values, and social norms) to the national entrepreneurship in developing countries. Specifically, Li (2025) argues that individuals with greater educational capital are more likely to pursue opportunity-based entrepreneurship. Jiménez *et al.* (2015) found that different levels of education have varying effects on formal and informal entrepreneurship. Not all characteristics of entrepreneurs can be trained. Higher educational attainment also equips individuals with the knowledge and tools necessary for establishing businesses and helps young entrepreneurs identify market opportunities, thus stimulating their entrepreneurial desires. On the other hand, the knowledge and skills gained through entrepreneurship education also influence individuals' self-efficacy, which can impact their intention to start a business, leading individuals to be more inclined to engage in entrepreneurial activities (Amofah & Saladrigues, 2022; Lee & Wong, 2003).

Another measure to promote entrepreneurship is increasing social consumption of the country (McMullen *et al.*, 2008). Governments of developing countries can enhance spending on social safety nets and welfare programs, promote public investment projects, including infrastructure investments in transportation, communication, electricity, and water supply. Increasing public expenditure contributes to boosting social consumption demand, creating profit opportunities, and thus stimulating national entrepreneurship (Castaño *et al.*, 2015). The implementation of public investment emerges as a pivotal policy, not only in promoting entrepreneurship but also improving infrastructure, creating favourable conditions for attracting investment and economic development, consequently engendering the country's economic conditions. Moreover, the presence of social safety net initiatives assumes significance, offering a mechanism to mitigate potential downsides of business failures and reduce the fear of potential entrepreneurs from leaving salaried jobs, thus encouraging individuals to start their ventures.

Furthermore, investing in research and development (R&D) plays a significant and positive role for entrepreneurship by driving innovation, digitisation, and digital transformation (de Lucas Ancillo & Gavrila Gavrila, 2023). Noteworthy, R&D development can lead to important inventions and patents, fostering innovations or even revolutionary changes not only in the economy but also across multifarious domains spanning political, social, and cultural landscapes. Consequently, this imparts impetus to the ongoing advancement of developing countries. The economic and social development conditions create more resources and opportunities for entrepreneurs, encouraging them to engage in business ventures. On the other hand, strengthening national-level R&D activities can positively impact enterprise and individual-level R&D activities, driving businesses and individuals to seek innovation and improvements in their entrepreneurial and business ventures, thereby enhancing their efficiency and attractiveness, attracting more individuals and businesses to participate (Duguet, 2004).

Entrepreneurial activities also exhibit interdependencies with variables, including government investment in education, population-level educational attainment, and prevailing unemployment rates. These factors collectively influence the quality of life and resource endowment, thereby affecting the ambitions and entrepreneurial aspirations of individuals. Using data from 23 OECD countries spanning the period 1974 to 2002, Thurik *et al.* (2008) found that shifts in unemployment rates had a clear positive influence on subsequent changes in self-employment rates or start-up activity. Simultaneously, changes in self-employment rates negatively affected subsequent unemployment rates, with this latter effect proving more substantial than the former.

Thus, we can observe that social conditions strongly influence national entrepreneurship, where favourable ones support the provision of necessary resources and opportunities to foster entrepreneurial activities. Social conditions also influence the desires and entrepreneurial aspirations of individuals, galvanising their proactive engagement. Stemming from the above arguments, we proposed the second hypothesis as follows:

H2:   Social conditions significantly influence the national entrepreneurship of developing countries.

Institutional Entrepreneurial Conditions for National Entrepreneurship

In addition to economic and social conditions, institutional conditions officially constrain the establishment and subsequent operation of new firms.

These impacts, although occasionally detrimental (Chambers & Munemo, 2019; Dheer, 2017), can take on a favourable trajectory, potentially supporting the seamless progression of the entrepreneurial process. By shaping the business environment through laws and supportive policies, entrepreneurial institutions are among the most extensively scrutinised determinants of national entrepreneurship (Urbano *et al.*, 2019; Valdez & Richardson, 2013; Van Stel *et al.*, 2007). Specifically, Chambers and Munemo (2019) examined the impact of entrepreneurial regulations and institutional quality on new business activity in 119 countries in the period 2001-2012. The results show that institutional conditions, such as excessive barriers to entry and/or a lack of high-quality governmental institutions, significantly reduce new business formation. The application of complex and unpredictable regulations increases the costs of starting a business. In addition to the procedural costs, new businesses may need to spend extra on legal support services to expedite the registration process (Harraf *et al.*, 2021).

On the other hand, regulations that allow officials to manage sectors by obstructing or delaying the entry of new businesses, for personal or policy reasons, can result in cumbersome regulations and delays in obtaining licenses and necessary procedures. This time-consuming process could deter many potential entrepreneurs, as opportunities may have passed by the time all regulatory procedures are completed (Pfeifer *et al.*, 2021). In their empirical study on Worldwide Governance Indicators across 126 countries, Abegaz *et al.* (2023) assert that political stability, government effectiveness, regulatory quality, rule of law, and control of corruption all have significant impacts on entrepreneurship.

According to conventional reasoning about entrepreneurship, tax policies reduce the attractiveness of starting a new business because they take away a portion of the profits. Therefore, if an individual is considering entrepreneurship and perceives high corporate taxes, they may choose to forgo entrepreneurship and seek high-paying employment instead (Djankov *et al.*, 2002; Van Stel *et al.*, 2007). Consequently, policymakers need to make potential entrepreneurs see the attractive financial rewards of starting a business. This proposition necessitates the establishment of a low tax rate regimen so that entrepreneurs can preserve a substantial proportion of their earnings, simultaneously complemented by the provision of tax incentives tailored to newly established enterprises (Keuschnigg & Nielsen, 2003).

Moreover, the government can influence national entrepreneurship through their supportive policies. Specifically, the government of developing countries can assist newly established businesses through subsidy programs, providing physical support, and offering information for new business projects (Hamdan *et al.*, 2022; Keuschnigg & Nielsen, 2003). These programs often address the input factors of entrepreneurship, such as financial resources, market information, and human resources quality. For example, market development policies can enhance the accessibility of vital financial resources required for the establishment or expansion of small-scale enterprises through financial grants and loan guarantees (Wennekers, 2006). Therefore, the government's implementation of supportive policies can create incentives to boost national entrepreneurship.

In general, the institutional entrepreneurial conditions influence national entrepreneurship by impacting various aspects such as costs, time to start a business, input factors, and the availability of necessary resources for national entrepreneurship in developing countries. Thus, we propose the third hypothesis as follows:

H3: Institutional entrepreneurial conditions significantly influence the national entrepreneurship of developing countries.

RESEARCH METHODOLOGY

Data Collection and Research Sample

We gathered and consolidated data on developing countries from 02 sources of GEM's and World Bank's open databases. The World Bank database is a widely recognised and authoritative source providing comprehensive economic and development indicators across countries since 1960. Meanwhile, GEM is

a network of primarily national teams affiliated with leading academic institutions which conduct continuous research on entrepreneurship and entrepreneurial ecosystems worldwide for over 20 years.

After collecting the data, we filtered the sample to include only developing countries, which are defined as either economies in transition that are not classified as high-income or developing economies, based on the annual *World Economic Situation and Prospects* reports by the United Nations (2003-2020). As income classifications may change over time, a country's inclusion in the sample may vary across years. For example, Poland, classified as upper-middle income until 2008, was considered a developing country in the sample and was excluded from 2009 onward after being reclassified as high income by the World Bank. Next, we excluded observations from years with missing data, primarily due to the absence of GEM data, resulting in a research sample that forms an unbalanced panel dataset, comprising 37 developing countries over the period from 2003 to 2019. The total number of observation years was 173, wherein different countries had varying observation years, yet ensuring that each country has at least one complete year of data for all variables.

Table 1. List of countries in the research sample

Countries	Observations (years)
South Africa, Colombia, Chile	> 10 years
Peru, Uruguay, Guatemala, Israel	9
Thailand	8
Türkiye, Brazil, South Korea	7
Panama, Iran	6
Egypt, Ecuador, Malaysia	5
Tunisia, Indonesia, Mexico	4
El Salvador, Costa Rica, Croatia, Vietnam, Russia	3
Hong Kong, Georgia, Serbia	2
Ghana, Poland, Philippines, United Arab Emirates, Armenia, Hungary, Belarus, India, Singapore, Pakistan	1
Total: 37 countries	173

Source: World Bank.

Research Variables

Dependent Variable

In this study, the dependent variable (Y) was total early-stage entrepreneurial activity (TEA) sourced from the Global Entrepreneurship Monitor (GEM) database. Among collected data, the most famous index is the total early-stage entrepreneurial activity (TEA) index, measured by the percentage of an economy's 18-64 population who are either a nascent entrepreneur (actively planning a new business) or owner-manager of a new business (within the first 42 months of starting). Used by Wong *et al.* (2005) and Urbano and Aparicio (2016) to analyse national entrepreneurship, TEA serves as a valuable benchmark for entrepreneurial activity, particularly as it evolves.

Independent Variables

In this study, we examined specific economic, social, and institutional macro variables to better understand the conditions shaping national entrepreneurship in developing countries. Economic factors (*e.g.*, GDP growth, GDP per capita, imports, exports, FDI, inflation) influence resource availability and market opportunities. Social factors (*e.g.*, national expenditure, education, unemployment, labour) affect human capital and entrepreneurial capabilities. Institutional factors related to business creation shape the entrepreneurial environment by either reducing or increasing barriers to entry. Analysing these variables provides a comprehensive view of how macro-level conditions enable or constrain entrepreneurial activity in developing countries. We collected the data from the World Bank's open-access database. Specifically:

Table 2. Independent variables and their measurement

	Variable	Description	Measurement
	Economic indicators		
X1	GDP growth	Reflects national economic development	Annual % change of GDP
X2	GDP per capita	Indicates income level and quality of life	Logarithmic value of GDP / population
X3	FDI inflows	Measures investment inflows relative to the economy's size	% of GDP
X4	Exports	Represents the value of goods and services exported by the economy	% of GDP
X5	Imports	Represents the value of goods and services imported by the economy	% of GDP
X6	Consumer price index	Shows price changes in consumer goods.	% of base year 2010
	Social indicators		
X7	Gross national expenditure	Reflects domestic spending on consumption and investment.	% of GDP
X8	Government expenditure on education	Indicates public investment in education	% of GDP
X9	Research and development expenditure	Reflects spending from various sources on R&D activities	% of GDP
X10	Labour force with basic, intermediate, and advanced education	Proxy for workforce skills at different education levels	% of the total working-age population
X11	Unemployment rate	Indicates labour market health	% of labour force
	Entrepreneurial institutional indicators		
X12	Cost of business start-up procedures	Reflects the cost barrier to entrepreneurship	% of GNI per capita
X13	Time required to start a business	Reflects the complexity, difficulty, and efficiency of the start-up procedures and regulations	Number of calendar days

Source: World Bank.

The Pearson correlation matrix of research variables (Table 4) indicated that several independent variables showed significant correlations with the dependent variable Y, notably X10 ($r = 0.490$, $p < 0.01$), X11 ($r = -0.390$, $p < 0.01$), and X9 ($r = -0.327$, $p < 0.01$), indicating their potential influence in the regression model. Meanwhile, most variables exhibited low or insignificant correlations with each other, suggesting minimal multicollinearity concerns in the dataset. However, three variables – X3, X4, and X5 – showed notable correlations. In particular, X3 was moderately correlated with both X4 ($r = 0.650$, $p < 0.01$) and X5 ($r = 0.702$, $p < 0.01$). More significantly, X4 and X5 exhibited a very strong correlation ($r = 0.966$, $p < 0.01$), suggesting potential multicollinearity that may affect the robustness of the regression analysis. To examine the impact of all independent variables on the dependent variable, we considered separating the highly correlated variables X4 and X5 into two distinct regression models.

Regression Method

In this research, for panel data, we applied the procedure outlined by Dougherty (2011) and Torres-Reyna (2007) to select appropriate models among the three: fixed-effects model, random-effects model, and pooled OLS model. According to Dougherty (2011), the process of selecting a regression model for panel data begins with checking whether the observations are randomly sampled from a specific country. If the observations come from a random sample, both fixed effects and random effects will be applied. Otherwise, a mixed-effects model should be used. Subsequently, we used the Lagrange multiplier (LM test) to decide if the random effects model or the pooled OLS model was appropriate for our present study (Breusch & Pagan, 1980). We used the Hausman test, also known as the Durbin-Wu-Hausman test (Hausman, 1978), to compare the fixed effects model and the random effects model. Then, we examined the presence of random effects. If random effects existed, we used the random effects model; otherwise, we applied the pooled OLS model.

Table 3. Descriptive analysis of research variables

Variable	Indicator	Unit	Obs.	Mean	Std. Dev.	Min		Max	
X1	GDP growth	Annual %	173	3.496	2.438	-3.747	Iran in 2012	11.314	Panama in 2011
X2	GDP per capita (current USD)	Logarithm value	173	3.915	0.319	3.100	Ghana in 2010	4.760	Singapore in 2014
X3	Foreign direct investment, net inflows	% of GDP	173	3.897	4.480	-0.901	Uruguay in 2016	41.532	Hong Kong in 2016
X4	Exports of goods and services	% of GDP	173	35.357	26.138	9.391	Pakistan in 2019	191.954	Singapore in 2014
X5	Imports of goods and services	% of GDP	173	36.605	23.835	11.801	Brazil in 2017	184.722	Hong Kong in 2016
X6	Consumer price index	(2010 = 100)	173	121.057	41.086	72.173	Turkey in 2006	508.339	Belarus in 2019
X7	Gross national expenditure	% of GDP	173	101.111	6.987	72.799	UAE in 2018	121.793	Serbia in 2008
X8	Government expenditure on education	% of GDP	173	4.368	1.056	1.511	UAE in 2018	6.680	Costa Rica in 2014
X9	Research and development expenditure	% of GDP	173	0.849	1.144	0.023	Guatemala in 2016	5.140	Israel in 2019
X10	Labour force with basic, intermediate and advanced education	% of labour force	173	199.869	26.004	123.870	Iran in 2013	263.280	Singapore in 2014
X11	Unemployment (national estimate)	% of labour force	173	8.189	6.321	0.250	Thailand in 2013	32.310	South Africa in 2003
X12	Cost of business start-up procedures	% of GNI per capita	173	13.034	10.993	0.200	South Africa in 2016	52.500	Guatemala in 2011
X13	Time required to start a business	Days	173	25.632	22.163	1.500	Hong Kong in 2016	100.500	Peru in 2004
Y	Total early-stage Entrepreneurial Activity – TEA	%	173	15.164	7.549	2.560	Croatia in 2003	40.270	Peru in 2004

Source: World Bank & GEM Global reports.

Table 4. Pearson correlation matrix of research variables

Variable	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
Y	1													
X1	0.073	1												
X2	-0.182*	-0.120	1											
X3	-0.010	0.056	0.315**	1										
X4	-0.203**	0.049	0.312**	0.650**	1									
X5	-0.196**	0.096	0.206**	0.702**	0.966**	1								
X6	-0.011	-0.278**	-0.048	-0.112	-0.039	-0.054	1							
X7	0.108	0.159*	-0.463**	-0.025	-0.434**	-0.188*	-0.033	1						
X8	-0.066	-0.199**	0.244**	-0.081	-0.112	-0.146	-0.001	-0.080	1					
X9	-0.327**	-0.063	0.666**	-0.061	0.110	0.028	-0.087	-0.314**	0.334**	1				
X10	0.490**	0.119	-0.027	0.127	0.160*	0.134	-0.115	-0.103	-0.086	-0.247**	1			
X11	-0.390**	-0.171*	-0.145	-0.127	-0.276**	-0.251**	-0.097	0.131	0.278**	-0.090	-0.357**	1		
X12	0.198**	0.205**	-0.340**	-0.156*	-0.210**	-0.127	-0.190*	0.366**	-0.322**	-0.243**	0.180*	-0.266**	1	
X13	0.104	-0.234**	-0.316**	-0.261**	-0.261**	-0.298**	-0.072	-0.065	0.104	-0.170*	-0.028	0.286**	0.014	1

Note: *. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).
Source: own study.
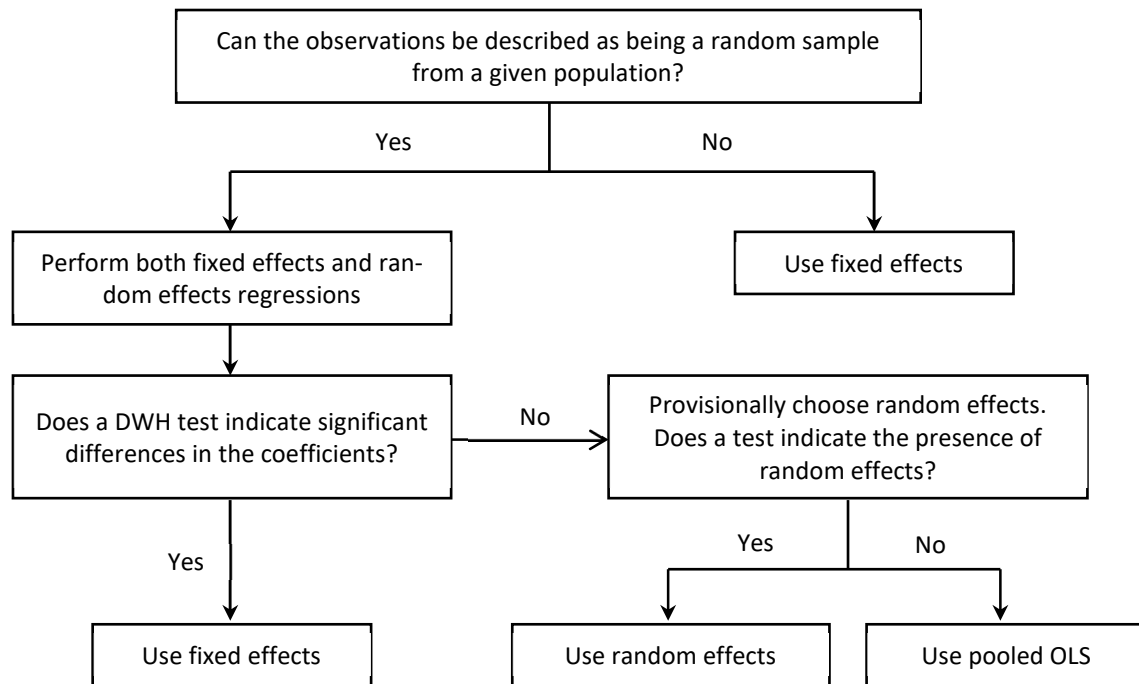
Figure 1. Process of selecting a regression model for panel data
Source: Dougherty (2011, p. 421).

Following the completion of the model selection process for panel data, the next step involved checking for multicollinearity and heteroskedasticity of regression. We applied the cutoff point of 5 suggested by Craney and Surles (2002, p. 393) and even the stricter threshold of 4 recommended by O'Brien (2007, p. 674) to ensure that the VIF value of any variable in the model did not exceed this limit, thereby preventing excessive or serious multicollinearity. Moreover, if the heteroskedasticity test results revealed the presence of these issues, we utilised a robust model to test the proposed research hypotheses (Greene, 2008).

Since the two variables X4 and X5 were strongly correlated, as detected in the correlation matrix analysis in Table 4, we conducted two separate panel data analysis processes, R1 and R2, with each of these variables, respectively, along with the other independent variables. The regression results yielded two corresponding models, R1 and R2, summarised in Table 5.

RESULTS AND DISCUSSION

According to the regression results in Table 5, the insignificant Hausman's tests (chi2(13) = 19.58; Prob>chi2 = 0.1063) support the null hypothesis by accepting the fixed-effects model at 95% confidence level in both two regression processes (with respectively chi2(12) = 28.54 & Prob>chi2 = 0.0046 for R1 and chi2(12) = 28.43 & Prob>chi2 = 0.0048 for R2). The significant LM tests refuse also the Pooled OLS model (with respectively chibar2(01) = 47.98 & Prob > chibar2 = 0.0000 for R1 and chibar2(01) = 48.05 & Prob > chibar2 = 0.0000 for R2). Finally, we identified the fixed-effects models as the appropriate ones for our study in both regression processes (Dougherty, 2011; Torres-Reyna, 2007).

Then, we examined the VIF values of the independent variables in both selected fixed-effects models. We found that the VIF values of all independent variables are less than 4, ensuring that the issue of multicollinearity can be neglected in our regression models (Craney & Surles, 2002; O'Brien, 2007). In the next step, we check the heteroskedasticity tests of the two selected fixed-effects models. These tests were both significant at a 95% confidence level (with respectively chi2 (37) = 1.40E+32 & Prob>chi2 = 0.0000 for R1 and chi2 (37) = 1.50E+32 & Prob>chi2 = 0.0000 for R2), by indicating the existence of a heteroskedasticity problem in our fixed-effects models. Therefore, we use the robust

option for correcting these fixed-effects models in both regression processes (Greene, 2008). Finally, we utilised the robust fixed-effects models to verify our research hypotheses.

Table 5. Regression results

Independent Variable	R1: Robust Fixed-effects model			R2: Robust Fixed-effects model		
	Coef.	*t*	*P > t*	*Coef.*	*t*	*P > t*
X1	0.415*	2.22	0.033	0.407*	2.21	0.034
X2	-9.994	-1.15	0.257	-9.802	-1.14	0.263
X3	0.139	0.85	0.400	0.128	0.82	0.420
X4	0.015	0.13	0.899			
X5				0.028	0.26	0.793
X6	0.042**	2.86	0.007	0.042**	2.90	0.006
X7	0.112	0.62	0.536	0.092	0.56	0.579
X8	3.473**	3.39	0.002	3.448**	3.42	0.002
X9	2.647†	1.95	0.059	2.721*	2.06	0.047
X10	-0.086	-1.44	0.159	-0.086	-1.43	0.161
X11	-0.527†	-1.99	0.054	-0.523*	-2.03	0.049
X12	-0.026	-0.17	0.864	-0.027	-0.18	0.859
X13	0.055	1.03	0.309	0.055	1.03	0.308
_cons	38.433	0.77	0.446	39.328	0.92	0.366
R^2	0.0035 (overall)			0.0063 (overall)		
VIF	All VIF < 4; Mean VIF = 2.05			All VIF < 4; Mean VIF = 1.95		
F statistics	F(12,36) = 7.00***; Prob > F = 0.000			F(12,36) = 7.21***; Prob > F = 0.000		
Correlation (corr(u_i, Xb)	-0.662			-0.672		
Hausman's test	chi2(12) = 28.54**; Prob>chi2 = 0.0046			chi2(12) = 28.43**; Prob>chi2 = 0.0048		
LM-test	chibar2(01) = 47.98***; Prob > chibar2 = 0.0000			chibar2(01) = 48.05***; Prob > chibar2 = 0.0000		
Heteroscedasticity Test	chi2 (37) = 1.40E+32***; Prob>chi2 = 0.0000			chi2 (37) = 1.50E+32***; Prob>chi2 = 0.0000		

(Table header: Dependent variable: Y (National entrepreneurship); N = 37 developing countries with 173 year-observations)

Note: significant codes: 0.001 '***'; 0.01 '**'; 0.05 '*'; 0.1 '†'
Source: own study.

Impact of Economic Conditions on National Entrepreneurship

Regarding the impact of GDP growth (X1): Based on the results of the robust fixed-effects models in Table 5, the independent variable X1 had a significant impact on the dependent variable Y at a 95% confidence level (with Coef. = 0.415 & P = 0.033 in R1 and with Coef. = 0.407 & P = 0.034 in R2). This result indicates that GDP growth significantly and positively affects the national entrepreneurship of developing countries. Indeed, economic growth creates a positive psychology and expectation for investors and potential entrepreneurs regarding the future of the economy. Consequently, this stimulation encourages them to pursue market prospects and engage in entrepreneurial activities or expand existing businesses to take advantage of such opportunities. Notably, developing countries often experience higher economic growth rates compared to developed nations due to factors such as rapid industrialisation, urbanisation, and rising domestic consumption. This sustained economic expansion provides fertile ground for entrepreneurship by continually generating new market opportunities and demand for innovative products and services.

This finding aligns with prior research (Acs *et al.*, 2018; Ordeñana *et al.*, 2024; Awoa Awoa *et al.*, 2022; Castaño *et al.*, 2015), which emphasised that economic development fosters entrepreneurship by providing financial and physical resources, improving perceptions of opportunities, and enhancing economic expectations. Higher GDP growth often translates into higher disposable incomes, which not

only increase consumer demand but also expand niche markets, creating opportunities for entrepreneurial ventures. Overall, our findings reaffirm the critical role of economic growth in stimulating national entrepreneurship by providing necessary financial resources, enhancing economic stability, and shaping positive expectations among entrepreneurs.

Regarding the impact of GDP per capital (X2)*:* According to the regression results, the independent variable X2 did not have a significant impact on the dependent variable Y – national entrepreneurship of developing countries, at a 95% confidence level (with Coef. = -9.994 & P = 0.257 in R1 and with Coef. = -9.802 & P = 0.263 in R2). This finding contrasts with previous findings suggesting that GDP per capita plays a crucial role in fostering entrepreneurship by improving economic conditions and increasing disposable income (Castaño *et al.*, 2015; Nafziger, 2012). It can be explained by the fact that many developing countries often experience high and frequent inflation rates, which lead to increased living costs despite the rise in per capita income. Consequently, there is not much financial accumulation, and it does not generate significant resources for entrepreneurship. McMullen *et al.* (2008) even found that GDP per capita has a negative impact on entrepreneurial action.

Moreover, most developing countries have partially industrialised economies and still rely heavily on agriculture. The modern business and production sectors are relatively small and are often owned by the government and private capitalists. Therefore, an increase in GDP per capita may be driven by the rising income of private capitalists, while the actual income of the majority of the population may not increase significantly or remain stagnant. This disparity indicates that even though GDP per capita may rise, only a few individuals accumulate significant financial resources. Potential entrepreneurs may not be among them, resulting in GDP per capita having an insignificant impact on financial resources for entrepreneurship.

Regarding the impact of FDI inflow (X3): the robust fixed-effects model results also show an insignificant impact of the independent variable X3 on the national entrepreneurship of developing countries at the confidence level of 95% (with Coef. = 0.139 & P = 0.400 in R1 and with Coef. = 0.128 & P = 0.420 in R2). This finding contradicts prior research by Zhao (2022) and Afi *et al.* (2022) but aligns with the finding of Hong *et al.* (2021), who suggested that FDI does not generally serve as a stimulus for entrepreneurship. Slesman *et al.* (2021) even found that FDI exert a negative impact on domestic entrepreneurship in emerging economies. The reasons for this could be that FDI firms often possess superior financial, technological, and managerial capabilities, which are often lacking in many developing countries. As a result, FDI firms have a significant competitive advantage in the domestic market, which potential entrepreneurs may perceive as a barrier and risk, discouraging them from making entrepreneurship decisions.

Furthermore, the proportion of equity ownership in FDI firms may result in unfavourable profit distribution for developing countries, meaning there may not be substantial financial resources available for accumulation and savings. Consequently, there may not be significant financial resources to support national entrepreneurship.

However, in the long term, FDI could have a positive impact on national entrepreneurship by opening niche markets, such as supporting industries for the FDI sector. It can also create opportunities for developing countries to enhance their technological and managerial capabilities, thereby increasing the competitiveness of domestic industries and businesses (Afi *et al.*, 2022). In turn, this can serve as motivation and create opportunities for individuals to engage in entrepreneurship.

Regarding the impact of export and import (X4 and X5)*:* According to the results of robust fixed-effects models, the independent variables X4 – Export and X5 – Import did not significantly impact the dependent variable Y – national entrepreneurship of developing countries (with Coef. = 0.015 & P = 0.899 in R1 for export, and with Coef. = 0.028 & P = 0.793 in R2 for import). Contrary to expectations, our findings indicate that export activities do not necessarily foster national entrepreneurship, and imports also fail to show a substantial effect in developing countries.

Previous research has often emphasised the role of exports and imports in enhancing economic growth and facilitating entrepreneurship (Purkayastha *et al.*, 2021; Shane & Venkataraman, 2000). However, our findings challenge these assumptions in the context of developing countries. One possi-

ble explanation lies in the structural challenges of export activities in developing countries. While international trade is often associated with economic growth, export-oriented businesses in these countries frequently face severe constraints, including inadequate infrastructure, logistical inefficiencies, quality control challenges, limited financial access, trade barriers, and technological gaps. As a result, even as export revenues grow, the benefits may not be evenly distributed or substantial enough to translate into increased entrepreneurial activity. This aligns with Nguyen *et al.* (2022), who argue that high export-intensive margins and diversification do not necessarily lead to entrepreneurial growth, as the complexities of entering global markets often outweigh the potential benefits.

Similarly, the insignificant impact of imports on national entrepreneurship suggests that merely increasing access to foreign goods and technology does not automatically translate into new business opportunities. While imports may provide domestic producers with access to better inputs, production efficiency, and cost advantages, these benefits are often contingent on the ability of local businesses to adapt and integrate new technologies effectively. In many developing countries, potential entrepreneurs may lack the technical expertise, financial capacity, or institutional support needed to effectively utilise imported materials and technologies for innovation and business creation. Additionally, high import penetration can intensify competition from foreign firms, making it more challenging for domestic start-ups to become established and achieve growth in local markets.

Regarding the impact of the CPI (X6): our robust fixed-effects model findings show that the variable X6 have a significant impact on national entrepreneurship of developing countries, with a 95% confidence level (with Coef. = 0.042 & P = 0.007 in R1 and with Coef. = 0.042 & P = 0.006 in R2). The CPI is used as an indicator of inflation because it reflects changes in the cost of living for the average consumer. An increase in the CPI implies rising prices of goods and services, potentially leading to inflationary pressures. Noteworthy, high inflation can lead to currency depreciation, posing fundamental challenges and prerequisites related to capital and interest rates for potential entrepreneurs. In the context of developing countries, this issue can become particularly severe, as a large portion of the population has low to moderate incomes, rendering them considerably more vulnerable to the ramifications of inflationary forces.

Interestingly, while inflation is often viewed as a macroeconomic challenge, our finding, in line with Izuchukwu (2023) and Khan *et al.* (2023), suggests that an increase in CPI can have a stimulating effect on entrepreneurial activities in developing economies. Inflation-driven price adjustments may enhance profit margins for businesses, particularly in sectors with high demand elasticity, providing incentives for new market entrants. Moreover, inflationary environments can encourage entrepreneurial investment as individuals and firms seek to hedge against currency depreciation by reallocating capital from savings to business ventures. This effect is particularly pronounced in developing countries, where limited access to financial instruments encourages individuals to seek alternative means of wealth preservation and income generation. Moreover, as wages and revenues adjust to inflation, entrepreneurs may perceive new opportunities in cost-sensitive industries, such as essential consumer goods and services.

Summarising, the regression results show that among the economic factors evaluated for their impact on national entrepreneurship in developing countries, there is a significant positive impact of GDP growth and CPI, but an insignificant one of import, export, GDP per capita, and FDI. Therefore, we can conclude that the hypothesis H1 is partially supported: only some economic factors, such as economic growth and inflation, significantly influence the national entrepreneurship of developing countries. These findings align with the RBV, which emphasises the role of economic resource availability in shaping entrepreneurial activities. We may explain the difference in the aggregate entrepreneurship rate across developing countries by variations in their economic conditions, particularly economic growth and inflation. As countries experience higher GDP growth, there is often an increase in market opportunities, consumer demand, and access to financial resources, all of which create a more favourable environment for entrepreneurship. Moreover, controlled inflation tends to encourage investment rather than savings, as it reduces the real cost of borrowing and provides entrepreneurs with greater access to credit. In contrast, countries with unstable economic growth or high inflation may face increased risks, which deter both investment and entrepreneurial activities.

Impact of Social Conditions on National Entrepreneurship

Regarding the impact of national government expenditure (X7): Based on the results of the robust fixed-effects models, the variable X7 does not have a significant influence on the dependent variable Y – national entrepreneurship within developing countries at a 95% confidence level (with Coef. = 0.112 & P = 0.536 in R1 and with Coef. = 0.092 & P = 0.579 in R2). This suggests that higher government spending does not necessarily translate into increased entrepreneurial activities. Prior research has argued that public expenditure can stimulate economic activity, improve infrastructure, and create a favourable environment for business development (Castaño *et al.*, 2015; McMullen *et al.*, 2008). However, our findings indicate that in developing countries, the impact of government expenditure on entrepreneurship is not straightforward.

One possible explanation is that government spending in these countries tends to be allocated to social welfare programmes, public sector wages, and administrative costs rather than directly supporting entrepreneurial ventures. While infrastructure investments and economic stimulus programs may benefit established businesses, they do not necessarily create new entrepreneurial opportunities. Moreover, excessive government intervention can sometimes crowd out private-sector activities. When public spending dominates key industries, private entrepreneurs may find it difficult to compete, limiting their ability to establish and expand new ventures. Moreover, inefficient public expenditure, misallocation of resources, and bureaucratic inefficiencies in developing countries further weaken the link between government spending and entrepreneurship. Another critical factor is the prevalence of corruption, which distorts the intended benefits of government expenditure (Jiménez *et al.*, 2015). High levels of corruption can divert resources away from productive investments, increase regulatory burdens, and create an uneven playing field for businesses.

Regarding the impact of government investment in education (X8): the robust fixed-effects models showed that variable X8 had a significant and positive impact on national entrepreneurship (Y) at the confidence level of 95% (with Coef. = 3.473 & P = 0.002 in R1 and with Coef. = 3.448 & P = 0.002 in R2). It means the more developing countries' governments invest in education, the higher the national entrepreneurship becomes. Our finding supports Lee and Wong (2003) and Jiménez *et al.* (2015), who identified a positive relationship between investment in education and the establishment of new businesses. This is readily comprehensible because investing in education not only elevates the collective educational attainment but also establishes the fundamental prerequisites of knowledge and consciousness essential for potential entrepreneurs.

Specifically, investing in education is beneficial for any country regardless of its developmental stage. It stands as a foundational requirement for the enhancement of human resource elements within the socioeconomic framework. In developing countries, this investment can be particularly transformative, as it addresses the gap in skills and knowledge that often limits entrepreneurial potential. Investment in education fosters transformative shifts in perceptions, enhances general knowledge, and consequently leads to constructive changes in cognitive processes and behavioural paradigms. For instance, agricultural practitioners benefit significantly from educational exposure, enabling them to adopt new technologies and increase productivity, thus improving both individual and national economic outputs. Furthermore, reinforcing education and raising educational levels within the workforce of developing countries equip them to respond effectively to the evolving demands of modern industries. This enhanced skillset contributes to higher personal earnings and economic value for businesses, which, in turn, creates a more robust resource pool for national entrepreneurship. As a result, these countries experience a conducive environment for entrepreneurship to thrive. Moreover, enhancing education and understanding also improves the ability to identify and seize new business opportunities. As a result, aspiring entrepreneurs in developing countries are more inclined to break away from traditional occupations, such as family farming, and explore new ventures, leading to increased business creation and income generation.

Regarding the impact of government investment in research and development (R&D): The regression results indicate that variable X9 has a significant impact on national entrepreneurship (Y) (with

Coef. = 2.647 & P = 0.059 in R1 and with Coef. = 2.721 & P = 0.047 in R2). This finding aligns with previous studies, such as those by Castaño *et al.* (2015) and Duguet (2004), who emphasised that R&D investment fosters national entrepreneurship. In developing countries, where resource constraints and technological gaps often limit entrepreneurial potential, government investment in R&D plays a crucial role in fostering innovation and the development of new industries. These investments enhance access to advanced technologies and help build essential infrastructure and knowledge networks.

Moreover, government-backed R&D initiatives help alleviate entry barriers faced by aspiring entrepreneurs in developing countries, such as limited access to critical resources, infrastructure challenges, and financial constraints. These initiatives provide entrepreneurs with access to technological advancements and locally adapted business models, thereby fostering innovation and new venture creation. Furthermore, R&D funding stimulates the creation of innovation ecosystems, in which collaboration between entrepreneurs, research institutions, and businesses leads to the commercialisation of new technologies and products. In turn, this strengthens national industries, attracts private investment, and enhances the overall business environment. By cultivating a conducive environment for innovation, government investment in R&D empowers and positions entrepreneurs in developing countries to leverage emerging opportunities.

Regarding the impact of the labour force with different education levels (X10): According to the results of the regression model, the variable X10 did not have a statistically significant effect on national entrepreneurship (Y) at a 95% confidence level (with Coef. = -0.086 & P = 0.159 in R1 and with Coef. = -0.086 & P = 0.161 in R2). This finding contrasts with prior studies that emphasise the positive role of labour force quality in fostering entrepreneurship (Bae *et al.*, 2014; Jiménez *et al.*, 2015). Traditionally, higher education and specialised training are believed to equip individuals with the skills necessary to innovate, adopt technology, and establish businesses. However, our finding suggests that, in the context of developing countries, these expected benefits do not necessarily translate into a substantial increase in entrepreneurial activity.

A possible explanation for the insignificant relationship between labour force quality and national entrepreneurship in developing countries lies in the persistent structural mismatches between the skills provided by education systems and the demands of the entrepreneurial ecosystem. While formal education may enhance theoretical knowledge, many graduates still face significant barriers, such as limited access to financial capital, bureaucratic challenges, and weak institutional support, which hinder their ability to start and sustain businesses (Purkayastha *et al.*, 2021; Duguet, 2004). Moreover, in many developing countries, entrepreneurship is often driven by necessity rather than opportunity (Acs *et al.*, 2018). Thus, individuals may engage in entrepreneurial activities regardless of their education level. Thus, even a well-trained labour force may struggle to convert their skills into new business creation.

Regarding the impact of unemployment (X11), the regression findings show that the variable X11 significantly and negatively affected the dependent variable (Y) – national entrepreneurship (with Coef. = -0.527 & P = 0.054 in R1 and with Coef. = -0.523 & P = 0.049 in R2). This result contradicts the findings of other studies that suggested individuals might turn to entrepreneurship out of necessity when the fear of unemployment forces them into self-employment (Hessels *et al.*, 2008; Thurik *et al.*, 2008). It is readily explicable as increasing unemployment leads to a decrease in income, thereby resulting in a lack of financial resources to support entrepreneurship. In low-income countries characterised by rapidly growing populations and underdeveloped economies, high unemployment rates and a scarcity of job opportunities are prevalent. In certain impoverished countries, it is noteworthy that unemployment rates may even be lower than those in developed countries. However, the literature primarily attributes this discrepancy to the willingness of the labour force to accept precarious and low-paid work, which is less economically efficient and more vulnerable. This is often due to the absence of social security policies, subsidies, and welfare programmes within the country. Therefore, in the context of developing countries, even when unemployment rates appear low, national entrepreneurship may still be hindered.

Prolonged unemployment can also deplete human resources, as it may prevent the labour force from keeping pace with changes in the job market and technological advancements. Over time, some knowledge, skills, and experience may erode due to neglect or a lack of practice, further impeding

entrepreneurship. Moreover, for individuals facing unemployment, the struggle to make a living becomes burdensome and a source of anxiety, negatively impacting their motivation and capacity to engage in entrepreneurship. Consequently, this reduces the overall rate of newly established businesses in the country.

Summarising, our research findings regarding social conditions reveal a negative impact of unemployment, as well as positive impacts of government expenditure on education and R&D expenditure. However, we observed an insignificant impact of gross national expenditure and the labour force quality on national entrepreneurship of developing countries. Thus, we partially accepted the hypothesis H2: only some social factors (such as government expenditure on education, R&D expenditure, and unemployment) influence significantly the national entrepreneurship of developing countries. These findings align with the RBV, which emphasises the role of social resource availability in shaping entrepreneurial activities. Accordingly, differences in entrepreneurship rates across developing countries can be explained by these social conditions, where disparities in education and R&D investment, as well as labour market dynamics, play a crucial role in shaping entrepreneurial outcomes.

Impact of Institutional Entrepreneurial Conditions on National Entrepreneurship

The impact of the cost of business registration procedures (X12); according to the regression results of our research, the variable X12 had an insignificant effect on the dependent variable (Y) – national entrepreneurship at a 95% confidence level (with Coef. = -0.026 & P = 0.864 in R1 and with Coef. = -0.027 & P = 0.859 in R2). Theoretically, the cost of business registration procedures can contribute to the overall cost of entrepreneurship, thereby reducing financial resources available for new businesses. However, once an entrepreneur has accumulated sufficient necessary resources and identified significant business opportunities, such cost may no longer pose a significant financial constraint.

In the context of developing countries, while issues related to costs and finances appear crucial and significantly impact the decisions of potential entrepreneurs, the cost of business registration procedures is not excessively high compared to the expenses associated with developing a business idea and operating the business after official launch. Therefore, this cost does not considerably deter potential entrepreneurs from starting a business. Furthermore, in some cases, supportive measures and institutions from the government or relevant organisations in developing countries can mitigate the impact of business registration costs and create a more favourable entrepreneurial environment. These supportive measures may include reduced fees, streamlined registration processes, or financial incentives to encourage and facilitate entrepreneurship.

The impact of the time required to start a business (X13); according to the results of the regression model, the variable X13 did not have a significant effect on business entrepreneurship (Y) at a 95% confidence level (with Coef. = 0.055 & P = 0.309 in R1 and with Coef. = 0.055 & P = 0.308 in R2). In practice, instead of primarily fixating on this temporal aspect, potential entrepreneurs in developing countries frequently find themselves compelled to await extended durations until they accumulate adequate resources and encounter substantial business opportunities prior to embarking on entrepreneurial endeavours. On one hand, the process of starting a business varies markedly depending on factors such as industry type, business model, and company size. Certain entrepreneurial undertakings can promptly commence operations right from their nascent stages, whereas more intricate and sizable ventures necessitate preparatory work, market analysis, infrastructure development, and partnership establishment. Nevertheless, the availability of financial resources significantly influences the time required to start a business. Entrepreneurs may need to allocate time to amass requisite capital, seek investments, or foster relationships with financial institutions and banks to ensure financial stability during the nascent phases. Furthermore, the duration required for building networks and cultivating partnerships can also affect national entrepreneurship. Partnerships and relationships assume an indispensable role in generating business prospects and enlarging the customer base.

Although administrative processing times are generally not unduly protracted in many countries, in contexts where complex and burdensome regulations and procedures exist, entrepreneurs may rely on legal support services to reduce the time required for business initiation and avoid missing opportunities. Moreover, entrepreneurs may choose to operate informally while awaiting

the completion of formal procedures, thereby minimising the impact of administrative delays on their decision-making processes. Consequently, research findings suggest that the time required to start a business does not fully capture the complexity of entrepreneurship and is not a central concern for entrepreneurs in developing countries.

Summarising, we did not find significant impacts of institutional entrepreneurial conditions on national entrepreneurship in developing countries. This result is surprising, as institutions directly related to business creation are typically considered essential for fostering entrepreneurship. Therefore, we did not accept hypothesis H3. This finding contrasts with previous studies that emphasise the negative impact of high entry costs (Chambers & Munemo, 2019; Dheer, 2017), lengthy and complex registration procedures (Van Stel *et al.*, 2007; Pfeifer *et al.*, 2021) on entrepreneurial activity. This suggests the need for further research to understand why these factors may not have the expected impact in developing economies, possibly due to weak policy implementation, institutional inefficiencies, or, as argued by Sendra-Pons *et al.* (2022), variations in socioeconomic characteristics across countries.

Table 6. Validity of research hypotheses

Hypothesis	Variable	Finding
H1 is partially valid	GDP growth (X1)	Positive impact
	GDP per capital (X2)	Insignificant impact
	Foreign Direct Investment (X3)	Insignificant impact
	Exports (X4)	Insignificant impact
	Imports (X5)	Insignificant impact
	Consumer price index (X6)	Positive impact
H2 is partially valid	Gross national expenditure (X7)	Insignificant impact
	Government expenditure on education (X8)	Positive impact
	Research and development expenditure (X9)	Positive impact
	Labour force with basic, intermediate and advanced education (X10)	Insignificant impact
	Unemployment (X11)	Negative impact
H3 is invalid	Cost of business start-up procedures (X12)	Insignificant impact
	Time required to start a business (X13)	Insignificant impact

Source: own study.

CONCLUSIONS

Main findings and contributions: The current study has clarified the macro conditions influencing national entrepreneurship, which is considered a key driver of economic growth and development in developing countries. We found that with hypotheses H1 and H2 partially supported and hypothesis H3 unsupported, some macro factors have a positive impact, some have a negative impact, and some have no significant impact on national entrepreneurship in developing countries. Specifically, economic growth, CPI, government expenditure on education, and R&D investment positively impact national entrepreneurship of developing countries, whereas unemployment exhibits a negative impact. However, other macro factors such as GDP per capita, FDI inflows, import, export, gross national expenditure, labour force quality and entrepreneurial institutions do not show a significant impact on national entrepreneurship of developing countries.

This study has made significant contributions to the literature on national entrepreneurship by addressing an underexplored research gap. Unlike previous research that often focuses on individual-level entrepreneurship and its determinants, this study shifts the focus to macro conditions influencing national entrepreneurship from the perspectives of the RBV and institutional theory at the country level. By clarifying the macro conditions that governments in developing countries can influence to promote national entrepreneurship, the study provides new and valuable insights into the field. Methodologically, our empirical study contributes by employing panel data analysis on a sample of developing countries using data available from GEM's and the World Bank's open databases. This method enabled a comprehensive cross-country analysis that identifies the factors with positive, negative, or insignificant impacts, thus providing a deeper understanding of how each macro factor influences national entrepreneurship

in developing countries. These findings offer policymakers a clearer perspective on the impact of macro factors on entrepreneurial activity. Consequently, policymakers can formulate strategies and policies to enhance positive factors and mitigate negative ones, fostering an environment conducive to entrepreneurship and sustainable economic development in developing countries.

Policy implications: Our research findings imply interesting policy implications for national entrepreneurship in developing countries, specifically:

Firstly, the positive impact of economic development (GDP growth) on national entrepreneurship underscores the importance of fostering macroeconomic stability and growth as a foundation for entrepreneurial activity. Policymakers in developing countries should prioritise strategies that stimulate sustainable economic growth, such as promoting investment in infrastructure, innovation, and high-potential industries. Additionally, fostering a conducive environment for entrepreneurship, such as reducing barriers to entry, ensuring access to capital, and enhancing market opportunities, would further leverage the benefits of GDP growth. In practice, this may involve targeted fiscal policies, such as tax incentives or subsidies for emerging industries, that encourage business formation and innovation. Long-term growth strategies should focus on building resilient and diversified economies capable of supporting entrepreneurship even during periods of economic uncertainty.

Secondly, the positive relationship between the CPI and national entrepreneurship highlights the need for price stability in fostering entrepreneurial activity in developing countries. Inflation control policies should remain a priority, as erratic price fluctuations can undermine investor confidence and limit the purchasing power of consumers. Policymakers should focus on maintaining low and stable inflation through effective monetary policies, such as adjusting interest rates and controlling money supply growth. Additionally, price stability can enhance the predictability of business costs and revenues, enabling entrepreneurs to plan and make long-term investments with greater certainty. As such, central banks and governments should work collaboratively to ensure inflation remains within a manageable and sustainable range, thereby supporting entrepreneurial ventures in developing countries.

Thirdly, the positive impact of government expenditure on education on national entrepreneurship suggests that investment in human capital is crucial for fostering entrepreneurial capabilities. Policymakers should increase investment in education systems, with a particular emphasis on programs that equip individuals with the skills, knowledge, and an entrepreneurial mindset necessary to start and grow businesses. This could include expanding vocational training, entrepreneurship education, and access to higher education, particularly in fields relevant to emerging sectors. By improving the quality and accessibility of education, governments can ensure a skilled workforce that drives innovation and entrepreneurial development. Moreover, policies that promote lifelong learning and entrepreneurship support programs can encourage individuals to pursue entrepreneurial careers, thereby enhancing national entrepreneurship levels in developing countries.

Fourthly, recognising the positive influence of government expenditure on education on national entrepreneurship underscores the importance of investing in education as a means to foster entrepreneurial skills and innovation. Governments in developing countries should allocate resources to enhance the quality and accessibility of education, especially in fields relevant to entrepreneurship. Additionally, initiatives that promote entrepreneurship education and skill development should be encouraged and expanded.

Fifthly, addressing the negative effects of unemployment on national entrepreneurship requires a multi-faceted approach. Governments in developing countries should focus on job creation through entrepreneurship promotion programs, support for startups, and incentives for small business growth. Additionally, comprehensive labour market reforms that reduce barriers to employment can help mitigate the negative consequences of unemployment.

Research limits and perspectives: By focusing on developing countries, we may not capture the full spectrum of entrepreneurship dynamics present in the global context. Another limitation consists of the macro-level analysis, which may not provide a comprehensive understanding of the individual experiences and challenges faced by entrepreneurs within these countries. The intricacies of personal motivations, access to resources, and the impact of cultural and social factors on entrepreneurship remain beyond the scope of this study. Additionally, our data coverage was limited to a 16-

year period (2003-2019), which constrains the ability to capture long-term patterns or assess delayed effects and temporal dynamics that could provide deeper insights into how the impact of macro factors evolves. Notably, the dataset is unbalanced, as some countries have data spanning up to 10 years while others only have one year, due to differences in data availability. This limit underscores the need for future research to collect more temporally uniform and extended datasets, despite the considerable time and resource requirements involved.

Moreover, the absence of certain institutional variables, such as control of corruption, government effectiveness, regulatory quality, and the rule of law, further limits the comprehensiveness of our analysis. We also did not examine disparities between countries, as the primary aim of this study was to analyse national entrepreneurship in developing countries as a group, rather than to explore differences among countries within different economic contexts. Therefore, while our research offers valuable insights into the macroeconomic conditions shaping national entrepreneurship in developing countries, it is essential to acknowledge these limitations when interpreting our findings.

Future studies may benefit from incorporating a more extensive array of macro indicators, particularly institutional ones such as control of corruption, government effectiveness, regulatory quality, and the rule of law, to enhance the comprehensiveness of the analysis. Moreover, exploring the micro-level dynamics of entrepreneurship, such as individual motivations, access to resources, and the influence of cultural and social factors, could provide a more nuanced understanding of entrepreneurial behaviours and challenges within developing countries. This would complement the macro-level analysis and offer a more holistic perspective on the entrepreneurial phenomenon.

Moreover, future studies could examine the disparities between different countries, as this study focused on developing countries as a whole. A comparative analysis of countries with varying economic structures – such as factor-driven, efficiency-driven, and innovation-driven economies – could uncover how different macroeconomic and institutional factors influence entrepreneurship in each context. Such analysis would allow for a more detailed understanding of the specific needs and challenges faced by entrepreneurs in distinct economic environments. Further, future research could benefit from analysing sector-specific entrepreneurship to identify how macroeconomic conditions and institutional factors influence entrepreneurship across different industries. Sector-specific studies could provide valuable insights into the varied challenges and opportunities entrepreneurs face in specific fields, which might differ from the general trends observed at the national level.

Moreover, expanding the temporal scope of the analysis to include longer time horizons would allow for the examination of delayed effects and temporal dynamics, helping to understand how the impact of macroeconomic and institutional factors evolves. By addressing these aspects, future research could build upon the limitations of this study and offer more comprehensive insights into the factors influencing national entrepreneurship.

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Use of Artificial Intelligence

We acknowledge the use of ChatGPT to check the spelling and grammar of this article. The prompts used include general instructions for grammar and spell-checking. The output from these prompts was used to enhance the language of this article but did not generate any of the ideas or explanatory logic shared.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Assessing the influence of digitalisation on systemic risk in the insurance sectors of European Union countries

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A B S T R A C T
Objective: The article aims to study how much digitalisation influences the systemic risk (SR) in the insurance sector of European Union (EU) countries.
Research Design & Methods: In this research, we introduce an innovative, quantitative method for exploring the impact of digitalisation and assessing the similarities and interconnections among all European Union countries' insurance sectors from 2004 to 2018 within the framework of Industry 4.0. The study integrates statistical and econometric tools with network modelling techniques, focusing on the topological indicators of minimum spanning trees (MST) derived from multidimensional dynamic time warping (DTW) distances. We analysed two datasets. The first one comprises exclusively data describing insurance sectors, while the second incorporates data detailing both insurance sectors and the digitalisation processes of individual EU countries. We assessed the similarity of the sectors' dynamics over the analysed period, examining network behaviour during subprime crises, periods of excessive public debt, and immigration-related crises in Europe.
Findings: The proposed tools made it possible to determine how digitalisation contributes to the increase in systemic risk in the EU insurance sector over the periods examined and effectively measure similarity levels, and outline indirect connections between insurance sectors.
Implications & Recommendations: Because similarity can be a potential indirect channel for systemic risk contagion, countries with comparable insurance sectors and shared digitalisation-related behaviours may undergo similar repercussions during global financial downturns. Research endeavours in the insurance sector must consider digitalisation indicators that encompass technological advancements and consumer behaviour.
Contribution & Value Added: We developed a new method to examine the similarity of the insurance sectors of the European Union countries and to assess the dynamics of changes in this similarity in the era of Insurance 4.0. Such an analysis allows for a long-term assessment of the possibility of spreading threats in the insurance sector throughout the European Union.
Article type: research article
Keywords: digitalisation; dynamic time warping; minimum spanning trees; systemic risk; insurance sector
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INTRODUCTION

The prevalent functional classification of financial institutions typically divides them into investment, deposit, and risk-dispersing institutions. The latter group includes entities such as insurance companies, reinsurance companies, life insurance firms, and those offering financial security for old age. Recognising the paramount importance of the insurance sector in economics and finance, and 'given the diversity of initiatives and the high speed of developments, monitoring of digitalisation initiatives in the European insurance sector and assessing opportunities and risks have become an increasingly important priority'

(EIOPA, 2024). Therefore, there is a compelling need for a thorough examination within the framework of the fourth industrial revolution, referred to as Insurance 4.0. Although the World Economic Forum in 2018 (Schwab & Davis, 2018) was dedicated to the Fourth Industrial Revolution, participants gave relatively little specific attention to the insurance sector itself. On the other hand, in IMF (2020) Staff Discussion Notes (SDNs) showcase policy-related analysis and research being developed by IMF staff members and are published to elicit comments and to encourage debate. This document emphasises that due to technological progress and the ever-increasing possibilities of good use of this advanced development, the threat of cyber risk is growing, which is becoming a cross-border and therefore systemic problem. The authors of the document 'Cyber Risk and Financial Stability: It's a Small World After All' present the results of the discussion on this phenomenon. And although they do not devote special attention to the insurance sector, they do indicate the need to subject it to additional financial supervision due to its important position in the entire system.

In Nicoletti's work (2020), the rationale behind and how Insurance 4.0 can holistically revolutionise the insurance industry are explored. Nicoletti (2020) affirms that, thus far, insurance has largely remained on the periphery of the digital transformation wave. However, the global recession and the pandemic have inflicted severe blows on this industry. Post-pandemic, it becomes imperative to devise and execute innovative strategies within the insurance domain. Already, significant segments of the insurance industry are witnessing substantial impacts from digitalisation, particularly in the realm of distribution, which is undergoing a profound digitisation process. Digitalisation is poised to bolster other facets of the insurance industry's value network as well, with customers eagerly anticipating the advent of Insurance 4.0.

Ronken (2018) delves into the concept of Industry 4.0 and its significance for the insurance sector. Insurance 4.0 entails the seamless integration of insurance into a symbiotic ecosystem that fosters exchange-to-exchange (E2E) interactions, where information exchange benefits all participants. This interconnectedness not only expedites the evolution of the insurance sector but also introduces the risk of heightened susceptibility to systemic disruptions and the emergence of novel global risks.

To effectively navigate these challenges and bolster resilience, it is imperative to conduct research aimed at understanding, measuring, and predicting the evolution of interdependencies between various risk types, thereby necessitating the introduction of new concepts to traditional risk management frameworks.

The present article adopts a unique approach by analysing data pertaining to the insurance sector and the levels of digitalisation across the 28 EU countries, employing network theory and the multidimensional DTW algorithm. It addresses a notable gap in the existing literature by exploring the dynamics of similarity among insurance sectors across countries following the EU enlargement.

The next two sections delve into the insurance sector within the context of Industry 4.0, systemic risks within the insurance industry, and present the data used in the analysis. Then, in the following section, we outline the methodology, featuring DTW and MST, elucidating MST topological indicators and introduce a novel approach to MST construction. The next section presents the results, analysing the interconnections between countries, thereby shedding light on potential pathways for the transmission of financial issues. The study concludes by offering insights into the ramifications of digitalisation on the insurance sectors of EU countries.

LITERATURE REVIEW

In this section, we present the literature review concerning phenomena connecting the fourth industrial revolution with systemic risk in the insurance sector, and we motivate the use of the DTW algorithm.

Fourth Industrial Revolution in the Insurance Sector

Technological advancements are fundamentally reshaping production methods and driving economic growth. The initial industrial revolution, which sparked in the eighteenth century, harnessed steam power and mechanised production. Subsequently, the second industrial revolution emerged in the nineteenth century with the introduction of electricity and the assembly line. The third industrial revolution, beginning in the 1970s, brought about partial production automation through programmable memory

controllers and computers. According to Hilbert (2020), in the late 1980s, less than 1% of data was digital, while by 2012, 99% of the world's information had become digital. Presently, we find ourselves amidst the fourth industrial revolution, commonly referred to as 'Industry 4.0,' characterised by the integration of information and communication technologies into industrial operations. We may find an example in the burgeoning LendTech sector within FinTech (Kaur & Singh, 2023; Waliszewski *et al.,* 2024).

This transformative phase, driven by artificial intelligence (AI), the Internet of Things (IoT), robotics, and big data, is reshaping global economic systems, including the insurance sector. However, Lyons (2019) highlights the insurance sector's limited or slowed involvement in the fourth industrial revolution. Simultaneously, it underscores the immense potential for transforming insurance into Insurance 4.0. Masiello (2020), in the book 'Insurance Agency 4.0: Prepare Your Agency for the Future; Develop Your Road Map for Digitalisation; Increase Profit, Scalability and Time,' gathers solutions and strategies for insurance agents and the sector to support the development of Insurance 4.0. Eling and Lehmann (2018) argue that while other industries have already undergone significant transformation through the integration of analogue and digital worlds with new technologies, the insurance industry's transformation has been relatively slow, with digital technologies yet to be fully exploited. They support their argument by analysing 84 scientific articles and creating a database of research, articles, and working papers assessing the impact of digitalisation on the insurance sector, focusing on business and economic literature on risk and insurance. From their analysis, we can conclude that the relationship between new technologies and insurance will raise numerous new research questions.

Industry 4.0 brings forth many new issues and questions for the insurance sector. Participants in the Swiss Risk and Insurance Forum in 2016, 2018, and 2019 discuss the digitalisation of the insurance sector, summarising the main topics and findings from these forums (Albrecher *et al*., 2016; Albrecher *et al.,* 2018; Albrecher *et al.,* 2019). The events gathered experts from the insurance industry, regulatory bodies, and consulting firms to discuss the challenges arising from the impact of data science and digitalisation in the insurance sector. Eling and Lehmann (2018) assert that the academic community should also be part of the discussion on how to utilise digital technologies in the economy and society.

In a comprehensive analysis, as presented in the paper (Denkowska *et al.,* 2023), the authors observe notable disparities in the insurance markets of EU countries. Factors such as a nation's economic development, household wealth, and insurance premiums significantly influence the structure of its insurance market. Building upon the research by Denkowska *et al.* (2023), we continue to investigate the impact of digitalisation on the insurance sector of EU countries and its dynamics. To evaluate the dynamics of changes and their impact on development in these countries, we employed the multidimensional DTW algorithm, assessing classic measures describing the insurance sector. These measures include insurance market penetration, insurance market density, insurance market concentration, average value of total insurance assets, investment to GDP ratio, and the number of companies in the total market per 1 million inhabitants. To examine the quantitative impact of digitalisation on the EU countries' insurance sector, we utilise appropriate indicators to gauge digitalisation levels in various aspects of society. These indicators cover five key areas of digitalisation development: broadband internet and household connectivity, the percentage of households with an internet connection, people with ICT education based on employment status, online activities such as banking and information searches, individual online shopping behaviour, and efforts to promote e-commerce and digital integration among individuals. Our research spans the period of 2004-2018. In the context of the fourth industrial revolution, the Digital Economy and Society Index (DESI), established in 2014, serves as a crucial development indicator, which we considered separately in our research.

Systemic Risk in the Insurance Sector

The insurance market is now an integral component of the comprehensive safety net within the European Union financial market. This inclusion stems from the imposition of financial management rules on insurance companies, the establishment of regulations on the capital requirements of market entities, the introduction of common principles for public and internal supervision, the enforcement of strict procedures for financial services provision, and the extension of consumer safety guarantees. Oversight of the Union's financial security is conducted by the European Banking Authority,

the European Insurance and Occupational Pensions Authority (EIOPA), and the European Securities and Markets Authority.

EIOPA's primary goal is to ensure the effective implementation of legislation in the insurance sector to maintain financial stability and adequately protect consumers of financial services. Financial crises have underscored that SR is a crucial issue in a globalised economy. Despite historically insurance sector was viewed as a non-generating SR, in-depth research following the AIG crisis in 2008 has revealed the potential for the insurance sector to create or increase SR.

Academic research aims to identify effective predictive methods that support macro-prudential supervision. A key requirement for successful regulation and supervision is the authority's ability to collect and analyse comprehensive insurance market data. According to IAIS, IMF, and NAIC, collected data should offer the opportunity to assess insurance activity and risk based on indicators related to profitability, income generation, capital/provisions and leverage adequacy, liquidity, underwriting performance, risks, investment performance, and reinsurance performance and risks.

Kwon and Wolfrom (2017) discuss the analytical tools used by supervisory authorities for market and macro-prudential purposes in 24 OECD countries and beyond. The indicators described assess the insurance sector, including aspects of validity, competition, scope of activity, insurance market risk, and SR. The article presents information on monitoring indicators related to interconnections and changes in asset allocation – two areas with potential SR implications.

The OECD describes how 24 selected countries undergo Insurance Market Risk analysis with periodic reviews of market risk, key indicators, interconnectedness, changes in asset allocation, and stress testing indicators. A common analytical tool used in many countries involves periodic reviews of specific types of risk for the functioning of insurance markets. In Europe, insurance regulators contribute to the analysis of financial stability by publishing reports prepared by EIOPA every two years. The document by the EIOPA (2017) initiated a series of documents on SR in the insurance sector, supporting macro-prudential policy and contributing to the debate on the specific nature of insurance activity in the context of SR.

The International Association of Insurance Supervisors (IAIS), which aims to promote effective and globally consistent supervision of the insurance industry, brings together insurance supervision authorities from over 130 countries and international entities, including the OECD, World Bank, and International Monetary Fund. In July 2013, nine insurance institutions were identified as Global Systemically Important Insurers (G-SIIs), marking institutions of particular importance for global financial stability due to their size, market power, and global connections. The criteria for determining systemically important insurance institutions (EIOPA, 2017) include size (5%), global activity (5%), interconnectedness (40%), asset liquidation (45%), and substitutability (5%). Given the substantial weight assigned to interconnectedness, minimum spanning trees (MST) indicators and networks between countries are utilised to analyse the potential generation and spread of SR.

Regulation (EU) 2019/2176 of the European Parliament and the Council, amending Regulation (EU) No 1092/2010 outlines the determination of systemic risk. It establishes a European Systemic Risk Board and defines SR as undesirable events with systemic importance, affecting the financial system and the real economy. The reasons for the implementation of these events are systemically important, with general and specific reasons mainly related to the financial sector. The consequences of these events impact the real economy. The need to analyse systemic risk is highlighted in many studies on risk management (Jajuga, 2023).

We may find various concepts of systemic risk analysis in Harrington, 2009; Adrian and Brunnermeier, 2016; Jajuga *et al.,* 2017; Bisias *et al.,* 2012. Moreover, we find an approach based on different measures*, e.g.*, conditional value at risk (CoVaR) and ΔCoVaR (Adrian & Brunnermeier, 2016), Co-Risk (Chan-Lau, 2010), marginal expected shortfall (MES) (Acharya *et al.,* 2017), dynamic causality index (DCI) (Billio *et al.,* 2012), SRISK (Brownlees & Engle, 2017), systemic contingent claims analysis (Gray & Jobst, 2013). In recent years, apart from the measurement methods presented above, network analysis has become the basic tool for examining systemic risk where connections are established using different methods: Granger causality networks (Billio *et al.,* 2012), vector autoregression model (variance decomposition (Diebold & Yılmaz, 2014)), information theory (transfer entropy (Bekiros *et al.,* 2017)). Relevant associations are captured by, *e.g.*, minimum spanning trees; glasso, tlasso methods

(Torri *et al.,* 2018) and using topological network indicators derived from graph theory (Denkowska & Wanat, 2019; 2020a; 2020b; 2021; 2022).

We analysed the indirect links of institutions within the insurance sectors of EU countries, expressed by the similarity in the areas of insurance markets, considering digitalisation indicators. We assumed that in groups of countries with similar insurance sectors exhibiting comparable behaviours, economic conditions (*e.g.*, GDP), and a similar level of internet access and usage, we would observe similar behaviours in the event of a crisis. Hence, we encoded the SR transmission channel between sectors of EU countries in the apparent similarity of these sectors. The literature does not typically analyse the global (entire insurance sector) approach to SR. We analysed the entire insurance sector of EU countries based on data describing entire sectors and not individual insurers. The proposed approach in this article is innovative. The novelty is the new construction of MST based on the multivariate DTW algorithm. We present this construction in the methodology section.

Dynamic Time Warping Motivation

Dynamic time warping stands as one of the algorithms designed for assessing the similarity between two time series of varying lengths, even those that may exhibit temporal differences. Originally introduced in the 1960s by Bellman and Calaba (1959), DTW has gained prominence in recent years, emerging as the preferred distance measure for various time series data mining applications. Widely utilized in non-economic fields such as speech recognition (Sakoe & Chiba, 1978), image processing (Cedras & Shah, 1995), motion recognition (Geiger *et al.,* 1995), ECG analysis, biometrics, signal analysis, and data mining (Keogh & Pazzani, 2000), DTW has demonstrated its versatility.

In a study by Petitjean *et al.* (2011), the non-parametric DTW measure of similarity outperformed other measures like the Pearson correlation coefficient. However, despite its potential, Franses and Wiemann (2020) assert that economic research has not fully harnessed the capabilities of dynamic time warping. Notable exceptions include the study of Wang *et al.* (2012), representing some of the few instances where the DTW technique has been applied in economic research.

Noteworthy, the DTW algorithm goes beyond mere distance calculation. It captures the underlying similarity between time series. In our research, we used the multidimensional DTW algorithm. We used this measure of similarity of multivariate time series here as the value assigned to the edges between MST vertices that correspond to the insurance sectors of EU countries.

To sum up this introduction to the examined issue, we would like to emphasise that our contribution to the development of the methodology and our empirical research fills a research gap. The proposed methodology allows for a multidimensional analysis of the insurance sectors of EU countries. We will empirically confirm that the topological indicators of innovatively constructed MSTs allow for the assessment of systemic risk in the European Union insurance sector. The study provides evidence that the analysis of systemic risk in the insurance sector should take into account society's activities related to digitalisation. The dynamics of the structure of connections between the insurance sectors of EU countries change if we consider the processes of the Industrial Revolution 4.0. The effects of the Revolution 4.0 may increase threats in the entire insurance system.

RESEARCH METHODOLOGY

In this section, we present the data and tools used in the research. We considered two datasets: the first one characterises the insurance sector, while the second one describes consumers' behaviour in the context of digitalisation. We use tools such as the MST based on three types of weights. The first weight is determined using the Mahalanobis distance, while the other two are derived from the DTW algorithm applied in two different ways. The main goal of this research was to analyse the dynamics of the MSTs structure. We followed topological indicators of the MSTs to observe when and how potential risks may propagate during the period 2004-2018, focusing on different crisis subperiods within this timeframe.

Dynamic Time Warping Algorithm and Minimum Spanning Tree

In this part, we present the tools used in the research. We discuss the mechanism of the DTW algorithm, the construction of MSTs, as well as the indicators describing the structure of these MSTs and their interpretation in the context of systemic risk (Denkowska & Wanat, 2022).

We considered two time series $X = (x_1, \ldots x_n)$ and $Y = (y_1, \ldots y_m)$ for $n \in \{1\ 2\ , , \ldots, , N\}$, $m \in \{1\ 2\ , , \ldots, , M\}$, and $N, M \in \mathbf{N}$.

We denoted by S the space of the series elements that we compare

Therefore $x_n, y_m \in S$ for $n \in \{1\ 2\ , , \ldots, , N\}$ and $m \in \{1\ 2\ , , \ldots, , M\}$.

To compare different features, you need a local measure of costs, sometimes also known as a local distance measure, i.e. a function $c \colon S \times S \to \mathbf{R}_+$. Usually, c(x,y) is small (low cost), if x and y are similar; otherwise c (x, y) is large (high cost). Determining the local cost measure for each pair of terms of X and Y series, we obtained a cost matrix $C_{N \times M}$ defined by $C(n, m) \coloneqq c(x_n, y_m)$.

The local cost measure can be determined by e.g., $c(x_n, y_m) = |x_n - y_m|$ or $c(x_n, y_m) = (x_n - y_m)^2$.

Then the warping path is determined. A warping path is a sequence $w = (w_1, \ldots, w_K)$, for $w_k = (n_k, m_k) \in \{1, \ldots, N\} \times \{1, \ldots, M\}$, for $k \in \{1, \ldots, K\}$ and meets the following conditions:

(i) Boundary condition: $w_1 = (1,1)$ and $w_K = (N, M)$
(ii) Monotonicity condition: $n_1 \leq n_2 \leq \ldots \leq n_K$ and $m_1 \leq m_2 \leq \ldots \leq m_K$
(iii) Step size condition: $w_{k+1} - w_k \in \{(1, 0), (0, 1), (1, 1)\}$ for $k \in \{1, \ldots, K - 1\}$.

Note that the step size condition (iii) implies the monotonicity condition (ii), which is nevertheless explicitly cited for the sake of clarity. The warping path $w = (w_1, \ldots, w_K)$ defines the alignment between two series $X = (x_1, \ldots x_n)$ and $Y = (y_1, \ldots y_m)$ by assigning an item x_n from X to the item y_n from Y. The boundary condition (i) forces the first elements of X and Y respectively and the last elements of X and Y to be aligned respectively with one another. In other words, the alignment applies to the entirety of the X and Y sequences. The monotonicity condition reflects the requirement for faithful timing: if an element in X precedes the other, this should also be maintained for the corresponding elements in Y and vice versa. Finally, the step size condition expresses a kind of continuity condition: no element in X and Y can be omitted, and there are no repetitions in the alignment (in the sense that all the pairs of indices included in the warp path p are pairwise distinct).

The total cost $c_w(X, Y)$ of the *warping path w* between X and Y with respect to the local cost measure c (x, y) is defined as $c_w(X, Y) \coloneqq \sum_{k=1}^{K} c(x_{n_k}, y_{m_k})$

An optimal warping path between X and Y is denoted by w^* – it is a warping path with the minimum total cost of all possible paths.

$DTW(X, Y) \coloneqq c_{w^*}(X, Y) = \min\{c_w(X, Y), \text{where } w \text{ is an } (N, M) \text{ warping path}\}$.

Most studies in the literature consider only the one-dimensional case. The generalisation of DTW to the multivariate case is typically approached in one of two ways: dependent or independent warping. An algorithm that differentiates between data types and adapts the computation of multivariate DTW is discussed in Shokoohi-Yekta *et al.* (2017). Machine learning mechanisms can serve in the proposed approach, as described by Zhao *et al.* (2016), to learn multiple local Mahalanobis distance metrics for k-nearest neighbour (kNN) classification of temporal sequences.

Identifying, measuring, and predicting systemic risk within the financial sector necessitates employing tools that facilitate the assessment and quantitative analysis of the entire system. The interconnectedness pattern among the elements within the system plays a pivotal role in understanding its behaviour (Boccara, 2003). Indeed, one cannot fully comprehend a system by isolating its individual components (Andrzejak *et al.,* 2024). A widely adopted approach to scrutinising interaction patterns within a given system involves constructing a network (graph) comprising nodes and edges (Albert, 2002). Thus, we employed network theory in our research.

The MST utilised in our study, introduced by Kruskal (1956), encapsulates information about the global structure of the network, simplifying analysis by capturing the most significant connections among the studied entities. A minimum spanning tree is a connected and acyclic graph with the least

sum of weights assigned to each edge. Numerous recent studies in economics and finance leverage MSTs to investigate the topological structure of these networks. For instance, Andrzejak *et al.* (2024) analysed the currency network using various methods to determine the distance between nodes and compare the topological structures of the resulting networks. They identified a method that effectively describes the currency market's dependence structure, particularly sensitive to changes.

In our case, the vertices of MST are the insurance sectors of individual EU countries, and we assign a distance to each edge, as an innovation, we shall do this in three different ways (see the next point). The purpose of the modification of the MST structure, which was originally proposed by Mantegna (1999), is to use MST indicators to analyse the similarity dynamics of EU insurance sectors. The edges with the lowest weights are interpreted as relatively short distances and hence show great similarities between the pairs of EU insurance sectors.

Topological MST Indicators and Their Interpretation in the Context of Systemic Risk

We analysed the time series of selected MST topological indicators such as average path length (APL), maximum degree (Max.Degree), parameters 'alpha' of the power law of the degree distribution (alpha), network diameter (Diameter), assortativity.

Average path length (Wang *et al.,* 2014). This indicator is defined as the average number of steps along the shortest paths for all possible pairs of network nodes (vertices). It measures the effectiveness of information flow or mass transport in a given network. APL is one of the strongest measures of network topology, along with its grouping factor and degree distribution. It distinguishes an easy-to-go network from a more complex and inefficient one. The smaller the average path length, the easier the flow of information. Of course, we are talking about average, so the network itself can have several very distant nodes and many adjacent nodes.

Maximum degree (Wang *et al.,* 2014). This is the number of edges connected to a given vertex. If the maximum degree is growing, it means that in the group of insurers, some insurer has many more connections with others. In a situation of shock, in such a vertex, the risk of spreading its effects increases.

Parameter α of the vertex degree distribution required to follow a power law (Wang *et al.,* 2014). This indicator measures the scale-free behaviour of a network (Rak & Rak, 2020). The network is called scale-free if the distribution $P(s)$ of the number of links between the vertices follows a power law, i.e. it has (asymptotically) the form $P(s) = C \cdot s^{-\alpha}$, $\alpha > 0$, where α is a parameter specific to the given network. The power law followed by the degree distribution gives the network a kind of fractal self-similarity properties, which explains the name. A scale-free network is characterised by a small number of vertices having a large number of connections (such nodes are called hubs) and many vertices that have only one connection. Such a network is 'favourable' to the propagation of systemic risk, and the companies-hubs that it has are systemically relevant. If the MSTs are scale-free, with the alpha value being closer to 2, it means that the MST structure is star-shaped, the hubs are high-degree nodes.

Diameter of the network (Li *et al.,* 2018). It is determined by choosing from among all the shortest paths connecting any pair of vertices the longest one. For MST, this is simply the longest path in the MST. When the diameter decreases, it means that the farther lying nodes become closer.

Assortativity (Newman, 2002) is a graphic measure. It shows to what extent nodes in the network associate with one another by similarity or opposition (positive or negative mating). Basically, the network's assortativity is determined by the degree (number of direct neighbours) of nodes in the network. Assortativity is expressed as a scalar -1 ≤ρ≤ 1. The network is said to be assortative when high-degree nodes are mostly connected to other high-degree nodes, while low-degree nodes are mostly connected to other low-degree nodes. The network is said to be non-assortatative when high-degree nodes are connected mostly to low-degree nodes and low-degree nodes are mostly connected to high-degree nodes. Assortativity provides information on the structure of the network, but also on its dynamic behaviour and robustness. The original definition of assortativity (Newman, 2002) for unweighted, undirected networks is based on the correlation between random variables. A negative assortativity means that in each state the tree is rather non-assortative, *i.e.*, the vertices tend to merge rather on a less similar basis: those that have a high degree with those that have few connections. This is usually associated with the previously described property of a scale-free network.

MST Construction

In this part, we present how the MST is constructed in three different ways. The proposed methods allow for capturing the dominant structural patterns in the analysed time intervals. By analysing the topological indicators of each MST, which describe their structure, we assess the dynamics of changes in the interconnections between EU insurance sectors. To fully reflect the dynamic relationships, MSTs are constructed in three different ways, also using a rolling window approach. The first method assigns weights to the edges based on the standard Mahalanobis distance, calculated year by year between pairs of EU insurance sectors. The second method uses a multidimensional DTW distance as the edge weights. The distance between time series is determined incrementally for each subsequent year. The third method applies a multivariate DTW distance calculated over four-year periods. For each year, we determine the distance between the time series using the data from the corresponding four-year window. For each type of MST construction, we also provide an explanation of how to interpret the information contained in each constructed MST.

MST Based on the Mahalanobis Distance

For fixed multidimensional vectors describing a given country, we considered the Mahalanobis distance, which is the distance between two points in a multidimensional space that differentiates the contribution of individual component coordinates of points and uses the correlations between them.

It is defined as $d_m(x, y) = \sqrt{(x-y)^T C^{-1}(x-y)}$, where $x = [x_1, \ldots, x_n]$, $y = [y_1, \ldots, y_n]$ are vectors from $\mathbb{R}^n$ and C is a symmetric, positive definite matrix. This distance is commonly referred to as the Euclidean weighted distance, where C^{-1} is the weight matrix. While Euclidean distance measures the straight-line distance between two points, the Mahalanobis distance takes into account correlations and the spread (variance) of the data. This means that if the data is stretched in a certain direction (*e.g.*, due to variable correlation), the Mahalanobis distance will 'shorten' the distance along that direction. Since we aimed to capture similarities between multidimensional datasets, and because the Mahalanobis distance is also robust concerning differences in measurement units and scales, its application is more appropriate for our research than that of the standard Euclidean distance. Further, using Kruskal's algorithm, we construct the MST for each year in the analysed period from 2004 to 2018.

In the next step, we generated a time series of topological indicators that describe the structure of each MST. Based on these indicators, we concluded the interrelationships and similarities between the insurance sectors of EU countries each year. Each value of a topological indicator in a given year reflects the structural characteristics of the MST for that year, thus defining the links between the EU insurance sectors. Based on the topological indicators of the 15 MSTs constructed using data from 2004-2018, we assessed the dynamics of changes in interconnections between the insurance sectors of EU member states and evaluated the significance of these changes for systemic risk contagion across the Union.

MST Based on Multidimensional Distance DTW in an Incremental Manner

In this MST construction, we used vectors from $\mathbb{R}^n$ representing the EU countries for each year in the period 2004-2018. For the given time series, we computed a multidimensional DTW distance for each of the 28 countries in such a way that, for each year from 2004 to 2018, the DTW distance is calculated incrementally. That is, the DTW in the *n*-th year reflected the similarity of the time series from 2004 up to year *n*. Based on the DTW distances obtained in this way, we constructed MSTs for each year using Kruskal's algorithm, as in the previous approaches.

The MST corresponding to a given year reflects the structural similarity between EU insurance markets accumulated from 2004 to that year. The evolution of these MSTs and their associated topological indicators reveal how the interlinkages between the insurance sectors of EU countries have changed over time, and whether integration or fragmentation has taken place. Each yearly MST provides insights into the changing dependencies across the EU insurance sector, capturing both current and historical dynamics since 2004.

MST Based on Multidimensional Distance DTW from the Period in Four-Year Windows

In this construction, as in the second approach, we calculated a multidimensional DTW distance for each of the 28 countries based on the given time series. However, for each year in the period 2004-2018, the DTW distance was determined over a rolling four-year window. That is, the DTW value in year n reflected the similarity of the time series over the four years preceding year n. Using these DTW distances, we constructed MSTs for each year, as before, employing Kruskal's algorithm.

The MST for a given year captures, therefore, the structural similarity of EU insurance markets during the preceding four-year period, enabling an assessment of recent trends and short-term inter-dependencies between the sectors.

RESULTS AND DISCUSSION

In this section, we present the results concerning the evolving structure of MSTs. It is also important to emphasise that we applied the three proposed methods of MST construction to three distinct datasets. As mentioned earlier in the data section, we based the analysis on the following data sources: the first set described the insurance sector from 2004 to 2018, the second set included both the insurance sector and digitalisation indicators for the same period, while the third dataset extended the analysis to include insurance sector data alongside five DESI domains from 2014 to 2018.

We conducted an analysis comparing the development of the insurance sector with its progression, considering additional data that must be factored in during the era of the Fourth Industrial Revolution. Insurance activities are increasingly intertwined with Internet usage and the ongoing development of new technologies, such as real-time information transmission and location-based services. This comprehensive analysis of the intersection between the insurance sector and digitalisation has not been performed in the literature to date.

The time series of MST topological indicators reflects the dynamics of changes in the similarity and interconnections between the insurance sectors of EU countries over the 15 years. Each method of MST construction leads to distinct results. The topological indicators obtained from different approaches contain complementary types of information. The MST based on the Mahalanobis distance captures the relationships between the insurance sectors of EU countries only within a given year.

In contrast, the MSTs constructed using multivariate DTW distances reflect the similarity of development patterns across countries either over the entire period from 2004 to the given year or within rolling four-year windows. This allows us to detect similarity in trends even when countries develop at different rates but follow comparable trajectories. As such, DTW-based MSTs capture the structural convergence of insurance sectors over time. Thus, although in a given year the Mahalanobis distance may show significant differences between countries, the DTW-based approaches may reveal strong long-term or short-term similarities in the development paths of their insurance sectors.

In Figures 1 and 2, we present examples of MSTs, both constructed using data from the year 2007. The MST in Figure 1 illustrates the interconnections between the insurance sectors of EU countries based on the Mahalanobis distance, using only data describing the insurance sector. In contrast, Figure 2 presents an MST constructed using the same method but based on 17 variables – 9 describing the insurance sector and 8 related to the level of digitalisation.

The structures of these MSTs differ significantly. In Figure 1, the MST appears more dispersed and elongated, resembling a chain-like structure. In contrast, the MST in Figure 2 is more centralised, forming a star-like topology. In this structure, Portugal occupies a central position and plays a crucial role, it is the vertex with the highest degree, which is notably high.

If a negative financial event were to occur in the insurance sector of a particular country, and if similarity within the MST acts as a channel for systemic risk transmission, the 2007 MST structure shown in Figure 2 suggests that such an event could propagate rapidly to other countries closely connected to the affected one. This highlights the importance of considering digitalisation in the analysis of systemic risk (SR) within the insurance sector. By comparison, the structure of the MST in Figure 1 appears less concerning in terms of SR contagion.
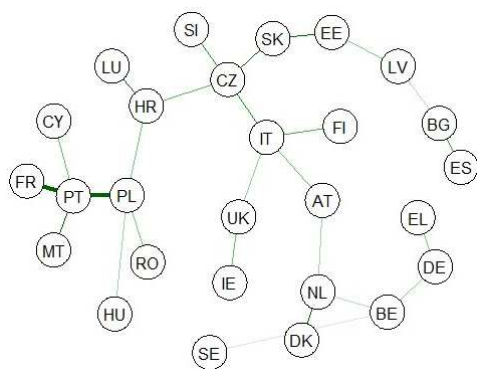
Figure 1. MST based on the Mahalanobis distance for the year 2007 (9 variables)
Source: own elaboration in RStudio.
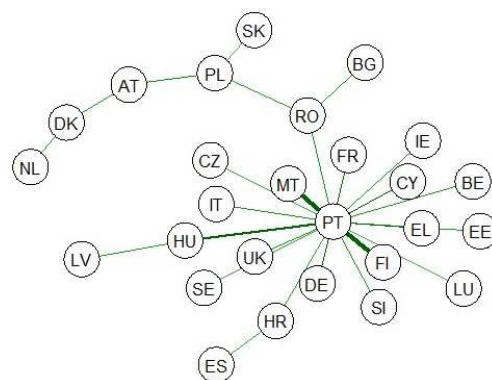
Figure 2. MST based on the Mahalanobis distance for the year 2007 (17 variables)
Source: own elaboration in RStudio.

To formally assess the MST structure and its implications, we applied several topological indicators defined in the subsection above.

All the Figures below present graphs of topological indicators for Minimum Spanning Trees (MSTs), constructed using three different methods. Figure 3 corresponds to MSTs built with the Mahalanobis distance. Figure 4 presents MSTs constructed using the cumulative multivariate DTW distance, while Figure 5 illustrates MSTs based on the multivariate DTW distance calculated over four-year rolling windows.

In each Figure (Figures 3, 4, and 5), the colour coding in the legend distinguishes between the datasets used:

Red line: based on 9 variables describing the insurance sector only (INS),
Black line: based on 17 variables, including insurance sector data and digitalisation indicators (INS and DIG),
Green line: based on 14 variables, combining insurance sector data with five indicators from the Digital Economy and Society Index (DESI) (INS and DESI).

In Figure 3, we may observe significant differences between the red and black charts, particularly in both the levels and trends of the topological indicators. The average path length (APL), maximum degree, and diameter show symmetrical yet contrasting values between the red and black lines, reflecting distinct MST structures. The differences in the values of the topological indicators confirm that the red charts represent a more dispersed, chain-like structure of the MST, as previously illustrated in Figure 1. In contrast, the black charts indicate a more centralised, star-like structure. Specifically, APL, alpha, and assortativity values are consistently lower in the black MSTs, while maximum degree and diameter are higher compared to the red MSTs. This suggests that, throughout the 2004-2018 period, MSTs incorporating digitalisation data (black) are structurally more susceptible to the negative effects of systemic risk.

The findings imply that although digitalisation positively supports the development of the insurance sector, it may also intensify interdependencies, thereby increasing the potential for risk contagion, an observation confirmed by our results. Our analysis also considers the impact of three major crises in Europe during the study period: the subprime crisis (2008-2009), the sovereign debt crisis (2011-2013), and the migration crisis (2018). Unfortunately, the consequences of these events are visible in certain EU member states.

To correctly interpret the changes in the MST structure, all topological indicators should be analysed simultaneously.

In Figure 3, all black graphs of APL, max.degree, and diameter in the years 2007, 2010, and 2017, that is, immediately before the crises, indicate that the MSTs are highly contracted. The APL decreases, the maximum degree increases, and the diameter becomes smaller. The alpha index rises, while assortativity declines.

During the crises themselves, the structure loosens, suggesting that the inhabitants of EU countries exhibit behaviour aimed at shielding themselves from the effects of crises. The red charts show opposite behaviour. Before crises, the MSTs are less concentrated, and during crises, we observe clustering and growing similarity among insurance markets. This is not surprising.

Unfortunately, such a structure of interconnections between countries reinforces the spread of undesirable financial disruptions. Noteworthy, the time series of black-coloured topological indicators may serve as a predictive tool, before each of the analysed crises, these indicators displayed similar patterns.
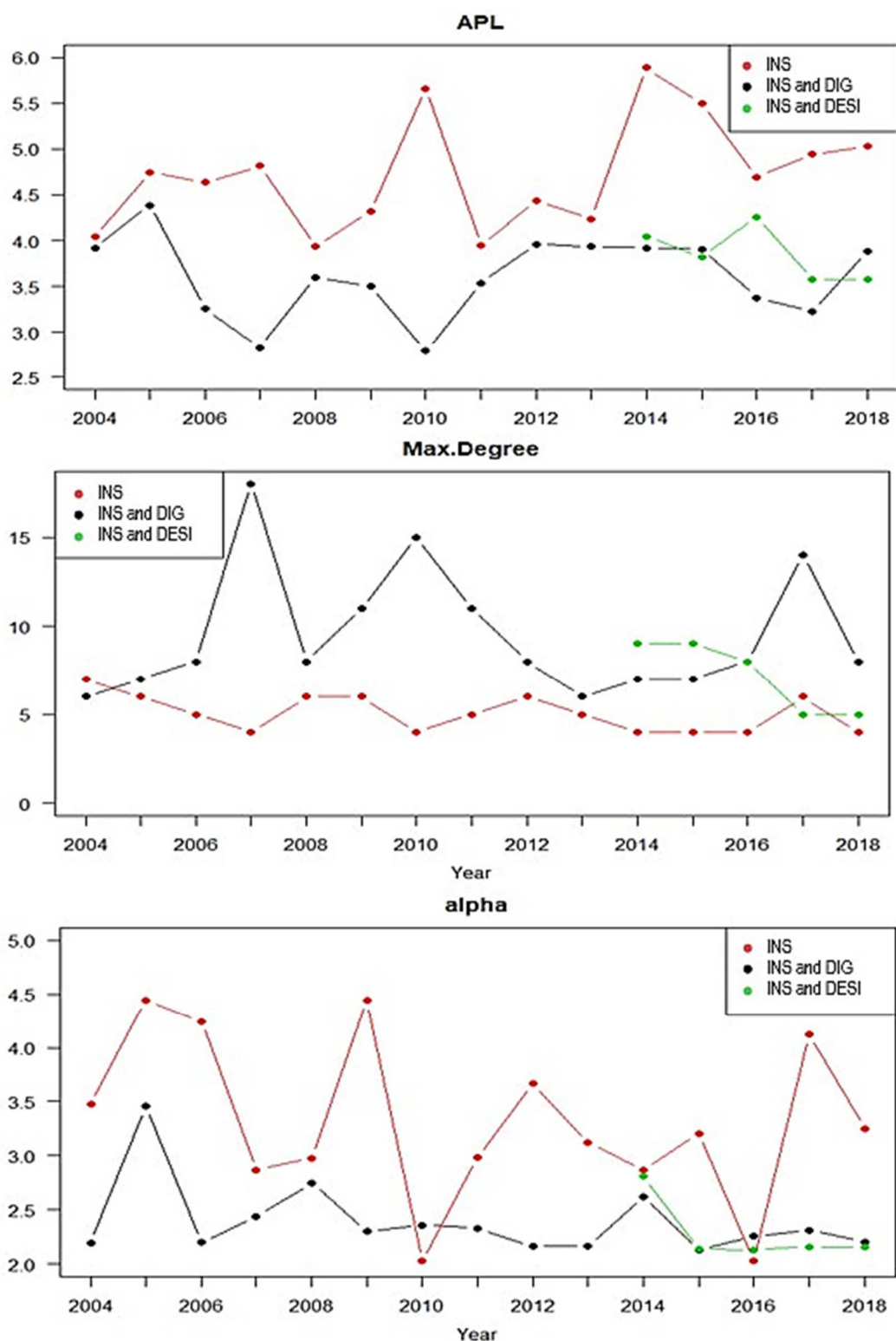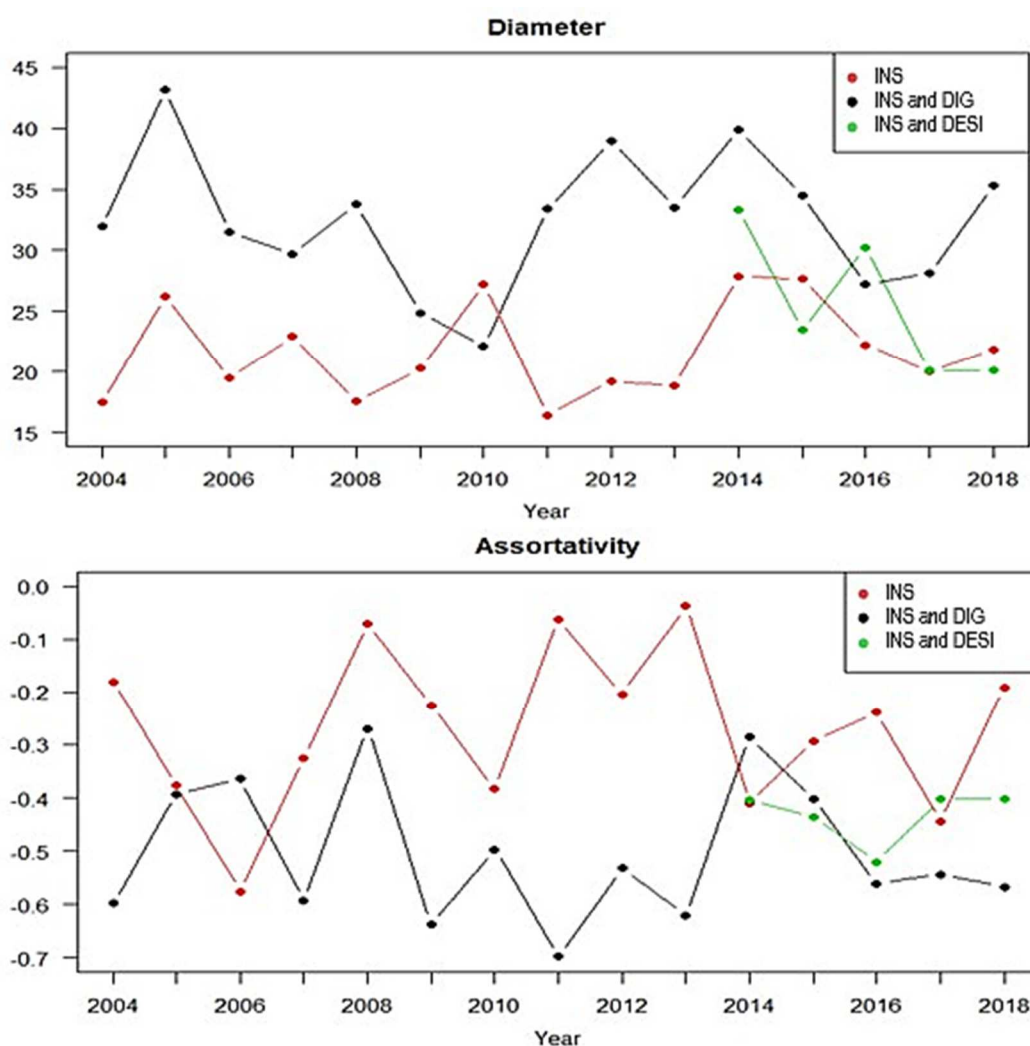
Figure 3. MST indicators for MST based on the Mahalanobis distance
Source: own elaboration in RStudio.

The analysis presented below focuses on the second direction of our research, presented in Figure 4. While the first part, already discussed, provided an empirical investigation of the annual similarity between the insurance sectors of EU countries, this stage aims to assess their similarity over extended periods. Each value of the minimum spanning tree (MST) topological indicators now informs us about how similar the insurance sectors are in the cumulative period from 2004 to a given year. This approach also allowed us to trace how similarity evolves as the dataset expands year by year.

As before, we present the time series of topological indicators with consistent colour coding for the respective datasets. The graphs in Figure 5 show the evolution of MST topological indicators calculated from: (1) nine time series describing the insurance sector (red) and (2) seventeen time series combining insurance sector data with digitalisation metrics (black). These series differ in both behaviour and value ranges.

Assessing similarity over extended periods using MSTs derived from multidimensional DTW distances enables the detection of structural changes in the EU insurance sector. It also facilitates the identification of long-term dependencies and similarities between countries. Notably, the black and red series display differences in magnitude. The red series tends to remain stable over time, while the black series shows higher variability.

The fluctuations in the black series suggest that extending the 17-dimensional dataset by a single year, especially one marked by structural change, significantly affects similarity with the previous period. For instance, a decline in APL and Diameter accompanied by a rise in max. degree, as observed in

2008, 2010, 2014, and 2016, points to increasing similarity among EU insurance sectors. The alpha and assortativity indices further illuminate the way sectors (represented as vertices) are connected. The MST structure is irregular and non-fractal, as alpha deviates from 2. There are no dominant hubs, and vertex connections form uneven clusters of varying sizes.

These structural changes are likely driven by the inclusion of digitalisation indicators. For example, in 2008, the black APL chart drops below its 2007 value, indicating that the MST, based on the extended multidimensional time series, reflects lower average path length, and hence greater similarity. This underscores the influence of digitalisation on the evolving similarity structure.

In general, the black APL and diameter values tend to be higher than those of the red series, while max. degree is relatively lower. This combination, high APL and diameter with low max. degree characterises a more stretched MST, suggesting reduced potential for the rapid spread of negative systemic effects. During periods of financial stress, including 2008, 2010, 2011, 2014, and 2016, changes in the black series confirm that digitalisation meaningfully impacts the evolving similarity and interconnectedness of EU insurance sectors.
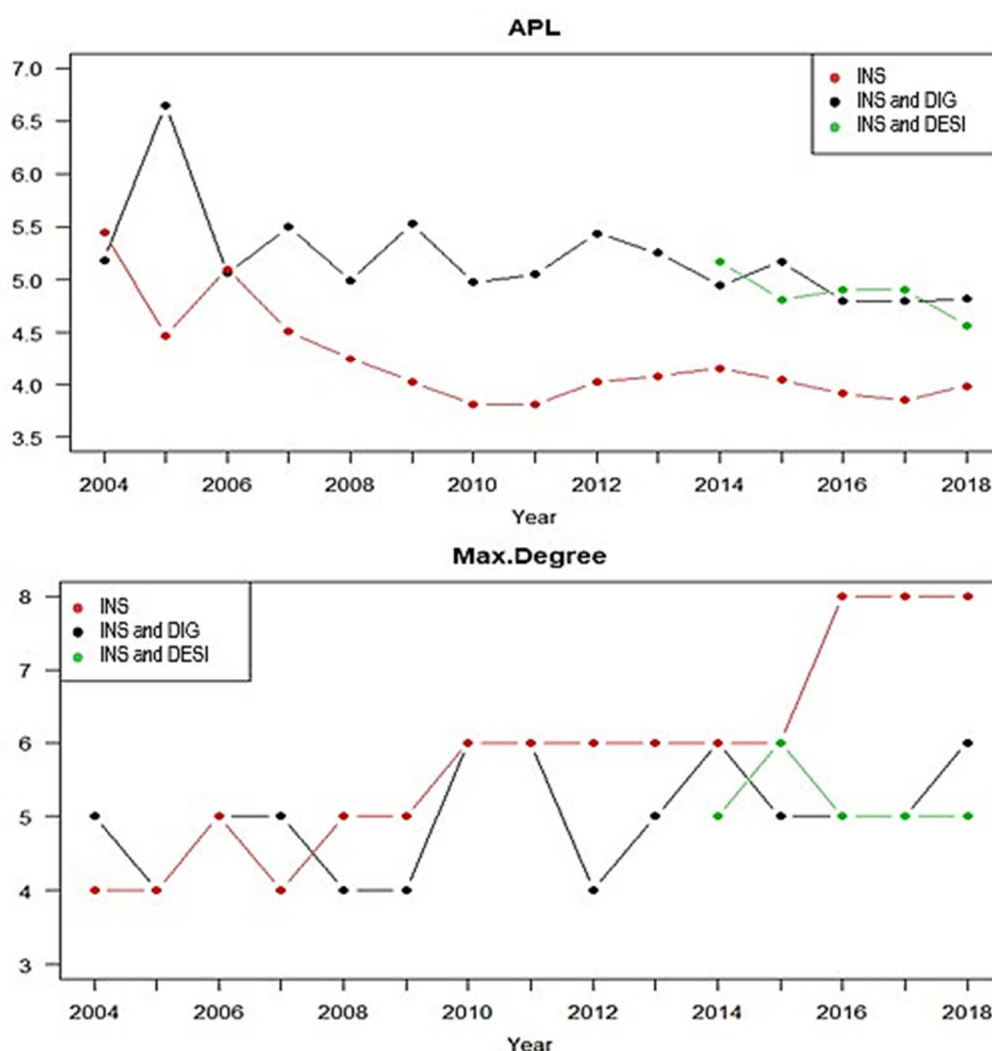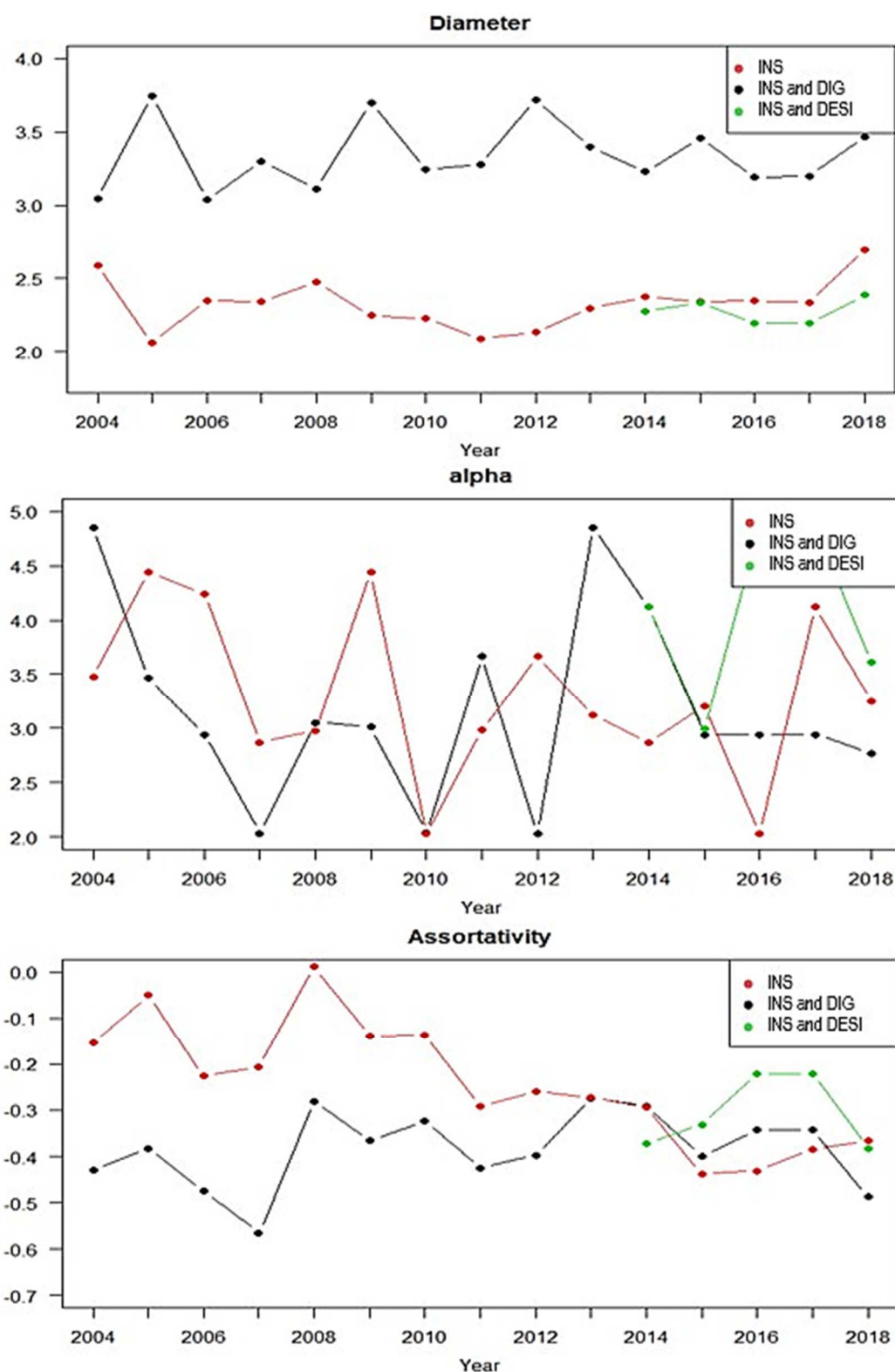
Figure 4. MST indicators for MST based on multidimensional distance DTW in an incremental manner
Source: own elaboration in RStudio.

In the next step, we present the graphs of topological indicators in Figure 5, which describe the structure of the MST constructed using the third method. Each value of the MST indicator reflects the similarity within the groups of countries based on nine time series (red) and seventeen time series (black).

The dynamics of these indicators differ from the previous cases, and both data sets exhibit noticeable volatility.

During the crisis periods of 2007-2009, 2010-2012, and 2015-2017, the black lines representing APL and diameter show a downward trend, while the maximum degree increases. This suggests that, in each four-year window preceding a given year, the MST had a less centralised (less star-like) structure compared to the structure observed in that specific year. The shift toward a more star-like structure indicates an elevated potential for the propagation of negative effects from financial shocks. This shift is particularly significant when considering the role of digitalisation in the insurance sector. Digitalisation intensifies the interdependencies between countries, amplifying the risk of contagion in the face of global financial disruptions, which further increases the systemic risk within the EU's insurance markets.
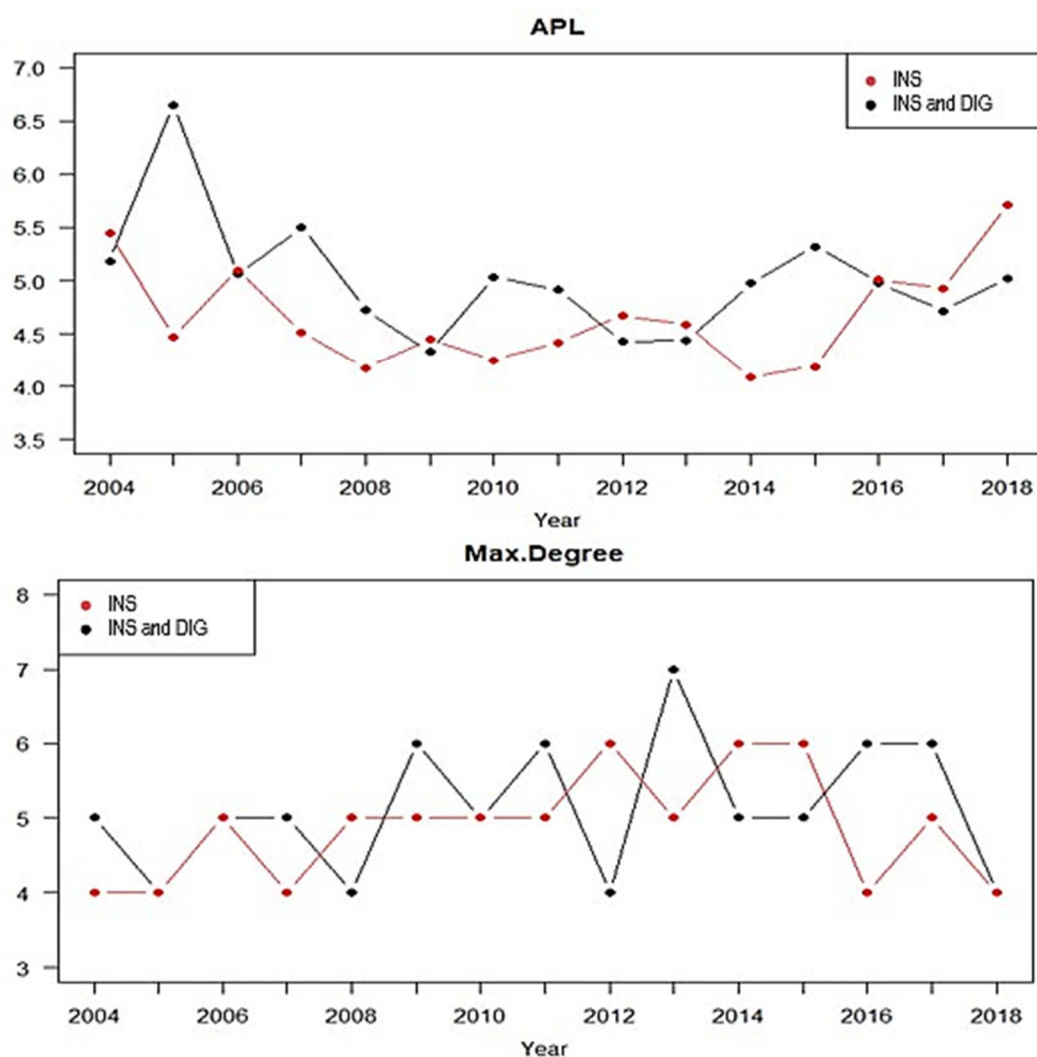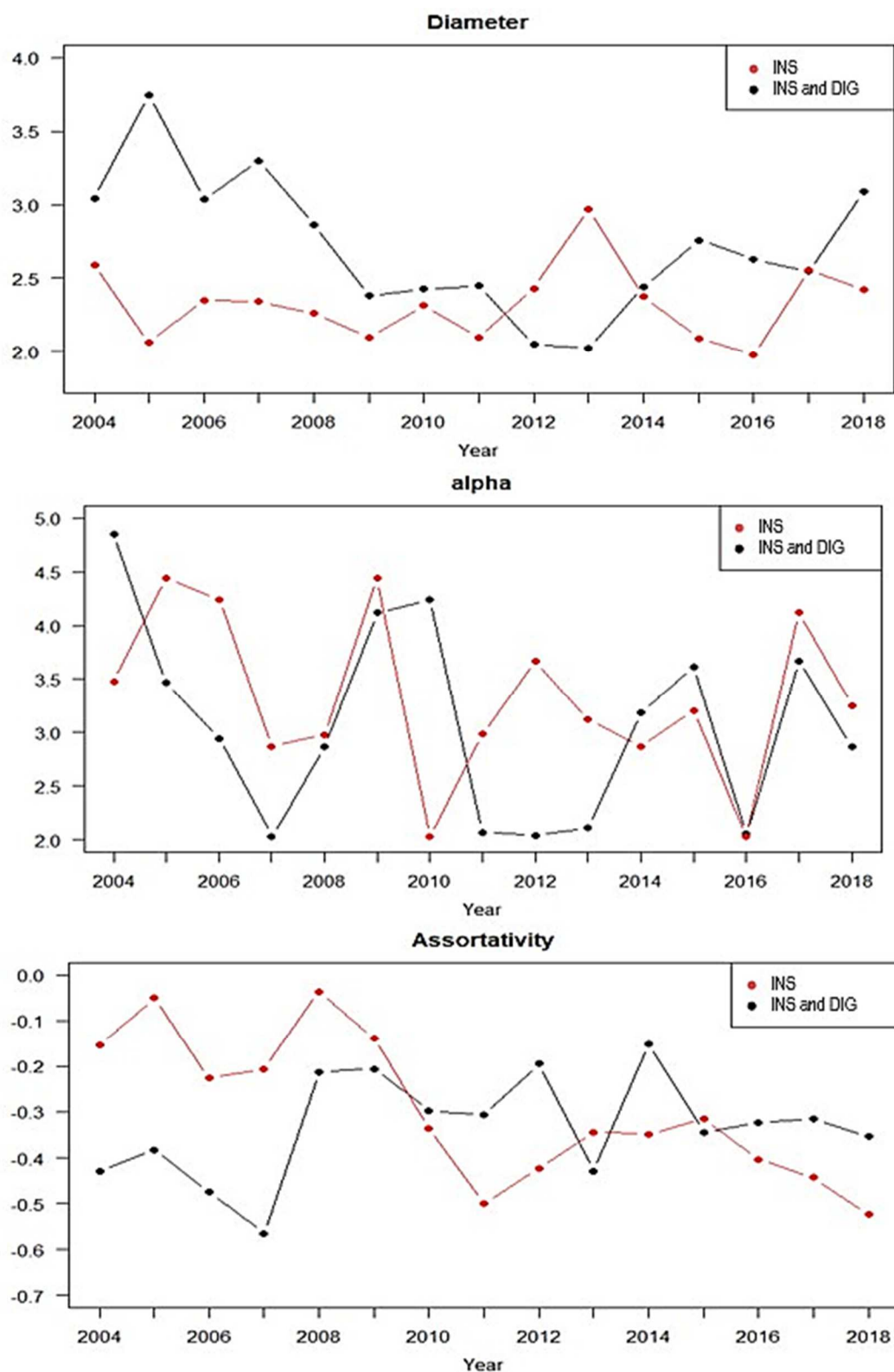
Figure 5. MST indicators for MST base multidimensional distance DTW from the period in four-year windows
Source: own elaboration in RStudio.

CONCLUSIONS

Research in the insurance sector must consider digitalisation indicators that reflect both technological advancements and consumer behaviour. Due to the delay with which the data are issued our empirical

analysis covered the years 2004-2018. This research demonstrates the impact of digitalisation on the similarity of insurance sectors across EU countries during this period.

The applied methodology, constructing minimum spanning trees (MSTs) in three distinct ways, enables the assessment of dependency structures on an annual basis, over four-year periods, and cumulatively across the entire 2004-2018 timeframe.

MST topological indicators allow for the identification of crisis periods and facilitate comparisons of network connection structures during these critical moments.

Time series analysis of MST topological indicators, incorporating digitalisation data via the first method (based on the Mahalanobis distance), provides an annual overview of MST structures. These MSTs, reflecting the similarity of insurance sectors across seventeen dimensions, reveal structures that are conducive to systemic risk propagation prior to crises. In contrast, the second method, based on multivariate dynamic time warping (DTW) distance, shows relatively stable similarities over longer periods, with distinct behaviours emerging during crisis years. The resulting MST structures suggest a slower potential pace of financial shock propagation within the sector. The third method, which directly analyses the dynamics of topological indicators, effectively captures structural shifts before and during crises, with MST configurations varying depending on the period in question.

MST topological indicators exhibit strong sensitivity to structural dynamics, showing characteristic patterns both before and during financial crises. Thus, they hold promise as predictive tools in the analysis of global financial disruptions.

In this study, we defined 'similar countries' as those whose populations exhibit comparable behaviours regarding insurance activity and everyday life, influenced by modern technologies, digitalisation, and Internet use. We assessed this similarity in three different ways, each reflecting a distinct approach to measuring it. When comparing multivariate time series, similarity is typically calculated by transforming several variables into vectors in a multidimensional space and computing the Euclidean distance between them. The DTW distance measure allows for nonlinear alignment of one series to another, minimising the temporal distance between them.

Since the early twenty-first century, DTW has been widely used in data analysis tasks, including classification, clustering, and anomaly detection in time series data. Our research opens up new avenues for further study, including the potential application of this methodology for grouping EU countries based on the developmental dynamics of their insurance sectors, as well as exploring the methodological aspects of using multivariate DTW distances to assess the similarity of MST topological indicator time series constructed using various techniques.

The conclusions drawn from this study highlight the critical role of digitalisation in shaping the systemic risk profile of the EU insurance sector. The methodology applied, which incorporates minimum spanning trees (MSTs) constructed using the Mahalanobis distance and dynamic time warping (DTW), reveals significant structural patterns that inform about both the assessment of risk contagion pathways and the long-term stability of insurance networks. These insights not only enhance our understanding of systemic risk transmission but also provide valuable guidance for policymakers and industry stakeholders aiming to strengthen the resilience of the insurance sector.

There are several implications for the Insurance Sector. Firstly, the impact of digitalisation: the study demonstrates that digitalisation significantly influences the systemic risk profile of the EU insurance sector, particularly during periods of financial crises. High levels of digital integration can increase the similarity among insurance markets, potentially amplifying the transmission of financial shocks across borders. Next, we found international dependencies: the use of MST and DTW models reveals that insurance sectors in countries with similar digitalisation levels are more prone to shared systemic risks, highlighting the need for coordinated regulatory oversight at the international level. Then, we discovered risk transmission channels: the structure of connections within EU insurance sectors, as represented by MST models, suggests that high degrees of similarity can act as indirect channels for systemic risk propagation, increasing the speed and extent of financial contagion. Finally, we exposed crisis sensitivity: the analysis of MST topological indicators shows that sectors with more centralised network structures are more vulnerable to rapid changes in market conditions, potentially accelerating the spread of systemic risk during financial disruptions. On the other hand, we can also enumerate implica-

tions for insurance policies. On the one hand, in risk management, the high degree of interconnectedness observed in digitally advanced insurance sectors emphasises the need for more sophisticated risk management strategies that account for both local and cross-border risk exposures. On the other hand, for product personalisation digitalisation enables more precise tailoring of insurance products to individual customer needs, but also requires a greater focus on systemic risk management as global interconnections grow. As far as innovation and risk are concerned, the introduction of new technologies, such as InsurTech and IoT-based products, may reduce operational costs but also increase systemic vulnerabilities, necessitating a balanced approach to innovation. Finally, a conclusion for portfolio diversification: insurers should consider diversifying their product portfolios to mitigate the impact of systemic crises that can spread more rapidly in a highly interconnected, digital insurance environment.

These findings reinforce the importance of integrating digitalisation indicators into systemic risk assessments and underline the need for a more resilient and diversified insurance sector capable of withstanding future global financial shocks.

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Use of Artificial Intelligence

This text is free of AI/GAI usage.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Exploring entrepreneurial capabilities and firm innovativeness to leverage financial technology start-up business performance

Anna Sardiana, Sudaporn Sawmong

A B S T R A C T
Objective: This article examines the role of entrepreneurial capabilities and firm innovativeness in driving the business performance of financial technology (fintech) start-ups. By cultivating entrepreneurial orientation, innovation capacity, and knowledge creation, firms can enhance their competitive edge, adapt to market shifts, and achieve sustainable performance.
Research Design & Methods: We conducted a quantitative study using a self-administered questionnaire and partial least squares structural equation modelling (PLS-SEM) to test our hypotheses. The sample included the management teams of 144 Indonesian fintech start-ups, each in operation for at least three years.
Findings: Our analysis reveals that both entrepreneurial capabilities and firm innovativeness significantly and positively impact the business performance of fintech start-ups. Furthermore, firm innovativeness mediates the relationship between entrepreneurial capabilities and business performance. Specifically, entrepreneurial capabilities and firm innovativeness collectively explain 58.3% of the variance in business performance, while entrepreneurial capabilities account for 48% of the variation in firm innovativeness.
Implications & Recommendations: This study demonstrates that firms with robust entrepreneurial capabilities are better equipped to identify and seize opportunities, leading to higher innovation and, consequently, stronger business performance. These findings suggest that fintech firms can enhance performance through increased market share, greater profitability from new products, and more efficient operations. We recommend that managers and entrepreneurs in the fintech sector use these insights to make informed decisions regarding resource allocation, strategic planning, and organisational design. Policymakers can also leverage these insights to develop programs that promote entrepreneurial capabilities and innovation, foster economic growth and boost competitiveness within the sector.
Contribution & Value Added: Our study adds valuable insights to the dynamic and competitive fintech sector by demonstrating that cultivating entrepreneurial capabilities and fostering innovation within fintech firms can significantly enhance their performance outcomes. This research provides actionable guidance for both industry practitioners and policymakers seeking to drive growth and competitiveness in the fintech ecosystem.

Article type:	research article
Keywords:	entrepreneurial capability; firm innovativeness; business performance; financial technology; start-up companies
JEL codes:	L25, M15, O32

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INTRODUCTION

The evolution of the financial sector, combined with advancements in information technology, drives innovations in financial technology. The integration of electronic finance, internet technologies, social networking services, social media platforms, artificial intelligence, and Big Data analytics has led to

significant transformative advancements in the fintech sector (Creamer, 2022). Financial technology, recognised as a key innovation within the financial sector, is experiencing rapid growth driven by factors such as the rise of the sharing economy, evolving regulatory frameworks, and continuous technological progress. This growth demonstrates its increasing importance and transformative impact on the industry (Ma, 2022). Like banks, fintech companies focus their business models on payment and lending services. In addition to the traditional financial industry, startups see this as a chance to enter the financial services sector. These financial services innovations include personal financial advisory services, crowdfunding platforms, virtual currencies, InsurTech (insurance technology), RegTech (regulatory technology), Big Data analytics, and cybersecurity measures. These advancements have shaped and redefined the landscape of modern financial services (Palmié *et al.*, 2020). However, fintech firms differ from traditional financial or technology firms because they operate under unique environmental conditions, particularly rapid technological disruption, evolving regulatory frameworks, and heightened customer expectations for security and transparency.

The growth of financial technology startups involves generating value through the strategic use of unique resources to identify and seize business opportunities (Silva *et al.*, 2021). This is consistent with the views that entrepreneurial values with an innovativeness will create new markets using novel methods (Buccieri *et al.*, 2020). This creative destruction theory describes the dynamics of business in the field of technology, which operates very dynamically and is one type of innovation (Hor *et al.*, 2021). The process of innovating and actively seizing this opportunity necessitates an entrepreneurial event and an entrepreneurial agent. The entrepreneurial event is concerned with the entrepreneurial capabilities, conceptualisation, and implementation of a new company in the field of innovation.

While previous research has established that entrepreneurial capabilities foster innovation and improve firm performance, this study extends the theory by examining these dynamics within the unique context of fintech. Fintech firms operate in an environment characterised by heightened regulatory oversight, digital financial risk, and continuous technology adoption cycles. These contextual pressures are not merely background factors but actively shape how entrepreneurial capabilities are deployed and how innovation is operationalised. In particular, we posit that in the fintech sector, innovation serves not only as a means of market differentiation but also as a mechanism for regulatory compliance, data-driven trust building, and platform scalability. Therefore, we argue that the mechanisms and strength of the relationships between entrepreneurial capability, innovation, and performance are distinct in this setting.

Entrepreneurial capabilities and firm innovativeness play a crucial role in determining business performance. Studies have consistently demonstrated that entrepreneurial abilities, a firm's innovative capacity, and its potential to innovate have a positive effect on business performance (Ferreira *et al.*, 2020). Entrepreneurial capability, characterised by proactivity, creativity, willingness to take risks, aggressiveness in the marketplace, and independence, facilitates the pursuit of opportunities and leads to improved business performance (Mostafiz *et al.*, 2021). Furthermore, the ability to innovate has been linked to increased efficiency, productivity, profits, market share, and sales growth, all of which contribute to enhanced business performance (Ali *et al.*, 2022; Phong & Tam, 2024). While these relationships are well-established, our study highlights how their operation within fintech firms, where regulatory and technological demands are tightly intertwined, necessitates an extension of traditional entrepreneurial and innovation theories.

Moreover, entrepreneurial capabilities, such as entrepreneurial attitude, learning capacity, and individual resources, are essential for driving business growth and success (Wulandari, 2021). These capabilities allow firms to effectively recognise, pursue, and manage business opportunities, even in highly competitive and challenging environments (Adinata *et al.*, 2023). Moreover, research has highlighted the mediating role of entrepreneurial self-efficacy and innovation competence in strengthening the connections between supply chain integration, value creation, and organisational performance (Ali *et al.*, 2022). The literature considers innovation capability a key driver of a firm's efficiency and productivity, which ultimately enhances business performance (Ali *et al.*, 2022). Furthermore, studies have underscored the critical need to align entrepreneurial orientation with innovation capacity to

achieve success, particularly in creative sectors, where a strong link between entrepreneurial management and creative capabilities is vital for performance (Prijadi *et al.*, 2024).

Overall, the literature underscores the significance of entrepreneurial capabilities and firm innovativeness in driving business performance. Earlier research spans various industries and contexts, consistently highlighting the significance of entrepreneurial abilities, innovation potential, and dynamic capabilities in improving organisational performance. The studies highlight that entrepreneurial alertness, innovativeness, and proactive behaviours are instrumental in driving organisational success (Abbas *et al.*, 2023; Mbore, 2021). As the sector expands, fintech firms face increasing competition, regulatory challenges, and ever-evolving technological landscapes. The literature demonstrates customer satisfaction, profitability, and sustainability as highlights of the beneficial effect of innovation on essential performance metrics in previous studies (Fegada & Veres, 2024; Maina *et al.*, 2023; Garousi Mokhtarzadedeh *et al.*, 2022). Entrepreneurial capabilities enable organisations to recognise and capitalise on opportunities, while innovation allows them to adapt, distinguish themselves, and generate value that aligns with customer needs. Our study emphasises that these two factors are not just important in isolation, but that their intersection is critical to achieving sustained business success in the fintech industry.

This study contributes to both academic research and practical applications. It extends existing entrepreneurship and innovation frameworks by contextualising them within the fintech industry. We argue that the simultaneous demands for technological advancement, customer-centric innovation, and regulatory compliance require firms to deploy entrepreneurial capabilities in more complex and dynamic ways than in traditional sectors. In doing so, our study reveals how fintech firms create value under multi-dimensional uncertainty – an area underexplored in prior research. Practically, our findings offer guidance to fintech managers and policymakers on how to design organisational strategies that align entrepreneurial capability and innovation to achieve sustainable performance. These insights can inform decisions related to resource investment, regulatory readiness, and capability development in an increasingly competitive digital finance environment.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

From a resource-based view (RBV), entrepreneurial capabilities are considered valuable intangible assets that play a critical role in enhancing firm performance and securing a competitive edge (Ingram & Kraśnicka, 2023). These capabilities reflect a firm's ability to deploy internal resources through innovation and agility in response to external challenges (Niyawanont, 2023). Entrepreneurial competencies, such as networking skills, market orientation, and a proclivity for risk-taking, are viewed as essential for a firm's survival and growth in a dynamic market environment (Mostafiz *et al.,* 2021). These competencies are often described using different terminologies – such as entrepreneurial competencies (Pennetta *et al.*, 2024), entrepreneurial orientation (Pulka *et al.*, 2021; Khan *et al.*, 2021), or even dynamic capabilities – yet they share a common emphasis on innovation, proactiveness, and risk-taking as foundational elements.

Entrepreneurial orientation (EO), in particular, is a strategic posture focused on identifying and exploiting opportunities ahead of competitors (Wales *et al.*, 2023). It is a psychological and behavioural disposition reflecting senior management's readiness to pursue ventures despite uncertainty (Makhloufi *et al.*, 2021). EO is known to shape learning behaviours, decision-making speed, and strategic flexibility, thereby influencing firm-level innovation and long-term performance (Simpson & Sariol, 2022). Consequently, scholars widely regard entrepreneurial capabilities – encompassing EO and entrepreneurial competencies – as a firm's ability to leverage internal resources to generate innovation-driven performance outcomes.

While these relationships are well-established across industries, existing research has not sufficiently addressed how entrepreneurial capabilities operate in fintech, a sector characterised by its high regulatory intensity, rapid technological evolution, and platform-based customer interactions. Prior literature has largely approached the entrepreneurial–innovation–performance nexus in generalised terms, overlooking how fintech firms must develop distinct capabilities to navigate their context. For example, in fintech, EO may not only involve being proactive in market entry but also in anticipating regulatory

changes or integrating compliance-by-design into service innovation. Similarly, digital trust – users' perception of security, transparency, and reliability – becomes a crucial capability for fintech firms, shaping user acquisition and retention, yet this is rarely incorporated into capability-performance frameworks.

Moreover, fintech firms often operate in ecosystems involving APIs, open banking standards, and cross-platform integrations, demanding customer interface adaptability and data-driven service personalisation. These conditions suggest that the traditional resource-based assumptions may be insufficient or incomplete for capturing the full scope of entrepreneurial success in fintech. Hence, the performance implications of entrepreneurial capabilities are likely mediated or moderated by fintech-specific dimensions such as regulatory agility, digital trust, and platform adaptability – factors which remain underexplored in the extant literature.

We sought to extend the existing theory by analysing how entrepreneurial capabilities – operationalised as innovativeness, proactiveness, and risk-taking – interact with these fintech-specific contextual factors to shape firm performance. By positioning the research within the fintech sector, this study responds to calls for greater contextualisation in entrepreneurship research and addresses a critical gap: the need to adapt and refine capability-based theories for digital-native, regulation-intensive, and customer-centric business models. Our contribution lies not only in confirming established constructs but in uncovering how they function differently in fintech, thereby advancing both theory and practice.

Relationship of Entrepreneurial Capabilities and Business Performance of a Fintech Startup Company

Entrepreneurial capabilities are critical in improving organisational processes and supporting business performance (Fan *et al.*, 2021). Numerous studies offer valuable insights into the positive effect of entrepreneurial orientation, particularly proactiveness and innovativeness, on business performance. Entrepreneurial capabilities have become a central focus in entrepreneurship research, with an expanding body of literature highlighting their critical role in shaping business outcomes (Kimjeon & Davidsson, 2022). The components of entrepreneurial capabilities, such as proactiveness and innovativeness, have been identified as key factors in driving improved business performance (Mostafiz *et al.*, 2021). Entrepreneurs who exhibit proactivity and innovation are more inclined to pursue entrepreneurial endeavours and attain superior levels of business performance (Putniņš & Sauka, 2020).

Studies suggest that entrepreneurial capabilities enhance business performance through multiple mechanisms. For example, research has shown that entrepreneurial capabilities contribute to the improved performance of small and medium-sized enterprises (SMEs) in developing countries, highlighting their positive effect on business success (Fan *et al.*, 2021). Our research also emphasises that proactivity and innovation, key elements of corporate entrepreneurship, have a positive impact on business performance (Jiménez-Barrionuevo *et al.*, 2019). Moreover, various dimensions of entrepreneurial orientation, including innovativeness, proactiveness, risk-taking, autonomy, and competitive aggressiveness, have been demonstrated to significantly enhance business model innovation and performance (Al-Mamary & Alshallaqi, 2022).

Moreover, the link between entrepreneurial capabilities and business performance has been explored across different sectors, including the hospitality industry, where these capabilities are considered a strategic asset for improving performance (Abu-Rumman *et al.*, 2021). Xiao *et al.* (2021) highlight the significance of entrepreneurial behaviours, such as proactivity, creativity, and innovative work practices, in enhancing business performance. Furthermore, scholars have examined the effect of entrepreneurial capabilities on business performance across various industries, including tourism, underscoring the substantial role these capabilities play in driving business success (Dias *et al.*, 2021).

In conclusion, literature underscores the positive impact of entrepreneurial capabilities, particularly proactiveness and innovativeness, on business performance. Entrepreneurs displaying proactive and innovative traits are more inclined to reach greater business success. By comprehending and nurturing entrepreneurial orientation, businesses across diverse sectors and organisational settings can enhance their performance outcomes. These findings collectively contribute to understanding how entrepreneurial capabilities influence business performance in various contexts and industries. Hence, we hypothesised:

H1: Entrepreneurial capability has a positive impact on the business performance of a fintech start-up company.

Relationship of Firm Innovativeness and Business Performance of a Fintech Startup Company

Comprehending the impact of different dimensions of innovation, such as product, process, marketing, and organisational innovation, on firm performance is essential for organisations aiming to enhance their competitive edge and overall success. Several studies provide meaningful insights into the link between firm innovativeness and business performance. The ability to innovate, whether through processes or market innovations, plays a crucial role in a firm's competitiveness and overall performance outcomes (Bibi *et al.*, 2020). The effect of business model innovation on firm performance is complex and shaped by elements like industry trends, competitive positioning, and strategic alignment (Hurtado-Palomino *et al.*, 2022). Moreover, organisational innovativeness has a positive influence on firm performance, with an innovative organisational culture acting as a moderating factor in this dynamic (Strychalska-Rudzewicz & Rudzewicz, 2021).

Groza *et al.* (2021) and Aslam *et al.* (2022) have highlighted the beneficial effect of organisational innovation on firm performance, emphasising the role of product, process, marketing, and organisational innovation in achieving business success. Moreover, Hoang and Ngoc (2019) examined the link between innovation capability and firm performance, uncovering a positive relationship between a company's performance and its innovation capabilities. Furthermore, investigations into the dimensions of innovation and business performance under conditions of environmental uncertainty have revealed diverse impacts of firm innovativeness on performance, stressing the importance of contextual factors (Kafetzopoulos *et al.*, 2019).

The existing literature also highlights that business model innovation can have a profound effect on firm performance, with several studies showing a positive link between business model innovation and overall performance (Xue *et al.*, 2019). Dong (2023) identified transformational leadership as a key factor in fostering innovation performance, thereby contributing to firm success. Furthermore, scholars explored the influence of external relationships on organisational innovation and performance, emphasising the role of partnerships and collaborations in driving innovation within firms (Ferreira *et al.*, 2020). Drawing from these findings, we suggest that a positive relationship exists between innovativeness and the business performance of fintech companies. Thus, we hypothesised:

H2: Firm innovativeness has a positive impact on the business performance of a fintech start-up company.

Relationship of Entrepreneurial Capability and Firm Innovativeness of a Fintech Startup Company

Makhloufi *et al.* (2021) demonstrated that entrepreneurial orientation significantly influences innovation capability. Earlier studies have explored the relationship between entrepreneurial capabilities and firm innovation, shedding light on how these factors interact to affect business performance. For example, Li *et al.* (2020) examined how entrepreneurial leadership impacts innovative work behaviour, suggesting that the organisational environment for innovation mediates the connection between leadership and employee innovation. In a similar vein, Kwoba and Ebewo (2022) found a positive relationship between capabilities and knowledge creation, with competitive aggressiveness and innovativeness acting as mediators between knowledge creation and firm performance. Collectively, these studies underline the critical role of entrepreneurial capabilities in promoting innovation and driving business outcomes. Moreover, research by Mostafiz *et al.* (2021b) examined how international entrepreneurial capabilities enhance the ability of export firms to identify opportunities and improve performance, highlighting the importance of such capabilities for firm success. Prasetyo (2021) emphasised the role of information technology capability in fostering innovation and adaptation, particularly in dynamic business environments. Moreover, the relationship between knowledge management capability, entrepreneurial creativity, and firm performance has been established, with ambidexterity serving as a mediator (Garousi Mokhtarzadedeh *et al.*, 2022). Scholars have also recognised innovation capability as essential for improving efficiency and productivity within firms (Ali *et al.*, 2022).

These studies offer important perspectives on how various entrepreneurial capabilities, such as leadership, networking, and international expertise, play a crucial role in promoting innovation and, in turn, enhancing firm performance. In summary, the integration of these studies highlights the essential connection between entrepreneurial capabilities and firm innovation in driving business success. By fostering entrepreneurial skills, cultivating innovative capabilities, and utilising dynamic capabilities, organisations can strengthen their competitiveness, adaptability, and overall performance in an ever-changing business landscape. Continued research in this field could provide a deeper understanding of the specific processes by which entrepreneurial capabilities influence innovation and performance within firms. As a result, we proposed the following hypotheses based on these insights:

H3: Entrepreneurial capability has a positive impact on the firm's innovativeness of a fintech start-up company.

The Role of Firm Innovativeness as a Mediator in The Link Between Entrepreneurial Capabilities and Business Performance in Fintech Startups

Investigating how firm innovativeness mediates the relationship between entrepreneurial capability and business performance is an important research area. In this context, Makhloufi *et al.* (2021) examined the impact of entrepreneurial orientation on innovation capability, emphasising the mediating roles of absorptive and organisational learning capabilities. The study highlights how entrepreneurial orientation affects innovation capability, which subsequently influences business performance. Similarly, Hwang *et al.* (2020) identified that the indirect effects of entrepreneurial competencies, mediated by organisational innovation capabilities, contribute more significantly to competitive advantage than direct effects alone. In the realm of firm sustainability, organisational innovation capabilities are crucial in mediating the connection between entrepreneurial competencies and maintaining a competitive market position. Moreover, Fan *et al.* (2021) found a positive relationship between entrepreneurial orientation, innovativeness, and firm performance, noting that innovativeness moderates the link between social media adoption and performance. Ferreira *et al.* (2020) explored how exploitative and explorative capabilities impact firm performance indirectly through innovation competencies, especially in firms with a strong entrepreneurial orientation, further stressing the importance of innovation. Sijabat *et al.* (2021) highlighted how dynamic capabilities in new ventures impact competitive advantage, with innovation serving as a key mediator in this process. Moreover, Mbore (2021) identified innovation capability as a key mediator in enhancing firm performance, reinforcing the importance of fostering innovation within organisations. Furthermore, Maina *et al.* (2023) found that entrepreneurial passion moderates the relationship between process innovation and performance, with higher passion levels leading to better outcomes from process innovation (Maina *et al.*, 2023).

Furthermore, Khalid (2019) explored the mediating effects of both exploratory and exploitative innovations in the relationship between entrepreneurial orientation and firm performance. This research provides valuable insights into how various types of innovation mediate the connection between entrepreneurial orientation and business performance. By reviewing these studies, it becomes clear that firm innovativeness plays a critical role in facilitating the transformation of entrepreneurial capabilities into improved business performance. Based on this understanding, we conclude that innovativeness serves as a mediator in the relationship between entrepreneurial capabilities and the business performance of fintech firms. Drawing from these empirical findings, we proposed the following research hypotheses:

H4: Firm innovativeness significantly mediates the relationship between entrepreneurial capability and business performance of a fintech start-up company.

The Role of Firm Innovativeness as a Moderating Factor in The Relationship Between Entrepreneurial Capabilities and Business Performance in Fintech Start-ups

Entrepreneurial capabilities are fundamental drivers of business performance, and the moderating influence of firm innovativeness can further strengthen this connection. To examine the interplay between entrepreneurial capabilities and business performance within the context of fintech companies,

moderated by firm innovativeness, we may draw insights from relevant literature. For example, Ariasih *et al.* (2024) investigated the impact of entrepreneurial leadership on business performance, focusing on the mediating roles of entrepreneurial orientation, team creativity, dynamic capabilities, and competitive advantage. Their findings highlight the role of technological innovation capabilities in linking entrepreneurial orientation to performance, suggesting that firm innovativeness, facilitated by entrepreneurial leadership, contributes positively to business outcomes. Furthermore, Hoang *et al.* (2023) explored how entrepreneurial leadership influences innovation performance, pointing to the moderating effects that enhance the relationship between innovation and business performance. Similarly, Fegada and Veres (2024) identified significant correlations between innovation orientation, technological capabilities, and key performance indicators like profitability, sustainability, and customer satisfaction. These studies emphasise the critical role of firm innovativeness in shaping business performance in the fintech sector. Based on these insights, we proposed the following hypothesis:

H5: Firm innovativeness significantly moderates' relationship between entrepreneurial capability and business performance of a fintech start-up company.

Drawing on existing literature and prior research, we constructed the conceptual framework and corresponding hypotheses for this study, as illustrated in Figure 1.
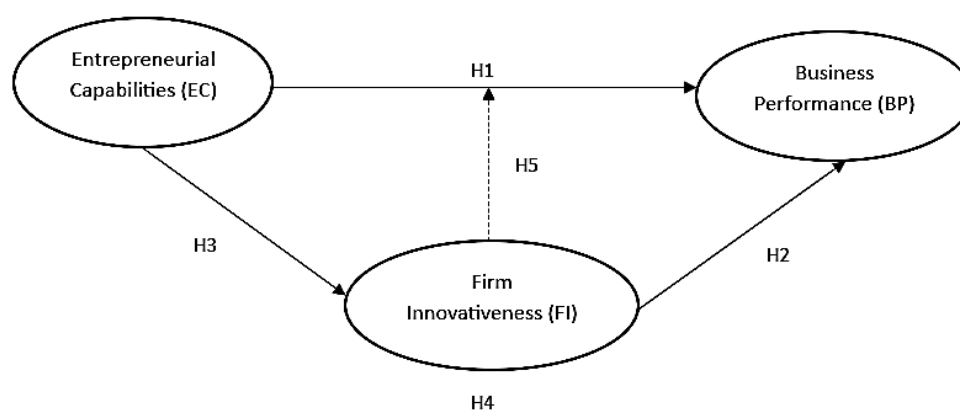
Figure 1. The Conceptual framework and hypotheses of the study
Source: own elaboration.

RESEARCH METHODOLOGY

Sample and Data Collection

In this study, we utilised a quantitative research design, focusing on a sample of financial technology start-ups. These companies, representing various business models (verticals), were licensed by the Indonesian Financial Services Authority and include both digital financial institutions and technology firms within the digital financial services ecosystem. We employed a probability sampling technique to ensure the sample accurately represents the broader population of fintech companies. By using stratified random sampling, the study ensures that every company in the industry had an equal opportunity to be selected, thereby enhancing the representativeness and accuracy of the sample (Henry, 2009).

There were 223 registered fintech company when we conducted the study (OJK International Information Hub, 2023). For determining the sample size, we applied the sample size determination method proposed by Krejcie and Morgan (1970) as the theoretical framework of our study has several variables of interest. Based on their guidelines, a sample size of 140 was deemed appropriate for a population of 220 financial technology start-ups, ensuring a robust and reliable decision model for the study (Sekaran & Bougie, 2016).

In this study, we selected the respondents from managerial roles within financial technology start-ups, including C-level executives, managers, supervisors, and staff who had been with the company for over two years. We chose these individuals due to their in-depth knowledge and access to critical information regarding the operations of their respective companies (Sandvik & Sandvik, 2003). To gather

data, we conducted a survey using a questionnaire, where respondents rated their level of agreement or disagreement with various statements on a 5-point Likert scale. We distributed the survey to managers of fintech start-ups through both online platforms and face-to-face interviews (Prijadi *et al.*, 2024). We sent a total of 200 questionnaires and received 180 responses. After screening for eligibility, we excluded 36 responses, leaving 144 completed questionnaires for analysis.

Measures and Statistical Methods

For this study, we adapted the measurement of latent variables from existing research, ensuring relevance to the context of financial technology start-ups. In the first section of the questionnaire, we collected demographic information about the respondents, including their position within the company and the year the company was established. In the second section, we included questions on business performance, covering financial, marketing, and operational aspects, with seven items based on the work of Singh *et al.* (2022), Olabode *et al.* (2022), Bodlaj and Čater (2019), and Shashi *et al.* (2019). The third section focused on entrepreneurial capabilities, with seven items related to innovativeness, proactiveness, and risk-taking, adapted from studies by Fan *et al.* (2021), Dias *et al.* (2021), Ciampi *et al.* (2021), Makhloufi *et al.* (2021), Faroque *et al.* (2021), Park and Xiao (2020), Monteiro *et al.* (2019), and Mehrabi *et al.* (2019). Finally, in the fourth section, we asked 23 questions regarding firm innovativeness, covering topics such as marketing innovation, new product development, product improvement, and product innovation, drawing from the work of Żur and Wałęga (2023), Domi *et al.* (2019), Yang and Tsai (2019), Shashi *et al.* (2019), and Anees-ur-Rehman *et al.* (2018).

We employed SmartPLS software to conduct data analysis in a two-step procedure, which includes evaluating the measurement model and the structural model. As outlined by Sarstedt *et al.* (2022), SmartPLS is capable of analysing both the outer model (measurement model) and the inner model (structural model). This software facilitated the processing of our data using structural equation modelling(SEM) techniques, allowing for an in-depth examination of relationships and variables (Sarstedt *et al.*, 2022). The analysis involved evaluating the structure of the measurement model, testing the proposed hypotheses, and investigating the relationships within the structural model (Cheung *et al.*, 2024).

SmartPLS is crucial for examining the measurement model, assessing constructs, and testing hypotheses to derive meaningful insights from the data (Foltz & Foltz, 2020). The process of data analysis with SmartPLS involves key steps. Our analysis began with the specification of the model, followed by a thorough evaluation of the measurement model to ensure its accuracy and reliability. Once we validated the measurement model, we proceeded to assess its structure and perform hypothesis testing to confirm the relationships within the structural model. We tested the hypotheses through causality assessments and prediction models (Al-Mannaei *et al.*, 2023), focusing on the influence of latent variables during the structural model phase. To evaluate the inner model, we analysed key metrics such as the coefficient of determination (R^2), predictive relevance (Q^2), and goodness of fit (GoF).

RESULTS AND DISCUSSION

Results

Established since 2016, the financial technology startups sampled in this study have been in operation for between 2 to 6 years; 56 companies under 3 years, 40 companies about 3 to 4 years, and there were 48 companies have been more than 5 years. In our analysis, we initially examined the validity and reliability of each measurement to ensure that all constructs met the necessary standards. To assess these qualities, we employed composite reliability, Cronbach's alpha, and average variance extracted as key indicators of both validity and reliability.

Table 1 presents the Cronbach's alpha values for all constructs, which exceed 0.7, confirming the reliability of the measures (Sarstedt *et al.*, 2022). We assessed construct validity through both convergent and discriminant validity. Convergent validity reflects the extent to which items within a construct are closely related. As shown in Table 1, the average variance extracted (AVE) values and factor loadings were above 0.5, indicating strong convergent validity. Moreover, the AVE values for all variables exceed 0.5, signifying that the indicators for each variable are both convergent and valid. The

Cronbach's alpha and composite reliability (CR) values were all greater than 0.6, further supporting the reliability and validity of the variables and items used in our study (Sarstedt *et al.*, 2022).

Table 1. Validity and reliability construct

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)	Factor loading range
BP	0.846	0.865	0.883	0.520	0.609-0.827
EC	0.838	0.851	0.877	0.504	0.662-0.760
FI	0.969	0.970	0.971	0.587	0.631-0.873

Source: own study.

Furthermore, we conducted a goodness-of-fit test to evaluate the relationships between entrepreneurial capabilities, firm innovativeness, and business performance, ensuring the data reliability in measuring these variable relationships. This test involves two indicators. Firstly, we used the coefficient of determination to assess the extent to which entrepreneurial capabilities and firm innovativeness explain their connection to business performance. We derived the determination coefficient by analysing the R-squared values for each variable relationship (Bentler & Bonett, 1980).

Table 2. The coefficient of determination

Variable	R-square	R-square adjusted
BP	0.583	0.574
FI	0.480	0.476

Source: own study.

The R-squared values for business performance and firm innovativeness were 0.583 and 0.480, respectively. These values suggest that entrepreneurial capabilities and firm innovativeness explained 58.3% of the variance in business performance, with the remaining 41.7% attributed to factors outside the model. Moreover, entrepreneurial capabilities accounted for 48% of the variation in firm innovativeness, with the remaining 52% explained by external variables. Consequently, it is important to consider additional factors that could better account for business performance.

Subsequently, we conducted a model fit test using several statistical indicators, such as standardised root mean square residual (SRMR), normed fit index (NFI), and RMS_theta. For the model to be deemed suitable, the indicators must meet specific thresholds: SRMR < 0.08, NFI > 0.90, and RMS_theta should approach zero (Bentler & Bonett, 1980).

Table 3. Model fit summary

Model fit summary	Saturated model	Estimated model
SRMR	0.081	0.082
d_ULS	4.920	4.959
d_G	3.374	3.371
Chi-square	2074.363	2076.029
NFI	0.614	0.613

Source: own study.

The results show that the SRMR value was 0.081, which was below the threshold of 0.10, indicating a good fit according to Bentler and Bonett (1980). However, the NFI value of 0.614 was below the recommended threshold of 0.900. On the other hand, the RMS_theta value of 0.247 was close to zero. Given these outcomes, we may conclude that the model met the fit criteria, making it suitable for describing the relationships between the variables.

The SEM model includes both direct and indirect effects. A T-statistic with a p-value below 5% signifies a significant relationship between variables. The results, presented in Table 4, show that all direct relationships were statistically significant, with p-values under 0.05, confirming the hypotheses H1 to H4. However, hypothesis H5 was not supported, as its p-value was 0.442.

Table 4. Path coefficient

Hypotheses	Relationship	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H1	EC -> BP	0.347	0.346	0.076	4.560	0.000
H2	EC -> FI	0.692	0.697	0.051	13.465	0.000
H3	FI -> BP	0.496	0.498	0.073	6.794	0.000
H4	EC -> FI -> BP	0.343	0.349	0.068	5.083	0.000
H5	FI x EC -> BP	0.040	0.046	0.049	0.802	0.422

Source: own study.

Discussion

The output in Table 4 provides a comprehensive interpretation of the relationships among entrepreneurial capability, firm innovativeness, and business performance. Entrepreneurial capabilities positively and significantly enhance business performance, demonstrating an effect size of 0.347. Therefore, enhancing entrepreneurial capabilities results in improved business performance, and conversely, improved business performance reinforces entrepreneurial capabilities. The results of our study align with prior research, which suggests that entrepreneurial orientation has a positive impact on business performance by promoting innovation and effective strategic decision-making (Żur & Wałęga, 2023). Moreover, the integration of entrepreneurial leadership and orientation within the framework of dynamic capabilities contributes significantly to improving firm performance (Nguyen *et al.*, 2024).

As entrepreneurial orientation has been associated with successful new product development, high financial performance, and overall business success (Żur & Wałęga, 2023), this aligns with our findings that new product development – one of our observed variables of firm innovativeness – exerts a pronounced and beneficial influence on business performance, yielding a substantial effect size of 0.496. This strong association further underscores that innovativeness is not merely a desirable trait but a performance-enhancing capability, particularly in dynamic sectors such as fintech. Consequently, an increase in a firm's innovativeness correlates positively with enhanced business performance.

Next, we found that entrepreneurial capabilities contribute positively and significantly to firm innovativeness, demonstrating a coefficient of 0.692. Therefore, augmenting entrepreneurial capabilities fosters heightened firm innovativeness, and vice versa. In line with these results, numerous studies have demonstrated that the entrepreneurial capability, innovation capability, and technological competence in enhancing firm performance (Omar *et al.*, 2016; Fegada & Veres, 2024b). Proactiveness, risk-taking, and innovation, as entrepreneurial capabilities, have been shown to enhance firm performance by cultivating an environment that supports innovation and informed strategic decision-making (Mojica-Carrillo *et al.*, 2021). Moreover, innovation capability, defined as the capacity to develop and execute novel ideas, has been linked to improvements in efficiency, productivity, and the overall performance of organisations (Ali *et al.*, 2022).

Our findings indicate that entrepreneurial capabilities, when mediated through firm innovativeness, have a positive and significant effect on business performance, with a value of 0.343. This supports previous research that highlights the importance of innovation capability in enhancing organisational efficiency and productivity, and the mediating influence of entrepreneurial self-efficacy and innovative competence on firm performance (Ali *et al.*, 2022). These results suggest that firm innovativeness is vital in transforming entrepreneurial capabilities into improved business performance.

As such, innovativeness within the firm plays a key mediating role in connecting entrepreneurial capabilities to business performance, particularly in the context of fintech start-ups. This finding is consistent with Han *et al.* (2022), who demonstrated that business model innovation mediates the relationship between entrepreneurial orientation and firm performance in more traditional industries. However, in the fintech sector, innovation assumes an even more significant role due to the fast-paced technological changes, complex regulatory environment, and the need for disruptive market strate-

gies. These sector-specific pressures make the effective deployment of innovativeness not just advantageous but necessary for survival. This underscores the critical importance of innovative approaches in driving performance outcomes in firms with strong entrepreneurial orientations.

In contrast, our analysis revealed that entrepreneurial capabilities have a positive but statistically insignificant impact on business performance, with a score of 0.040 when firm innovativeness is used as a moderating factor. This suggests that firm innovativeness does not significantly moderate the relationship between entrepreneurial capabilities and business performance in fintech start-ups. This finding aligns with the work of Abbas *et al.* (2019), who found no significant connection between entrepreneurial business networks and firm performance, indicating that entrepreneurial capabilities may not directly enhance business performance when influenced by other factors. Similarly, Fegada and Veres (2024) highlighted the positive relationships between innovation orientation, technological capabilities, and firm performance indicators, such as profitability and customer satisfaction, but did not establish a significant moderating effect of firm innovativeness on the entrepreneurial capabilities–performance relationship.

Interestingly, while firm innovativeness positively mediates the relationship between entrepreneurial capabilities and business performance, we found its moderating effect to be statistically insignificant. This divergence offers a critical insight into the complex dynamics within fintech firms. Unlike traditional sectors where innovation may consistently strengthen the entrepreneurial-performance link, fintech operates under unique environmental pressures, namely, regulatory volatility, rapid digital disruption, and strong reliance on external technologies (*e.g.*, blockchain, AI, digital identity systems). These factors may diminish the moderating influence of internal innovativeness because the pace and nature of innovation in fintech is often reactive and externally imposed rather than internally driven.

Furthermore, the insignificant moderation effect could suggest that once a baseline level of entrepreneurial capability is in place, additional firm innovativeness does not proportionally amplify performance outcomes. This aligns with recent findings by Crick *et al.* (2021), which caution that overemphasising innovation, without strategic alignment, can lead to inefficient or unprofitable outcomes. In fintech, over-innovation or 'innovation fatigue' can be particularly detrimental due to customer sensitivity to trust, usability, and regulatory compliance. As such, the findings challenge the often-assumed linear benefit of innovativeness and call for more nuanced theorisation around context-specific limits of innovation's strategic utility. Future studies should consider environmental dynamism, regulatory agility, and digital trust as potential boundary conditions that shape these effects.

In the context of fintech companies, we may attribute this lack of moderation to the highly dynamic and rapidly changing nature of the industry (Hor *et al.*, 2021), where the direct influence of entrepreneurial capabilities on performance might overshadow any moderating effect from innovation. Moreover, fintech innovation is often driven by external factors like technological advancements and regulatory shifts (Ma, 2022), which could reduce the significance of firm-level innovation in moderating the relationship. Consequently, entrepreneurial capabilities alone may be sufficient to drive performance outcomes, independent of innovation as a moderating variable.

In conclusion, entrepreneurial capabilities are generally associated with improved business performance. The significant relationships between entrepreneurial capability, firm innovativeness, and business performance suggest that, within the competitive financial technology sector, firms that possess strong entrepreneurial capabilities, foster a culture of innovation, and maintain technological proficiency are more likely to experience growth, attract customers, and achieve sustained success. By strategically utilising these capabilities, fintech companies are better equipped to navigate the complexities of the industry, adapt to shifting market conditions, and seize emerging opportunities to drive innovation, enhance business performance, and secure long-term success. However, the relationship between these factors is not universally positive. Crick *et al.* (2021) highlight that an entrepreneurial orientation, if not carefully managed, may lead to unprofitable decisions, emphasising that the outcomes of entrepreneurial actions can vary widely depending on the context and execution. Moreover, our finding of the non-significant moderating role of firm innovativeness further supports this nuance. It highlights that greater innovation does not always amplify entrepreneurial outcomes and may even

lead to diminishing returns if disconnected from external contingencies or strategic focus. This suggests that while entrepreneurial capabilities can contribute to enhanced performance, they may also result in negative outcomes if not properly aligned with the firm's strategic goals.

CONCLUSIONS

The significant connections identified between entrepreneurial capability, firm innovativeness, and business performance highlight the critical role that entrepreneurial capabilities play in driving innovation within financial technology startup companies. Our study offers fresh theoretical perspectives on how entrepreneurial capabilities influence both firm innovativeness and business performance in the context of fintech startups. By emphasising innovation's mediating role, we challenge the view that entrepreneurial capabilities directly drive performance, proposing instead that innovation is a key mechanism linking capabilities to performance outcomes.

We also challenge the notion that entrepreneurial capabilities are universally applicable across industries. In fintech, where disruption and rapid change are common, capabilities are crucial for driving innovation in response to market and regulatory shifts.

Our study calls for expanding existing theoretical frameworks to account for industry-specific dynamics in fintech. Unlike traditional models, which often focus on linear, technology-driven innovation, we highlight the multifaceted nature of innovation in fintech, which blends technological, regulatory, and market-driven factors. In conclusion, our study proposes a more context-driven approach to understanding entrepreneurial capabilities and innovation in fintech, offering a dynamic perspective on how these factors contribute to business performance.

However, our study has some limitations. Firstly, our sample included all identified financial technology startup companies, since we found it a small population within the industry. Secondly, as an emerging industry, characterised by agility, creativity, and adaptability, financial technology is unique and different from one company to another, but we did not divide the companies into types categorised by the authority because of the very small number of companies. Thus, we suggest future research to explore all identified financial technology companies by type and use only the founder and core management, such as C-level management or top management of the company. In addition, we also suggest that future research can explore the innovativeness of financial technology companies based on the type of company considering that the type of company in the digital financial innovation category has many variations of platforms including Aggregator, Credit Scoring, Financing Agent, Transaction Authentication, RegTech-eSign, Electronic-Know Your Customer (E-KYC), Funding Agent, Financial Planner, Insurance Tech, Tax & Accounting, Insurance Hub, Online Distress Solution (ODS), RegTech-PEP, Property Investment Management (PIM), Wealth Tech, Digital Banking, Digital Payment/Payment Gateway/Payment System.

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Use of Artificial Intelligence

We hereby declare that our manuscript does not involve the use of AI/GAI.

Conflict of Interest

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Do companies walk the talk: The case of foreign companies in Russia after aggression on Ukraine

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A B S T R A C T
Objective: The article examines the influence of prior corporate social responsibility (CSR) initiatives and the reputation accrued from these efforts on the response of foreign companies operating in Russia during the country's invasion of Ukraine.
Research Design & Methods: Our study includes all publicly traded corporations listed in the Yale Chief Executive Leadership Institute list of companies leaving and staying in Russia (CELI Yale list). We acquired corporate data for these companies from the LSEG Eikon database (formerly Refinitiv Eikon). To evaluate the impact of the explanatory variables on the type of the firm's reaction to the adverse event, we used multinomial logistic regression.
Findings: Our study revealed that firms with a history of extensive social engagement and resulting superior CSR reputation tend to display a reduced inclination toward opportunistic behaviour and reluctance to maintain business as usual during adverse events. While analysing the relationship between prior CSR activities and the reaction to adverse events, we concluded that more socially responsible firms favour symbolic reactions. Moreover, our study shows the existence of a relationship between the form of the crisis reaction and a firm's CSR strategy profile. We found that an adverse event occurring in the same domain as the firm's CSR strategy profile triggers reactions aligned with that strategy.
Implications & Recommendations: Our study provides evidence that supports the existence of the relationship between prior record of CSR activities and the reputation built upon those activities, and the firm's behaviour during the crisis.
Contribution & Value Added: Our study enhances the understanding of the nature of the firm's reactions to adverse events. We concentrated in particular on the crisis caused by factors external to the firm. We contribute to the discussion of the permanency and cohesion of CSR actions, and the role of prior CSR activities and reputation, building upon these actions in the nature of the firm's reaction to negative events. Our results indicate that firms with better CSR reputation react to such events in a more socially responsible way. This finding suggests the existence of other motives for such actions beyond reputation protection, as has been suggested by the earlier studies. We demonstrate that a firm's reactions to a crisis are path dependent and dictated by its prior CSR strategy. Moreover, our study broadens the view on the relationship between the antecedents and consequences of CSR and shows that such a relationship is mutually enhancing.
Article type:	research article
Keywords:	corporate social responsibility; crisis situation; CSR reputation; Russia aggression on Ukraine; multinomial logistic regression
JEL codes:	L14, M14

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INTRODUCTION

In this article, we examine how the prior record of CSR and the reputation built upon it relate to the company's re actions to a crisis caused by external factors. The research aimed to determine how companies behave in a crisis situation that creates a conflict between their existing CSR policy and current perfor-

mance. If firms engage in CSR activities only as a form of window dressing, their behaviour during the crisis may lead them to discontinue their earlier strategy because of the increased cost of walking the talk. We analysed the problem using a natural experiment of the Russian aggression on Ukraine as a context.

Many studies document the importance of permanency and consistency in CSR activities. These studies show that permanency and consistency support the accumulation of reputation (Pérez-Cornejo *et al.*, 2022), increase firm value (Wang & Choi, 2013; Jeong *et al.*, 2018), and provide insurance-like effects in the face of negative events (Shiu & Yang, 2017). These studies fit within the broader avenue of research that describes the impact of CSR on various groups of stakeholders. Studies have shown a relationship between CSR and consumer behaviour, including purchasing patterns and recommendations (Sen & Bhattacharya, 2001; Deng & Xu, 2017), product reviews (Brown & Dacin, 1997), satisfaction (Luo & Bhattacharya, 2006), confidence (Pivato *et al.*, 2008), and the level of brand identification (Peloza & Papania, 2008; Pérez, 2009). The attention paid to the price of products (Viciunaite & Alfnes, 2020) and their acceptable levels (Obermiller *et al.*, 2009) are other important factors mentioned in this context. The impact of CSR on a firm's attractiveness for potential employees (Turban & Greening, 1997; Lin *et al.*, 2012) as well as the attitude of current employees, is another emphasised group of factors. In this context, CSR relates to increased personnel engagement (Peterson, 2004; Kantabutra & Ketprapakorn, 2020), the level of its identification with the firm and organisational pride (Zhou *et al.*, 2018), and greater loyalty to the employer (Flammer & Kacperczyk, 2019). Social engagement evokes positive reactions from regulators and policymakers (Brown *et al.*, 2006; Kolcava *et al.*, 2021), analysts (Ioannou & Serafeim, 2015), and investors (Luffarelli & Awaysheh, 2018; Park & Lee, 2018). It has been argued that such a broad range of advantages motivates organisations participating in CSR initiatives to adopt more ethical practices (Dobson, 1989). Finally, other studies confirm that companies investing more resources in CSR are less likely to engage in wrongdoing (Chen *et al.*, 2018).

However, various studies show that they could be socially responsible and irresponsible simultaneously. Wrongdoers use CSR to alleviate negative consequences. In such a case, the resources invested by the firm in social engagement may simply allow it to compensate or overshadow wrongdoing. Studies of relationships between corporate philanthropy and corporate misconduct identified such behaviour, which confirms that firms react philanthropically to their socially irresponsible behaviour (Chen *et al.*, 2008; Koehn & Ueng, 2010; Du, 2015). Kang *et al.* (2016) described the nature of the relationship in which a firm engages in CSR activities in the aftermath of socially irresponsible behaviour as the penance mechanism. Several studies also describe the reverse mechanism. Moral licensing theory argues that the advance collection of good deeds by the firm allows it to behave in a more irresponsible way in the future, when it becomes convenient and profitable. From that point of view, CSR becomes the cause rather than the effect of CSiR (Corporate Social Irresponsibility) (Ormiston & Wong, 2013).

The question of whether firms walk the talk and maintain consistency in their CSR activities remains unanswered. Our study adds another voice to this discussion. Moreover, this study fills a significant research gap. Few earlier studies of a firm's CSR activities during a crisis (Kang *et al.*, 2016; Lenz *et al.*, 2017; Li *et al.*, 2019) pertain to events related to social irresponsibility, which *ipso facto* results in the culpability of the crisis being attributed to the firm. This type of crisis strongly affects reputation (Coombs & Holladay, 2002; Coombs, 2007), thus requiring CSR actions that protect or restore reputation. The nature of the crisis we analysed is different. The crisis was caused by external factors, so we cannot blame firms for its occurrence. As a result, the event poses little threat to its reputation (Benoit, 1997; Reuber & Fischer, 2010). This creates a particular challenge to the integrity of a company's CSR, as it weakens the incentives to 'walk the talk' and strengthens the incentives for opportunistic behaviour. How companies address this challenge has not yet been the subject of research, which highlights the originality and novelty of our approach.

Crises generate stakeholder expectations regarding how companies should respond to the crisis. The nature of the crisis shapes normative expectations, which are the same for all companies. In contrast, predictive expectations are more diverse, as they are based on a company's past behaviour. This difference in expectations helps explain the reasons behind possible variations in how companies react to negative events. Companies are aware that acting against expectations may lead to negative reactions from stakeholders. According to the expectation violation theory (Burgoon, 1993; Burgoon & Le Poire,

1993), the greater the discrepancy, the stronger the reaction will be (Afifi & Burgoon, 2000). Foreign corporations active in Russia reacted differently to Russia's invasion of Ukraine on February 24, 2022. The range of reactions encompassed all conceivable courses of action, from strictly opportunistic decisions of continuing business activities as usual to symbolic actions such as pledges to halt new investments or scale back business activities, and finally to substantive actions such as suspending operations or completely exiting the Russian market. The main topic of our research is the relationship between an earlier firm's CSR strategy and the reputation built upon that strategy, and the type of crisis reaction. These results confirm the existence of such a relationship. Firms that had previously been more involved in CSR activities and had a better reputation were less likely to engage in opportunistic behaviour and continue with business as usual. A higher level of CSR increased the probability of socially responsible behaviour in response to the crisis. This effect was stronger for symbolic actions than substantive actions. Moreover, we identified the existence of a relationship between the form of reaction and the profile of CSR strategy – undertaking symbolic or substantive actions was typical for firms whose CSR strategies focus more on social factors rather than environmental factors or governance.

Our findings significantly contribute to the existing body of knowledge. They confirm that companies walk the talk during crises caused by external factors. Our study helps to better understand the causes of actions undertaken by firms during adverse events, such as the reactions of foreign corporations present in Russia in the aftermath of aggression. Furthermore, our research sheds new light on the role of path dependence in CSR decisions. This factor was not included in previous studies on the causes of corporate social engagement. Earlier studies have concentrated on the relationship between firm size and its resources (Waddock & Graves, 1997), corporate governance factors (Jo & Harjoto, 2011), organisational structure (Asmussen & Fosfuri, 2019), legal form (Acar *et al.*, 2001; Adamska *et al.*, 2022), and CEO personal traits (Petrenko *et al.*, 2016). Our study adds a new factor to this list. The notion of path dependence posits that the companies' prior choices influence their later decisions (North, 1995).

The remainder of this article is organised as follows. In the literature review and hypothesis development section, we discuss the available literature on CSR in the context of bad events and propose three research hypotheses. The following section describes the data and methods. The findings from the study are then presented, followed by a discussion of their theoretical and practical implications. The article ends with conclusions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Companies rely on the social approval and support of stakeholders, who provide the resources necessary for firm survival (Pfeffer & Salancik, 1978). Firms engage in various CSR activities to obtain approval and support. Owing to these activities, firms acquire legitimacy (Zyglidopoulos, 2003; Schaltegger & Hörisch, 2017) and build a reputation (Fombrun & Shanley, 1990; Siltaoja, 2006; Raithel & Schwaiger, 2015). However, legitimacy and reputation can be damaged by various crises. Such situations have a strong negative impact on reputation (Davies *et al.*, 2003; Tucker & Melewar, 2005; Dardis & Haigh, 2009), but additionally draw media attention (Fink, 1986), which results in closer scrutiny of the firm. Consequently, the discrepancies between a company's prior track record of CSR and its reputation for CSR and its actions during a crisis become more evident. The more visible a firm is, the simpler it is to evaluate its conduct.

A crisis creates expectations with respect to a firm's reaction. The expectations in question possess a dual character: they encompass both normative expectations, which dictate appropriate conduct for the company in specific situations, and predictive expectations that pertain to anticipated behaviour (Lin-Hi & Blumberg, 2018). Prior CSR reputation plays an important role in shaping predictive expectations. Better prior CSR reputation creates higher expectations (Olkkonen & Luomo-Aho, 2015). The expectancy violation theory (Burgoon, 1993; Burgoon & Le Poire, 1993) posits that firm behaviour in line with expectations does not draw external attention and scrutiny. However, the emergence of a large discrepancy will be noticed and will draw the attention and reaction of external observers. The larger the discrepancy between expectations and the firm's behaviour, the stronger the reaction (Afifi & Burgoon, 2000).

Crises pertaining to issues of morality, especially those that violate norms commonly shared by society, are specific. In the case of bad events of this nature, observers usually assign greater diagnostic value to negative information about the firm's reaction to the crisis. One might interpret positive information as an effect of conforming behaviour fuelled by the desire to avoid social criticism and not because of the true character of the firm (Mishina *et al.*, 2012). Consequently, the negative expectation disconfirmation effect will become stronger, as the observed discrepancies will be attributed to the wrong assessment of prior CSR activities, and such activities will be deemed dishonest. To protect their CSR reputation, firms with a prior record of high levels of social commitment walk the talk.

H1: In crisis situations pertaining to issues of morality, firms with higher social performance and a resulting better CSR reputation are less likely to act opportunistically and practice a business-as-usual approach.

Attribution theory posits that people make judgments about the causes of events based on their assessment of factors such as loss of control, stability, and controllability (Russel, 1982). In the context of crises, the first of these factors concerns whether the source of the crisis lies within the company or outside of it. The second factor relates to the assessment of whether the crisis results from the company's inherent characteristics or a random occurrence. The third factor refers to the degree of control the company had over the causes of the crisis. According to situational crisis communication theory, the danger that a crisis event poses to a firm's reputation depends on the extent to which the firm is to blame for the event (Coombs & Holladay, 2002; Coombs, 2007). The level of crisis responsibility attributed to the firm is the highest in the case of events whose roots originate inside the firm and whose nature indicates that it was caused by the intentional behaviour of the firm, which in turn stipulates ill will. Lack of ill will reduces perceived responsibility. The lowest level of responsibility is assigned to a firm when a crisis arises from sources that are beyond its control. The lower the extent of responsibility for the crisis attributed to the firm, the less negative its impact on reputation (Coombs & Holladay, 1996; Reuber & Fischer, 2010; Nardella *et al.*, 2020). The state of a firm's CSR reputation before the crisis modifies responsibility attribution. A good reputation allows for building moral capital (Godfrey, 2005). Larger moral capital results in the firm's ability to use the benefit of the doubt, which increases stakeholders' willingness to minimise the firm's culpability.

The nature of the crisis and the resulting degree of responsibility attributed to the company by stakeholders, as well as the level of moral capital accumulated by the company, influence how it responds to the crisis. Firms may undertake symbolic or substantive actions while reacting to bad events. Symbolic actions create the impression of responding to societal expectations without committing any significant resources (Mahon, 2002). These actions are mostly declarative in nature and demonstrate engagement. However, they do not cause any change in the firm's true operations (Truong *et al.*, 2021). Substantive actions result in implementing real changes in the organisation (Ashforth & Gibbs, 1990). Symbolic actions are more cost-efficient. Thus, undertaking them in reaction to the controversy is rewarded by stockholders (Li *et al.*, 2019). At the same time, in the case of bad events, whose nature makes it harder to assign responsibility to the firm, it may decide that symbolic actions are sufficient to meet the expectations of other stakeholders and protect the reputation.

H2: In crisis situations which make attribution of responsibility more difficult, companies with a higher CSR reputation are more likely to engage in symbolic than substantive actions.

A company's response to a crisis helps stakeholders judge if its CSR activities are consistent. Wang and Choi (2013) distinguish two types of consistency, *i.e.*, temporal and interdomain. Pérez-Cornejo *et al.* (2022) showed that both types of consistency improve a company's reputation. Chen *et al.* (2020) looked at the effects of corporate social irresponsibility (CSiR) events, focusing on whether they are in the same area as CSR activities or not. Inconsistency in the same area makes observers see the company as hypocritical. Other studies found similar results (Wagner *et al.*, 2009; Effron & Monin, 2010). When CSR and CSiR were in the same area, they caused a negative market reaction (Janney & Gove, 2011). Hypocrisy can also lead to more media attention and harm corporate reputation (Arli *et al.*, 2017). Past CSR activities might seem fake, hiding true intentions. These negative effects push firms to avoid hypocrisy (Carlos & Lewis, 2018).

During a crisis, a company can avoid looking hypocritical if it stays consistent with its past CSR activities while responding to the crisis. The company should consider two things, *i.e.*, the type of crisis and its past CSR strategy. The first thing depends on who is blamed for the crisis and what kind of crisis it is (environmental, social, and governance). The second thing is how much the company focuses on its past activities in these areas. If the company is blamed for the crisis, responding in the same area as the crisis can make observers see the company as inconsistent. This makes the company seem insincere and hypocritical (Yoon *et al.*, 2006). However, if the company responds in a different area, it does not seem inconsistent (Lenz *et al.*, 2017). If the company is not blamed for the crisis, it looks more consistent when it responds in the same area as the crisis. Companies with a CSR strategy that matches the crisis area can show more consistency. How the crisis area and the company's CSR strategy match can affect whether the company responds in the same or a different area, depending on whether the company is blamed for the crisis.

H3: If a crisis arises, whose nature makes it challenging to attribute responsibility for its occurrence to the firm, and it occurs within the same domain as the firm's previous CSR strategy, the firm's response will align with this strategy.

RESEARCH METHODOLOGY

Data and Method

We analysed how prior CSR activities and the reputation built upon them related to the firm's reaction to the adverse event, the nature of which makes it challenging to attribute to the firm the responsibility for the crisis. We analysed the period of Russia's invasion of Ukraine, which started on February 24, 2022. This was a sudden and surprising event that drew media attention and violated both legal and moral norms. Strong social condemnation of aggression in many countries, where foreign corporations present in the Russian market were incorporated, has threatened their reputation. Public opinion expected the firm's reaction to the situation.

Our research study includes all publicly traded corporations listed in the Yale Chief Executive Leadership Institute list of companies leaving and staying in Russia (CELI Yale list) as of 24 April 2022, or exactly two months since the outbreak of Russia's invasion of Ukraine. The above list has been used extensively in research on the reactions of foreign firms to the outbreak of the war, the antecedents of these reactions, and their economic consequences (Basnet *et al.*, 2022; Pajuste & Toniolo, 2022; Tosun & Eshragi, 2022; Ahmed *et al.*, 2023; Dincă *et al.*, 2023). From an initial population of 674 firms contained in the database, we excluded 53 firms due to a lack of data with respect to their CSR strategies. Moreover, we excluded five firms that were absent from the CELI Yale list in its version as of August 24, 2023. We acquired corporate data for these companies, utilised as explanatory variables and control variables from the LSEG Eikon database (formerly Refinitiv Eikon). We also used a similar approach based on ESG metrics and data from the same database in earlier studies concerning the Russian aggression against Ukraine (Basnet *et al.*, 2022; Ahmed *et al.*, 2023).

Variables

Dependent Variables

The dependent variable was the firm's reaction to an adverse event. CELI Yale list sorts companies according to the type of their reaction to Russia's invasion of Ukraine into five categories (F: digging in, D: buying time, C: scaling back, B: suspension, A: withdrawal), based on which, we proposed our own categorisation, distinguishing three types of reactions: opportunistic, symbolic, and substantive. The first category matched category F of the CELI Yale list and represents a business-as-usual approach. The symbolic reactions (combined categories D and C) included the suspension of new investments, but without leaving Russia. The substantive reaction (combined categories B and A) included the most far-reaching actions, such as complete abandonment of activities or withdrawal from Russia. While analysing the firm's reactions, we included two dates: 24 April 2022 (two months after the invasion),

and 24 August 24 2023 (18 months after the invasion). This allowed us to examine the robustness of our results to the passage of time, which could verify initial reactions as being only declarative.

Explanatory Variables

The first explanatory variable, *CSR performance*, was a continuous variable. In our calculations, we have used Refinitiv ESG Score, which is an overall company score based on the self-reported information. The second explanatory variable, *CSR controversy*, captures whether a company was involved in any prior bad events. The variable was dichotomous, coded 0 when the company was not involved in prior crises and 1 otherwise (ESG Combined Score lower than ESG Score). Thus, *CSR performance* and *CSR controversy* represented CSR reputation. The additional explanatory variables pertained to the CSR strategy. This strategy reflects the weights assigned by the firm to various CSR domains. Due to the limited resources available for such activities, the firm allocates them according to its preferences with regard to various domains. As a result, the firm is more active in one domain than in another. This allowed us to determine each firm's CSR strategy profile. We used Refinitiv scores – Environmental Pillar Score (*environmental pillar*), Social Pillar Score (*social pillar*), and Governance Pillar Score (*governance pillar*) to account for such a profile.

Control Variables

Furthermore, we included three control variables: *size* (Ln of total assets), *financial performance* (ROE), and *shareholding dispersion* (free float). Several studies demonstrated that a company's size and financial status influence its activities. Therefore, we used these variables in earlier studies (Li *et al.*, 2019; Nirino *et al.*, 2021; Pérez-Cornejo *et al.*, 2022; Lintukangas *et al.*, 2023). Larger firms have greater resources available to them, and their actions draw greater scrutiny from the media and public opinion and face greater pressure from external observers. In times of crisis, the resources available to them provide them with greater freedom of action, but at the same time, greater external scrutiny and public opinion pressure lead to an increase in reputational risk. However, poor financial conditions limit available actions, forcing the company to engage in loss-limiting actions during bad events. This increases the importance of cost as a key criterion for the choice of action in response to a crisis.

We included the *shareholding dispersion* variable to account for shareholders' ability to influence the management board decisions. In the case of companies with concentrated ownership structures, this influence is stronger and more direct. In the case of companies with more dispersed ownership structures, the influence of stakeholders other than the owners increases, and the role of the management evolves into one balancing the expectations of various stakeholder groups. As a result, ownership structure may affect the way the firm reacts to a bad event.

The data for the explanatory and control variables came from the year preceding Russia's invasion of Ukraine. Table 1 presents the summary statistics for the observations used in the analysis, and Table 2 shows the correlation coefficients.

Table 1. Summary statistics (N=616)

Variable	Min	Max	Mean	Std. Dev.
Size	3.89	15.53	9.95	1.83
Financial performance	-90.16	51.53	-0.01	4.78
Shareholding dispersion	3.60	100.00	81.16	23.86
CSR controversy	0.00	1.00	0.62	0.49
CSR performance	1.01	95.47	68.27	16.32
Environmental pillar	0.00	99.02	65.56	22.80
Social pillar	0.67	97.68	70.86	17.96
Governance pillar	2.47	97.92	66.02	20.15

Source: own study.

Table 2. Pearson correlation coefficients (independent variables)

CATEGORY	Size	Financial performance	Shareholding dispersion	CSR controversy
Size	1			
Financial performance	0.022	1		
Shareholding dispersion	0.081**	0.057*	1	
CSR controversy	-0.470***	0.025	-0.161***	1
CSR performance	0.446***	-0.007	0.166***	-0.366***
Environmental pillar	0.444***	-0.023	0.064*	-0.319***
Social pillar	0.354***	-0.026	0.128***	-0.352***
Governance pillar	0.300***	0.028	0.201***	-0.225***

Note: one-tailed statistical significance: *** at the 1% level (p<0.01); ** at the 5% level (p<0.05), and * at the 10% level (p<0.1).
Source: own study.

Estimation Methods

To evaluate the impact of the explanatory variables on the type of the firm's reaction to the adverse event, we used multinomial logistic regression. The same method has been applied in earlier studies (Lintukangas *et al.*, 2023). Multinomial logistic regression is a generalised form of logistic regression that is typically applied when a qualitative dependent variable can have more than two states. In our case, the dependent variable was an ordinal variable with three possible reactions: opportunistic, symbolic, and substantive. Using multinomial logistic regression, the probability of adopting a particular state (type of company response– symbolic or substantive) by the dependent variable in relation to the base state (in our case, it was an opportunistic reaction) is estimated under the influence of each of the independent variables. We used the PS Imago PRO 10.0 software package to perform all calculations.

RESEARCH METHODOLOGY

The multinomial logistic regression analysis results indicated that both components (*CSR performance* and *CSR controversy*) of CSR reputation were related to the type of reaction of the firm to the adverse event (Table 3). This relationship exists regardless of the time since the original event (Model 1 and Model 2). The model diagnostics indicated a good fit for both models. The independent variables statistically significantly predicted the dependent variable. All variables included in the models (except for *Financial performance*) had a significant overall effect on the outcome (the *CSR controversy* was less significant in Model 2).

The outcome of our research suggests that a higher level of social engagement, as indicated by the ESG score, is associated with a greater likelihood of a more responsible response to the Russian invasion of Ukraine (taking symbolic or substantive actions in response to the invasion). This finding is consistent with H1. The results were robust over time, which enhanced the observed relationship. We found that the probability of firms with higher ESG scores responding with symbolic actions was greater than their likelihood of responding with substantive actions, which is in line with H2. The lack of *CSR controversy* was another factor that increased the likelihood of a responsible reaction to adverse events. That effect weakened as time passed since the original event. The absence of a history of past crisis records appeared to have a more profound influence on the likelihood of a substantial response than a symbolic one. A larger firm size decreases the probability of a change in the level of activity in Russia. We may partially explain this effect by the higher perceived cost of such a change resulting from the scale of prior commitments (larger firms could have invested more in Russia) and concerns about a stronger reaction by Russia's authorities in response to actions taken by the firm. The intensification of this effect over time further confirmed this explanation. On the other hand, *financial performance* had no noticeable effect on the firm's reaction to the crisis. A more dispersed ownership structure increases the probability of a firm taking symbolic or substantial actions. The effect was stronger in the case of substantial actions and

became more profound over time. This confirms the theory that companies that have to respond to a more diverse spectrum of stakeholders tend to react to the crisis in a more socially responsible way.

Table 3. Multinomial logistic regression results regarding CSR reputation

Adjusted odds ratios				
	substantive vs. opportunistic [b]		symbolic vs. opportunistic [b]	
	Model 1 (2022)	Model 2 (2023)	Model 1 (2022)	Model 2 (2023)
Explanatory variables:				
CSR performance	1.015*	1.029***	1.029***	1.041***
CSR controversy	2.953***	2.268**	2.172**	1.734
Control variables:				
Size	0.778***	0.659***	0.868*	0.747***
Financial performance	0.986	0.984	1.000	1.000
Shareholding dispersion	1.021***	1.026***	1.018***	1.019***
Constant	a	a**	a**	a
Model diagnostics				
	Model 1 (2022)		Model 2 (2023)	
Likelihood Ratios (Chi-square):				
Model	61.978***		67.476***	
Variables:				
CSR performance	9.657***		13.779***	
CSR controversy	13.140***		5.426*	
Size	12.242***		23.721***	
Financial performance	0.564		0.543	
Shareholding dispersion	21.014***		22.191***	
Information criteria:				
AIC	1128.821		996.490	
BIC	1181.900		1049.570	
Pseudo R-square:				
Cox i Snell	0.096		0.104	
Nagelkerke	0.113		0.127	
McFadden	0.053		0.065	
N	616		616	

Note: a) for a Constant Adjusted odds ratios is not calculated b) the reference category is opportunistic; statistical significance: *** at the 1% level (p<0.01); ** at the 5% level (p<0.05), and * at the 10% level (p<0.1).
Source: own study.

Decomposition of the ESG score into environmental pillar score, social pillar score, and governance pillar score revealed that the CSR strategy profile relates to the way the firm reacts to an adverse event (Table 4). The likelihood of a change in the level of commitment to Russia was most pronounced among firms whose CSR strategies focus on social factors. One of the elements of such a strategy is a human rights policy, which covers the firm's approach to human rights. Thus, we may interpret the reaction to Russia's invasion as a protest against human rights violations. Thus, the firm's reaction to the adverse events in the same domain as its CSR strategy profile is in line with this strategy (H3). The effect described in the previous sentence was more profound for symbolic actions than for substantive actions and remained stable over time. The *social pillar* variable was also the only variable which was statistically significant at the 1% level for both symbolic and substantive reactions and across all time points. The *environmental* and *governance pillars* variables offer less robust evidence of the statistical significance of the explanatory variables, which is dependent on the type of reaction and time point.

The ongoing debate surrounds the significance of corporate social responsibility in a company's management practices. Some studies point to the instrumentalisation of CSR (Chen *et al.*, 2008; Koehn & Ueng, 2010; Ormiston & Wong, 2013; Du, 2015; Kang *et al.,* 2016), while others underscore the

advantages of CSR as a lasting element of business practices (Wang & Choi, 2013; Shiu & Yang, 2017; Jeong *et al.*, 2018; Pérez-Cornejo *et al.*, 2022). The latter approach assumes that firms must walk the talk. Our study revealed that firms with a history of extensive social engagement and resulting superior CSR reputation tend to display a reduced inclination toward opportunistic behaviour and reluctance to maintain business as usual during adverse events (H1). The results of our study prove that firms remain consistent in their CSR activities. This observation confirms the conclusions drawn from previous studies.

Table 4. Multinomial logistic regression results regarding CSR strategy profile

	Adjusted odds ratios											
	substantive vs. opportunistic response [b]						symbolic vs. opportunistic response [b]					
	Model 1E (2022)	Model 2E (2023)	Model 1S (2022)	Model 2S (2023)	Model 1G (2022)	Model 2G (2023)	Model 1E (2022)	Model 2E (2023)	Model 1S (2022)	Model 2S (2023)	Model 1G (2022)	Model 2G (2023)
Explanatory variables:												
Environmental pillar	1.008	1.021***					1.015**	1.026***				
Social pillar			1.021***	1.026***					1.028***	1.033***		
Governance pillar					1.011*	1.019**					1.024***	1.027***
Control variables:												
Size	0.887*	0.716***	0.863**	0.736***	0.886*	0.730***	0.964	0.798**	0.955	0.825**	0.962	0.814**
Financial performance	0.984	0.985	0.985	0.983	0.981	0.977	0.999	1.000	1.000	0.999	0.995	0.992
Shareholding dispersion	1.024***	1.029***	1.023***	1.028***	1.023***	1.028***	1.021***	1.023***	1.020***	1.021***	1.019***	1.020***
Constant	a*	a**	a	a	a	a**	a	a	a***	a	a**	a

	Model diagnostics					
	Model 1E (2022)	Model 2E (2023)	Model 1S (2022)	Model 2S (2023)	Model 1G (2022)	Model 2G (2023)
Likelihood Ratios (Chi-square):						
Model	40.822***	55.949***	49.559***	58.254***	46.919***	54.685***
Variables:						
Environmental pillar	4.922*	11.140***				
Social pillar			13.658***	13.445***		
Governance pillar					11.018***	9.877***
Size	3.975	17.425***	6.449**	16.839***	4.395	16.275***
Financial performance	0.699	0.574	0.647	0.606	0.795	0.691
Shareholding dispersion	29.620***	29.820***	26.157***	26.784***	25.277***	26.604***
Information criteria:						
AIC	1145.980	1004.020	1137.240	1001.710	1139.880	1005.280
BIC	1190.210	1048.250	1181.470	1045.940	1184.110	1049.510
Pseudo R-square:						
Cox and Snell	0.064	0.087	0.077	0.090	0.073	0.085
Nagelkerke	0.075	0.107	0.091	0.111	0.086	0.104
McFadden	0.035	0.054	0.042	0.056	0.040	0.053
N	616	616	616	616	616	616

Note: a) for a Constant Adjusted odds ratios is not calculated b) the reference category is opportunistic; statistical significance: *** at the 1% level (p<0.01); ** at the 5% level (p<0.05), and * at the 10% level (p<0.1).
Source: own study.

Karwowski and Raulinajtys-Grzybek (2021), who conducted content analysis of integrated reports, found a significant degree of consistency between the identified ESG and the corresponding CSR actions that have been taken. Choi and Pae (2011) found that firms with a higher level of ethical commitment show higher quality financial reporting, while Chen *et al.* (2018) found that the quality of codes of ethics is associated with higher earnings quality. Similarly, Ahluwalia *et al.* (2018) found that the adoption of a financial code of ethics improves the integrity of financial reporting.

Other studies on the reactions of foreign firms present in Russia to the invasion of Ukraine have also noticed that firms that maintain higher CSR standards behave in a more responsible way. Analysing two categories of firms from the CELI Yale list (A and F), Basnet *et al.* (2022) proved that the firms with the lower ESG Score and Human Rights Score were more likely to take the business-as-usual approach. These observations are consistent with our findings. However, we used a more nuanced approach, considering additional firms that have chosen the middle ground, mostly firms whose reactions were named as symbolic in our study. We also accounted for the passage of time, which allowed us to verify the initial declarations of the firms about actions undertaken in response to Russia's aggression. In their research, Pajuste and Toniolo (2022) argued that concerns about losing reputation played a significant role in firms' decisions to leave Russia. These results support our hypothesis that firms with a better CSR reputation are more strongly motivated to perform in a more socially responsible manner, in line with their reputation. This is because the loss of reputation is more painful for these firms than for those with a poor reputation.

On the other hand, while analysing the behaviour of foreign firms present in Russia at the time of aggression against Ukraine, Ahmed *et al.* (2023) obtained different results. They found that firms with better scores on various ESG ratings were likely to react in a less socially responsible manner. However, this particular research differed significantly from our study. Firstly, the research covered a much narrower sample of companies, concentrated on European corporations included in the STOXX600 index. Thus, it did not consider firms from other countries present in Russia, especially those incorporated in the USA, which constitute a particularly large group of firms in the CELI Yale list. Secondly, the research was limited to firms that took 'real actions.' As a result, the analysis included only firms belonging to categories A and B of the CELI Yale list, which we describe as undertaking substantial actions. In our study, we also include the remaining categories from the CELI Yale list, thus covering companies undertaking symbolic actions. Thirdly, Ahmed *et al.* (2023) covered a much shorter time window, thus based their findings on very early declarations of firms with regard to their planned actions. Owing to a longer time horizon, our study allows for a more thorough verification of such declarations. Finally, both studies differ significantly in terms of the research methodology. Our methodology facilitates a comparative analysis between firms that utilised different responses to Russia's invasion, with the group of firms that opted for an opportunistic approach serving as a benchmark.

While analysing the relationship between prior CSR activities and the reaction to adverse events, we conclude that firms favour symbolic reactions (H2). This conclusion was consistent with the views present in the literature and the results of previous studies. In their seminal paper, Ashforth and Gibbs (1990) noted that the defence of legitimacy (which may be threatened in the case of a bad event) is associated with a greater tendency toward symbolic actions. Similarly, Li *et al.* (2019) determined that companies are more likely to engage in symbolic than substantive CSR in response to a crisis. Furthermore, David *et al.* (2007) showed that, in the case of external pressures, managers' responses are symbolic. The nature of the crisis, which makes it more difficult to assign responsibility for the event to the firm, is another factor that helps explain the motives of foreign corporations' reactions to adverse events. Such events generate fewer negative consequences than do other types of crises. Waniak-Michalak and Michalak (2024) showed that the magnitude of a firm's reaction to a crisis depends on the expected level of the crisis's consequences. Thus, a substantive reaction might be perceived as excessive, especially when high CSR performance provides additional protection to the firm (Kim *et al.*, 2023).

The study by Schaltegger and Hörisch (2017) indicates that legitimacy-seeking constitutes the dominant logic in CSR management. In response to crises, this may generate tension between decisions aimed at preserving moral legitimacy and actions that could harm pragmatic legitimacy. These two types of legitimacy lie at opposite ends of the continuum of benefit distribution related to company active-

ity (Bitektine, 2011). Moral legitimacy entails a broad distribution of benefits, as it relates to the alignment of corporate actions with the public interest, as defined by the prevailing system of norms and values. On the other hand, pragmatic legitimacy implies a narrow distribution of benefits, as it refers to the organisation's ability to deliver tangible outcomes to its 'most immediate audiences' (Suchman, 1995; p. 578). Our hypotheses (H1 and H2) reflect this tension, which is visible in our empirical findings. Companies with higher CSR standards exhibited less opportunistic behaviour in response to the Russian invasion, thereby safeguarding their moral legitimacy. At the same time, they tended to favour symbolic actions, perceiving them as less detrimental from the standpoint of pragmatic legitimacy.

Furthermore, our study shows the existence of a relationship between the form of the crisis reaction and a firm's CSR strategy profile. We found that an adverse event that occurs in the same domain as the firm's CSR strategy profile triggers reactions aligned with that strategy (H3). Previously, limited research differentiated between distinct CSR strategy types and examined them in relation to negative events (Jayachandran *et al.*, 2013; Lenz *et al.*, 2017). These studies indicated that firms may derive greater benefits from actions that differ from those observed in this study. However, there are important differences between earlier studies and our study. Prior studies have concentrated on the consequences of various reactions to bad events, whereas we searched for the antecedents of these reactions. Furthermore, earlier studies considered events that were representative of corporate social irresponsibility, where we may attribute responsibility for the event to the firm. Our study concentrates on a negative event that is unconnected to the firm's responsibility. Finally, previous studies concentrated on CSR performance in the aftermath of the crisis, whereas we included historical CSR performance. Incorporating in our research aspects that were not previously considered means extending the scope of the study and broadening the existing knowledge.

Our study contributes to the discussion of the permanency and cohesion of CSR actions (Koehn & Ueng, 2010; Wang & Choi, 2013; Du, 2015; Shiu & Yang, 2017; Jeong *et al.*, 2018), and the role played by prior CSR activities and reputation build upon these actions on the nature of the firm's reaction to negative events (Kang *et al.*, 2016; Lenz *et al.*, 2017; Li *et al.*, 2017). Prior studies on the latter topic included only firm-specific events related to social irresponsibility. Events of this type have a strong negative impact on a firm's reputation. Thus, the desire to protect reputation was considered a primary motive for a firm's CSR actions in response to the crisis. Our conclusions supplement these findings. We analysed the firm's reactions to a negative event caused by external factors, thus creating a lower reputational risk. Our results still indicate that firms with better CSR reputation react to such events in a more socially responsible way. This finding suggests the existence of other motives for such actions beyond reputation protection. We believe that path dependence may cause reactions to bad events.

CONCLUSIONS

Our research contributes to the discussion on the integrity of corporate social responsibility (CSR) policies. Treating Russia's aggression against Ukraine as a form of natural experiment that enables the analysis of corporate behaviour in a crisis, we examined the impact of prior CSR policies of foreign companies operating in the Russian market on their behaviour during the crisis. A particular characteristic of this crisis is its less negative impact on reputation compared to other crises studied so far. This is because of factors independent of the company and beyond its control that cause the negative event, making it impossible to attribute responsibility for the crisis to the company. Such a situation weakens incentives for socially responsible behaviour aimed at protecting reputation, especially when such behaviour entails additional costs. We demonstrated that despite this, companies with higher CSR standards acted more responsibly and consistently with their prior strategies during the crisis.

Our research makes a significant contribution in two areas. Firstly, it confirms that companies tend to 'walk the talk' in their CSR policies. The consequence of prior CSR activities is more socially responsible behaviour in subsequent periods. This mechanism reinforces behavioural patterns and serves as a driving force, helping to build CSR reputation. The second area in which our research expands knowledge concerns the relationship between CSR and crises. Until now, studies have mainly focused on crises resulting from corporate social irresponsibility, cases where the company could be blamed for causing the nega-

tive event. In the context of social responsibility, scholars have examined such situations within the frameworks of the moral balance model (Ormiston & Wong, 2013) or the penance mechanism (Kang *et al.,* 2016). Both assume a lack of continuity in CSR policy. In the moral balance model, social engagement creates a moral alibi for irresponsible actions when beneficial. In contrast, under the penance mechanism, CSR activity following a crisis serves to compensate for prior irresponsibility that led to the negative event. Our research broadened the range of crises analysed and allowed us to identify a different relationship between crisis and CSR based on path dependence – companies maintained continuity in their CSR policies in response to a crisis. By stating this, we do not determine whether this behaviour results from internal factors, from external stakeholder pressure, or from concerns about their reaction if the company's behaviour violated expectations based on its previous CSR activities.

Despite our contribution, this study also has some limitations. Our analysis covers only a single crisis. This crisis drew wide media and public attention and generated strong emotions. From the point of view of foreign companies present in Russia, this situation has increased reputational risk. The risk level was higher for firms with a better CSR reputation, as the lack of reaction could result in accusations of hypocrisy. Thus, one could perceive the nature of adverse events as a factor affecting the reaction. Thus, future research could include other crises caused by external factors, resulting in minimal reputational risk. Such studies can cover crises caused by natural disasters. Studying the relationship between prior CSR activities and the reputation built upon such activities, and the firm's reaction to this type of bad event, could allow us to determine whether a firm walks the talk in those situations, too. Another potentially interesting direction for further research concerning crises such as the Russian aggression against Ukraine could be a detailed analysis of the impact of other ESG factors on company behaviour. Among these factors, one should give particular attention to the structure and composition of the Board of Directors, as well as the structure of executive compensation (including the presence of ESG performance criteria within this structure).

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Use of Artificial Intelligence

The text is free of AI/GAI usage.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The impact of economic sentiment on European stock markets

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A B S T R A C T
Objective: This article aims to analyse the impact of sentiment indicators reflecting the condition of major economies on the returns and volatility of European developed, emerging, and frontier stock markets.
Research Design & Methods: We employed survey-based economic sentiment indicators, classified into forward-looking measures reflecting economic expectations and measures of current economic sentiment. We used survey-based economic sentiment indicators, namely the ZEW Economic Sentiment Index for Germany, the ZEW Economic Sentiment Index for the Eurozone, the ZEW Current Condition Index for the Eurozone and the Michigan Consumer Sentiment Index from the US. We modelled the daily stock returns for 27 markets over the period 2008-2022 using a GJR-GARCH model and a time-varying transition probability Markov switching model (TVPMS), where transition probabilities depend on lagged economic sentiment indicators.
Findings: The results from the GJR-GARCH model show that economic sentiment generally affects returns and their volatility. We observed the causal relationship between sentiment and returns for different types of markets. These results confirm that sentiment indicators in major economies have a global impact, affecting not only developed markets but also emerging and frontier markets. In addition to the GJR-GARCH methodology, the use of the TVPMS approach confirms the results and provides new insights. We found two market states: high and low volatility, and documented the impact of sentiment on market returns as a function of these states. The Michigan consumer sentiment index had the most substantial and persistent effect on European markets, with significant effects on volatility in both high- and low-volatility states; the ZEW economic sentiment indices affect volatility in high-volatility states, while the ZEW current situation index has a significant effect on volatility only in low-volatility states.
Implications & Recommendations: These findings provide investors and financial managers with valuable insights into the influence of different sentiment indicators on decision-making in various market conditions. During periods of high volatility, sentiment based on economic expectations can help to mitigate market fluctuations. In contrast, during stable periods, sentiment reflecting the current economic state is more informative. The U.S. Michigan Consumer Sentiment Index (MCSI) is particularly relevant in this regard, offering meaningful guidance about investment decisions in both stable and volatile environments. The influence of the same sentiment indicators on various European stock markets highlights the region's strong interconnections and suggests the presence of sentiment contagion.
Contribution & Value Added: This study makes an original contribution by combining two well-established models in a novel way. The GJR-GARCH model enables us to analyse the impact of economic sentiment on expected returns and conditional volatility, while the TVP-MS model identifies periods when sentiment exerts its greatest influence. Our research demonstrates that market behaviour responds differently to sentiment indicators, depending on their nature and the volatility regime.

INTRODUCTION

Predicting financial market volatility is critical for investors and decision makers, and has therefore been the focus of extensive research aimed at identifying factors that reliably predict market behaviour. Many studies have examined the role of macroeconomic indicators in predicting market volatility (*e.g.*, Rapach *et al.*, 2005; Chen, 2009; Pilinkus, 2010; Larsson & Haq, 2016). However, it is also valuable to explore how economic sentiment influences markets, as sentiment-driven factors may play a significant role in market movements.

In recent years, the financial literature has widely discussed investor sentiment. Many proposed indicators of investor sentiment focus on the stock market and include measures such as market liquidity, turnover ratio, and VIX (*e.g.*, De Long *et al.*, 1990; Baker & Stein, 2004; Wang *et al.*, 2022; Bossman *et al.,* 2023) or survey-based measures, such as the Sentix index (Schmeling, 2007). According to classical financial theory, arbitrage should diminish the influence of investor sentiment on asset prices. In reality, arbitrage is limited and investors often interpret identical information differently, allowing sentiment to have a significant impact on the stock market (Baker & Wurgler, 2007). For example, Lee *et al.* (2002) show that stock returns adjust to changes in investor sentiment, while others find that periods of high sentiment lead to more aggressive investment by sentiment-driven investors (Karlsson *et al.*, 2009; Yu & Yuan, 2011).

The literature also includes studies on survey-based indicators of consumer confidence, such as the University of Michigan Consumer Sentiment Index (MCSI) (Lemmon & Portniaguina, 2006). In Europe, there is a survey-based index produced by the ZEW Institute that monitors sentiment in Germany or the euro area (see *e.g.*, Homolka & Pavelková, 2018). Both MCSI and ZEW are economic sentiment indices that measure the general mood of consumers (MCSI) and experts (ZEW) regarding the broader economic outcomes. Unlike investor sentiment, which is more focused on short-term market movements and investor behaviour, economic sentiment reflects the public's perceptions and expectations about the economy, which can significantly influence both market trends and consumer behaviour.

In our analysis, we considered the MCSI index, which reflects the state of the US economy, two indicators of sentiment in the euro area (the ZEW index of expected and current conditions), and the ZEW sentiment index for Germany as the largest European economy. We took all sentiment indicators from the Bloomberg database. We examined their impact on returns in 27 European equity markets, divided into developed, emerging and frontier markets. We took the data from the Morgan Stanley Capital International (MSCI).

The empirical study used two modelling approaches: the GJR-GARCH model with AR component and the time-varying transition probability Markov switching model (TVPMS). These models provide complementary insights into the dynamics of returns: the AR-GJR-GARCH model directly measures how sentiment affects returns and conditional volatility, while the TVPMS model captures shifts between high- and low-volatility regimes influenced by sentiment. By using both models, we could more fully assess the impact of sentiment indicators on stock market returns. The choice of the regime shift model was driven by research showing that investor behaviour changes with market conditions (Gervais & Odean, 2001; Nofsinger, 2005; Li & Luo, 2017).

For the TVPMS model, we employed Filardo's (1994) framework for regime shift analysis. This approach assumes two market states of high and low volatility, with transitions governed by a time-varying transition probability matrix. By allowing the transition probabilities to depend on lagged economic sentiment indicators, we could identify when the effect of sentiment on market volatility is the most pronounced. We measured volatility using the standard deviation, which is a parameter of the state-dependent conditional distribution constructed for daily returns.

The primary objectives of this study were:

1. To evaluate whether sentiment in major economies influences returns and volatility across European stock markets, including emerging, frontier, and developed markets.
2. To analyse how the type of economic sentiment measure – reflecting either economic expectations or current economic conditions – affects the strength of this influence.

3. To investigate the impact of economic sentiment on local markets – developed, emerging, and frontier – and determine whether this effect is more pronounced under low- or high-volatility conditions.

Our study confirmed the conjecture that economic sentiment in major economies affects European stock market returns and volatility. Regardless of the type of economic sentiment measure, increases in sentiment reduce return volatility not only in developed markets but also in emerging and frontier markets. These results highlight the global nature of economic sentiment. The TVPMS model provides additional insights, indicating that the impact of the sentiment indicator depends on market conditions. For example, the impact of the Michigan Consumer Sentiment Index is significant in both high- and low-volatility states, the two ZEW indices based on economic expectations are significant in high-volatility regimes, while the ZEW current conditions index is significant only in low-volatility states.

This study contributes to the literature in the following ways. First, it shows that economic sentiment affects stock market returns and volatility not only in countries where economic sentiment is measured, but also in countries with less developed stock markets. Second, we applied a dual-model framework (AR-GJR-GARCH and TVPMS) to assess not only the average effects of sentiment but also how these effects may vary across different volatility regimes. The use of time-varying transition probabilities driven by lagged sentiment indicators adds a dynamic and regime-sensitive perspective that complements traditional volatility models. Thirdly, we focused specifically on economic sentiment – both forward-looking (expectations-based) and current – rather than sentiment derived directly from financial markets. This distinction allowed us to explore whether broad economic perceptions, as opposed to market-specific moods, have predictive power for returns and volatility. To the best of our knowledge, this approach has received limited attention in the literature. Our study fills an important gap by extending the analysis to a wider range of countries, capturing differences in market development and regional sensitivity to sentiment, and by applying the TVPMS model to understand sentiment's impact in different market regimes. It extends and enriches research by providing new insights into the interaction between types of economic sentiment and market conditions.

This article is structured as follows. The next section presents a literature review. The literature review is followed by a description of the data and methodology used in the empirical analysis. The Results and Discussion section presents the main findings, and the Conclusions section briefly summarises the results.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Numerous studies have examined the factors influencing financial markets, including political events, economic conditions, and investor expectations (Pilinkus, 2010; Larsson & Haq, 2016). Rapach *et al.* (2005) demonstrated that one can predict stock returns using macroeconomic variables, while Chen (2009) found that these variables can even signal recessions in stock markets. Mahmood and Dinniah (2009) discussed relationships between stock prices and economic indicators, while Humpe and Macmillan (2009), Kim *et al.* (2008), and Chang (2009) utilised the Hidden Markov Model (HMM) to assess the effects of macroeconomic variables on stock market volatility.

Investor sentiment has garnered significant attention for its influence on stock markets, and the literature provides several methods for its measurement. Baker and Wurgler (2006) proposed sentiment proxies such as retail transactions, closed-end fund discounts and IPO yields. Bossman *et al.* (2023) used the VIX volatility index as a sentiment proxy to study EU sector stocks amid geopolitical turmoil. Wang *et al.* (2022) found that the turnover ratio, used as a sentiment proxy, affects returns differently in bull and bear markets, with higher sentiment being associated with higher returns in bull markets but lower returns in bear markets. Lee *et al.* (2002) analysed the impact of the Investor Intelligence Index on the U.S. market and found that the direction of stock returns aligns with changes in investor sentiment. Optimism correlates with higher future returns and reduced conditional volatility, while pessimism aligns with lower returns and increased volatility. Using the measure of investor sentiment proposed by Baker and Wurgler (2006), Chung *et al.* (2012) found that investor sentiment predicts stock returns during economic expansions but not recessions, highlighting sentiment-driven asymmetric pricing behaviour.

Many studies measure sentiment based on media or survey data. For example, Shi *et al.* (2019) developed a sentiment measure from investor forum posts, Siganos *et al.* (2014) from Facebook, while Petit *et al.* (2019) used web search data to create sentiment indicators for investment portfolios. Ballinari *et al.* (2022) examined the effect of a firm's social media attention on return volatility. García (2013) demonstrated that sentiment derived from financial news columns significantly impacts U.S. stock markets, with negative news exerting a stronger influence on stock performance during recessions. Similarly, Lischka (2015) found that negative sentiment in German media intensifies stock market declines. Schmeling (2007) found that institutional sentiment is a stronger predictor of returns for major indices in the US, Europe, and Japan compared to individual sentiment.

Global events such as the 2008 financial crisis and recent geopolitical tensions highlight the interconnectedness of economies and the spillover of sentiment across markets. These events demonstrate how investor sentiment extends beyond local markets, influencing multiple economies through mechanisms like risk aversion, foreign direct investment (FDI), and global trade adjustments. Research by Baker *et al.* (2012) highlights the importance of a global sentiment. They showed that the investors across major economies share a common sentiment, and it influenced the markets more than the local fluctuations in the mood of investors. Corredor *et al.* (2015) further confirmed the impact of global sentiment on Central and Eastern European markets, highlighting how sentiment in major economies affects regions with close trade and investment links.

While scholars often study sentiment in the context of forecasting economic metrics, its relationship with financial markets remains less explored. Research on economic sentiment, measured primarily through surveys, often focuses on forecasting economic metrics such as GDP (Hansson *et al.*, 2005) or industrial production (Schröder & Hüfner, 2002). Studies linking economic sentiment to financial markets remain relatively limited. On the other hand, Lemmon and Portniaguina (2006) established a relationship between investor sentiment and MCSI. Cieślik and Ghodsi (2021) show that the European Economic Sentiment Indicator affects FDI flows within the EU. Homolka and Pavelková (2018) documented that the German ZEW Economic Sentiment Index predicted the 2008 crisis in the German market three months in advance, a result confirmed by Rakovská (2021).

Based on the literature and prior findings, we proposed the following hypotheses:

H1: Economic sentiment in major economies influences returns and volatility across European markets, including developed, emerging, and frontier markets, due to economic linkages and market contagion.

H2: The type of economic sentiment measure – whether reflecting economic expectations or current economic conditions – modifies the strength of its impact on stock market returns and volatility.

H3: The impact of economic sentiment on European stock markets varies under different market conditions, with the effect being more significant during high-volatility (crisis) periods compared to low-volatility (prosperous) periods.

While we focused on the predictive role of economic sentiment indicators, the observed effects may also reflect cross-market sentiment spillovers. Given increasing economic and financial integration, sentiment in one region, such as the US or Eurozone, can influence investor expectations and market behaviour elsewhere. This highlights the potential role of underlying macroeconomic linkages in transmitting sentiment internationally.

RESEARCH METHODOLOGY

Sentiment Indices

Sentiment indicators are meant to capture subjective assessments of the current or expected state of the economy or financial markets. They are increasingly used in financial and economic research to explain or predict market behaviour, especially stock returns and volatility. These indices reflect the psychological and behavioural components of decision-making, often preceding real economic activity or market adjustments.

In the literature, scholars commonly distinguish two broad categories of sentiment indicators (Wang *et al.*, 2022). The first includes investor sentiment indices, such as the VIX index or measures based on trading volume and market flows. These capture emotions and moods within financial markets themselves. The second category, *i.e.*, economic sentiment indicators, which are the focus of this study, reflect broader perceptions and expectations regarding the economy, as reported by either financial analysts or consumers.

These indicators differ across several key dimensions:

− Perspective – whether they are forward-looking, capturing economic expectations, or focused on current conditions.
− Respondents – ranging from financial experts to general consumers.
− Geographic scope – from specific countries to broader regions such as Germany, the Eurozone, or the United States.
− Construction methodology – based on net balances of optimistic and pessimistic responses or standardised composite scores.

In this study, we employed four sentiment indices to capture economic perceptions in three major economies: the United States, the Eurozone, and Germany. As the strongest European economy and the largest source of foreign direct investment in Europe (Davies, 2022), Germany is represented by a separate indicator. The selected indices were the ZEW Economic Sentiment Index for the Eurozone (ZEW-ES) and Germany (GER-ES), the ZEW Current Condition Index (ZEW-CS), and the Michigan Consumer Sentiment Index (MCSI).

ZEW Economic Sentiment Index (ZEW-ES and GER-ES) are forward-looking indicators based on monthly surveys conducted by the ZEW Institute (Leibniz Centre for European Economic Research). They reflect the economic outlook of up to 350 financial analysts and economists for the next six months. Respondents assess whether the economy will improve, remain unchanged, or deteriorate. The index is calculated as the net balance of positive and negative responses, producing values from −100 (total pessimism) to +100 (total optimism), with 0 indicating a neutral stance. While the ZEW-ES covers the Eurozone as a whole, the GER-ES specifically targets expectations about the German economy. This distinction allows for comparisons between regional and national sentiment and their respective impacts on European markets.

ZEW Current Condition Index (ZEW-CS), derived from the same ZEW survey, differs by focusing on the present state of the economy rather than future expectations. Analysts assess whether current conditions are good, neutral, or poor. This distinction is important, as sentiment about present conditions may influence markets differently than forward-looking expectations, especially in varying economic environments.

The Michigan Consumer Sentiment Index (MCSI) is a widely respected indicator published monthly by the University of Michigan. Based on telephone interviews with at least 500 US households, it captures consumer views on personal finances and both short- and long-term prospects for the US economy. The index is standardised to a base value of 100 (set in Q1 1966) and is considered one of the most influential sentiment indicators globally. Its significance stems from the size and global reach of the US economy and the fact that US consumer spending accounts for a large share of global demand. As financial markets become more globally integrated, sentiment in the US can affect investor expectations far beyond domestic borders, including in Europe.

These indices vary in their time horizons, respondent types, and geographic coverage, all of which may influence their predictive power regarding stock market behaviour. Economic optimism or pessimism can lead to changes in asset prices, investment flows, and risk assessments. Expectations-based sentiment may reduce uncertainty, lowering volatility and contributing to market stability during turbulent times. In contrast, current-condition sentiment, if negative during economic upswings, can act as an early warning signal of future downturns, thus potentially increasing perceived risk and market volatility.

By incorporating different types of sentiment indicators, we aimed to capture how both forward-looking economic optimism/pessimism and present-day assessments of economic health influence European stock markets under both normal conditions and during periods of financial stress.

Models

Market returns are calculated as $r_t = ln(P_t/P_{t-1})$, where P_t represents the closing price of the index at time t and P_{t-1} is a closing price of the previous day. We used two approaches in empirical analysis: the GARCH model, which is the most popular in sentiment research (Wang *et al.* 2022), and the less popular TVPMS model (Aloy *et al.*, 2014). This study is the first to jointly apply the AR-GJR-GARCH and TVPMS models to examine the impact of economic sentiment on returns and volatility across different types of European stock markets (developed, emerging, and frontier). While scholars have widely used the GARCH-type models to capture volatility dynamics, and applied TVPMS models in regime-switching analyses, their combined use in the context of sentiment analysis remains novel. This approach allowed us to examine both the average and regime-dependent effects of sentiment, and thus offer a more comprehensive understanding of how economic sentiment influences markets under varying conditions.

The GARCH Model Specification

As the first step in our analysis, we employed sentiment-augmented GARCH-family models to study the effect of sentiment indices on daily returns. Specifically, we used the GJR-GARCH model with an AR(1) component, augmented with external sentiment indicators. This model effectively captures asymmetries in volatility responses to shocks, aligning with the study's objectives. In these models, one treats the sentiment indices as external variables. We specifically considered sentiment values from the previous month as external sentiment indicators. The indices analysed included ZEW-ES, GER-ES, ZEW-CS, and MSCI, which serve as the external sentiment variables influencing daily stock returns.

The mean equation follows:

$$r_t = \mu + \beta_{mean}x_{t-1} + \phi r_{t-1} + \epsilon_t \qquad (1)$$

in which:

μ - is the constant;

β_{mean} - represents the external regressor term for sentiment x at time $t-1$;

ϕr_{t-1} - is the autoregressive term capturing the influence of the previous return;

$\epsilon_t = \sigma_t z_t$ - is the error term, with z_t as i.i.d. standard normal and σ_t is the conditional volatility of stock returns at time t.

For the variance equation, we assumed that:

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \gamma I_{t-1}\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \beta_{var}x_{t-1} \qquad (2)$$

in which:

ω - is the constant variance term;

α - represents the ARCH term for past squared shocks;

$\gamma I_{t-1}\epsilon_{t-1}^2$ - captures the leverage effect, where I_{t-1} is an indicator function equal to 1 if $\epsilon_{t-1} < 0$ (indicating an asymmetric response to negative shocks);

β - represents the GARCH term for the prior period's conditional variance;

β_{var} - is the external regressor term, where x_{t-1} denotes the economic sentiment indicator, allowing sentiment to influence conditional volatility directly.

The parameter β_{mean} in the mean equation captures the effect of sentiment on returns whereas the parameter β_{var} in the variance equation captures the effect of sentiment on volatility.

While GARCH models are effective at capturing the dynamic behaviour of returns and variance, they fall short in addressing *when* sentiment affects market returns – during periods of stability or periods of high volatility. To fill this gap, we used a regime switching model with two distinct states. In this framework, the transition probabilities in the hidden Markov chain are explicitly linked to sentiment indicators. This approach allowed us to disentangle the timing of sentiment's influence on market dynamics. By identifying transitions between high-volatility and low-volatility states, we aimed to examine whether sentiment has a more significant impact during periods of market turmoil versus more stable market conditions. This approach helped us understand how market participants respond to economic sentiment in different market environments.

The HMM and TVPMS Models

The Hidden Markov Model (HMM) provides a basic framework for capturing transitions between market states in financial time series. Building on the Hidden Markov Model (HMM), the Time-Varying Probability Markov Switching Model (TVPMS) incorporates dynamic transition probabilities influenced by economic sentiment indicators. This approach provides a more nuanced understanding of how sentiment drives regime shifts between high- and low-volatility states.

We assumed two distinct market states: a high-volatility state and a low-volatility state, where the transition between regimes is governed by a time-varying probability matrix (Aloy *et al.*, 2014; Hamilton, 1994). We assumed that the returns r_t, $(t = 1,2,\dots)$ were described as follows:

$$r_t = a_{s_t} + b_{s_{t-1}} (r_{t-1} - a_{s_{t-1}}) + \sigma_{s_t}^2 \varepsilon_t \tag{3}$$

in which:

$$s_t \in \{1,2\} \text{ and } \varepsilon_t \sim i.i.d.\,N(0,1).$$

Parameters a_{s_t} and b_{s_t} are regime-specific intercepts and slopes, $\sigma_{s_t}^2$ is the regime-specific variance, where higher values indicate a high-volatility state and lower values indicate a low-volatility state.

The model identified four distinct cases based on current and previous states, which allowed us to capture how returns evolve based on state transitions. We discussed the following four cases:

$$r_t = a_1 + b_1 (r_{t-1} - a_1) + \sigma_1^2 \varepsilon_t \tag{3a}$$

$$r_t = a_2 + b_1 (r_{t-1} - a_1) + \sigma_2^2 \varepsilon_t \tag{3b}$$

$$r_t = a_1 + b_2 (r_{t-1} - a_2) + \sigma_1^2 \varepsilon_t \tag{3c}$$

$$r_t = a_2 + b_2 (r_{t-1} - a_2) + \sigma_2^2 \varepsilon_t \tag{3d}$$

Parameters a_1, b_1, σ_1^2 characterise the high-volatility regime, while a_2, b_2, σ_2^2 describe the low-volatility state. Since (3) formula, we could find that the Hidden Markov Model (HMM) follows a four-state Markov chain with transition matrix:

$$\boldsymbol{P}^* = \begin{bmatrix} p_{11} & p_{12} & 0 & 0 \\ 0 & 0 & p_{21} & p_{22} \\ p_{11} & p_{12} & 0 & 0 \\ 0 & 0 & p_{21} & p_{22} \end{bmatrix} \tag{4}$$

in which:

p_{ij} denotes $P\{s_t = i | s_{t-1} = j\}$;

$p_{12} = 1 - p_{11}$ and $p_{21} = 1 - p_{22}$.

The density function of returns is defined as:

$$f(r_t | s_t = i, s_{t-1} = j, \Omega_t; \Theta) = 1/(2\pi\sigma_i^2) exp\left(-\left(r_t - a_i - b_j(r_{t-1} - a_j)\right)^2 / 2\sigma_i^2\right) \tag{5}$$

in which:

Ω_t - denotes historical information up to time t;

Θ - is the vector of model parameters.

In TVPMS, the probabilities are governed by lagged economic sentiment indicators. Specifically, for an economic sentiment indicator x_t, we assumed that:

$$p_{11}(t) = \frac{\exp(\alpha_1 + \beta_1 x_{t-1})}{1 + \exp(\alpha_1 + \beta_1 x_{t-1})} \tag{6a}$$

$$p_{22}(t) = \frac{\exp(\alpha_2 + \beta_2 x_{t-1})}{1 + exp(\alpha_2 + \beta_2 x_{t-1})} \tag{6b}$$

We estimated the model's parameters using maximum likelihood (ML) optimisation, following the method used in Aloy *et al.* (2014). To assess the significance of sentiment effects, we performed significance tests on the β parameters. The sign and significance of β_1 and β_2 indicate how sentiment affects transitions, with β_1 affecting high-volatility states and β_2 affecting low-volatility states. In addition, we tested whether the TVPMS model significantly outperforms the HMM using the Vuong (1989) likelihood ratio test:

$$LM = 2\big(L(r_t;\Theta) - L_F(r_t;\Theta)\big) \tag{7}$$

in which $L(r_t;\Theta_1)$) and $L_F(r_t;\Theta_F)$) are the log-likelihoods of the TVPMS and HMM models, respectively. Under the null hypothesis, the statistic follows a chi-squared distribution with degrees of freedom based on the parameter count difference (Czapkiewicz, 2018). The comparison test between two models, *i.e.*, the HMM and the TVPMS model, using this restriction test, allowed us to assess whether the economic sentiment indicator really affects returns.

Data

We investigated the influence of economic sentiment in major economies on stock market behaviour in Europe. The analysis spanned from January 2008, to January 2022, with a separate examination of the pre-COVID-19 period to ensure robustness. We sourced the data on sentiment indicators from the Bloomberg database and the European market data from the MSCI database.

European markets are divided into three groups: developed, emerging, and frontier. The 15 developed markets are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK. The six emerging markets are the Czech Republic, Greece, Hungary, Poland, Turkey and Russia, while the seven frontier markets are Croatia, Estonia, Lithuania, Kazakhstan, Romania, Serbia, and Slovenia. To represent these groups, we used three aggregate indices from the MSCI database, *i.e.*, the MSCI Europe Developed Markets Index (Developed), the MSCI Europe Emerging Markets Index (Emerging), and the MSCI Europe Frontier Markets Index (Frontier). These indices are calculated based on local stock market indices and are weighted by market capitalisation, with adjustments for free float. They reflect the performance of representative equity markets within each group. The MSCI indices are denominated in USD. Stock market data are observed at a daily frequency, while sentiment indices are available on a monthly basis. To address the lower frequency of sentiment indices (monthly) compared to daily stock market returns, we followed a common approach in the literature by assigning the same monthly sentiment value to all trading days within that month. This method allowed us to align the sentiment data with the daily frequency of stock market returns while preserving the temporal consistency of the sentiment indicators.

Figure 1 presents the data used in the analysis, *i.e.*, the top panel displays the daily prices of the selected MSCI indices, while the bottom panel shows the corresponding economic sentiment indicators over the study period. During major crises, such as the 2008 financial crisis, the Eurozone crisis, and the COVID-19 pandemic, the ZEW-ES and GER-ES indices dropped sharply, reflecting a significant decline in economic optimism. These indices typically rebounded strongly following each crisis. In contrast, the ZEW-CS index often exhibits low or negative values even during periods of optimism in the ZEW-ES and GER-ES, highlighting its focus on current economic conditions rather than future expectations. The MCSI values are consistently positive due to the index's construction. However, in this study, the MCSI has been detrended to capture deviations from a linear trend. We interpreted positive deviations as optimism and negative deviations as growing pessimism.

Table 1 (upper panel) presents basic descriptive statistics for stock market returns across developed, emerging, and frontier European markets. The data revealed that all return series exhibited high kurtosis and negative skewness, indicating fat tails and a tendency toward negative outliers. Emerging markets display the highest standard deviation and maximum return, highlighting their greater volatility and potential for larger gains (or losses). In contrast, frontier markets show the lowest standard deviation and maximum return, reflecting their relatively lower risk and reward. Developed markets exhibit the highest median and average returns, suggesting more consistent performance over time.

The lower panel of Table 1 presents descriptive statistics for the sentiment indices. The ZEW-ES and GER-ES indices, which reflect economic expectations, both show negative skewness and moderate kurtosis, with values ranging from strong pessimism to strong optimism. The ZEW-CS index, focused on current conditions, has the most negative mean and exhibits positive skewness, indicating more frequent mildly positive assessments but occasional severe downturns. The MCSI, reflecting U.S. consumer sentiment, shows low kurtosis and slightly negative skewness, with values always positive due to its construction. Its relatively low standard deviation suggests more stable consumer perceptions over time.

MSCI Index

Sentiment Indicators

**Figure 1. Daily prices of aggregate indices (top panel) and economic sentiment indicators
(bottom panel) from June 2008 to January 2022**
Source: own elaboration.

Table 1. Descriptive statistics of market returns and economic sentiment indices

Markets	Median	Mean	SD	Skewness	Kurtosis	Minimum	Maximum
MSCI indexes							
Developed	0.0005	0.0000	0.0141	-0.4342	13.5277	-0.1406	0.1070
Emerging	0.0003	-0.0003	0.0189	-0.4923	16.7588	-0.1993	0.1860
Frontier	0.0003	-0.0001	0.0116	-0.9644	13.9058	-0.1005	0.0794
Sentiment Indexes							
ZEW-ES	21.250	16.607	35.038	-0.400	2.423	-63.700	84.00
GER-ES	13.800	13.281	33.900	-0.205	2.415	-63.900	84.400
ZEW-CS	-23.300	-27.875	40.697	0.148	2.072	-95.000	57.700
MCSI	81.850	82.002	12.544	-0.208	1.966	55.300	101.400

Note: Descriptive statistics of daily indices' returns and economic sentiment indices from June 2008 to January 2022.
Source: own study.

Correlations between sentiment indicators states revealed other characteristics. The ZEW-ES and GER-ES indices were highly correlated (0.95), reflecting similar expectations for the euro area and Germany. However, the ZEW-ES showed a weak positive correlation with the MCSI (0.205) and a negative correlation with the ZEW-CS (-0.223 for the euro area and -0.347 for Germany). On the other hand, the

ZEW-CS and MCSI indices showed a moderate positive correlation (0.474), suggesting some convergence between current sentiment in Europe and consumer confidence in the US.

RESULTS AND DISCUSSION

GJR-GARCH Model Results

Firstly, we used the AR(1)-GJR-GARCH augmented with external sentiment indicators to model daily returns. We designed the empirical study for all stock returns, but we restrict the discussion to aggregated indices such as developed, emerging, and frontier. To assess the impact of economic sentiment on stock market return dynamics, we discuss each sentiment index separately. Table 2 summarises the results of the AR(1)-GJR-GARCH model, which shows the estimated values of the model parameters and the p-values. We are particularly interested in the significance and sign of the coefficients corresponding to each sentiment index for developed, emerging, and frontier market aggregates.

Table 2. Estimation results for AR(1)-GJR-GARCH model

CATEGORY?		μ	ϕ	β_{mean}	ω	α	β	γ	β_{var}
Panel A: Developed									
MCSI	Estimate	0.0002	-0.0073	**-0.0002****	2.11E-06	0.0132*	0.9003***	0.1465***	3.97E-13
	p-value	0.367	0.687	**0.009**	0.061	0.024	0.000	0.000	0.999
ZEW-ES	Estimate	0.0001	-0.0075	-0.0003	2.03E-06*	0.0167*	0.9001***	0.1427***	**1.08E-08*****
	p-value	0.541	0.662	0.256	0.048	0.028	0.000	0.000	**0.000**
ZEW-CS	Estimate	-0.0002	-0.0086	**-0.0009****	2.12E-06	0.0117***	0.9002***	0.1492***	6.67E-13
	p-value	0.302	0.637	**0.005**	0.069	0.000	0.000	0.000	0.998
GER-ES	Estimate	0.0003	-0.0076	-0.0006	2.52E-06	0.0216***	0.8882***	0.1414***	4.18E-13
	p-value	0.120	0.708	0.112	0.346	0.000	0.000	0.000	0.999
Panel B: Emerging									
MCSI	Estimate	0.0000	0.0557**	-0.0002	2.53E-06*	0.0150***	0.9296***	0.0900***	4.52E-12
	p-value	0.982	0.002	0.275	0.019	0.000	0.000	0.000	0.987
ZEW-ES	Estimate	0.0000	0.0544**	**-0.0004*****	2.42E-06*	0.0154*	0.9297***	0.0901***	**1.27E-07*****
	p-value	0.906	0.002	**0.000**	0.029	0.047	0.000	0.000	**0.000**
ZEW-CS	Estimate	-0.0001	0.0560**	-0.0001	2.5E-06**	0.0157***	0.9294***	0.0895***	3.03E-11
	p-value	0.686	0.002	0.794	0.010	0.000	0.000	0.000	0.949
GER-ES	Estimate	0.0000	0.0543**	-0.0001	2.76E-06	0.0058***	0.9364***	0.0842***	**2.17E-08*****
	p-value	0.965	0.005	0.793	0.101	0.000	0.000	0.000	**0.000**
Panel C: Frontier									
MCSI	Estimate	0.0003*	0.0502**	**-0.0003****	2.99E-06	0.0353***	0.8942***	0.0762***	7.91E-13
	Estimate	0.044	0.006	**0.018**	0.000	0.000	0.000	0.000	0.999
ZEW-ES	Estimate	0.0001	0.0506***	0.0005	2.87E-06	0.0380***	0.8951***	0.0727***	**7.11E-08*****
	p-value	0.562	0.000	0.231	0.006	0.000	0.000	0.000	**0.000**
ZEW-CS	Estimate	0.0001	0.0509***	**-0.0006***	2.94E-06	0.0367***	0.8948***	0.0742***	6.82E-14
	p-value	0.594	0.000	**0.045**	0.000	0.000	0.000	0.000	0.999
GER-ES	Estimate	0.0005**	0.0500**	**-0.0008****	3.3E-06	0.0108***	0.9014***	0.0799***	**5.4E-07*****
	p-value	0.006	0.011	**0.009**	0.000	0.000	0.000	0.000	**0.000**

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.
Source: own study.

According to the results, the sentiment indicators significantly influence market returns by impacting the mean, the conditional variance of returns, or both. Specifically, we observed a positive, significant coefficient for sentiment in the variance equation (β_{var}) and a negative, significant coefficient in the mean equation (β_{mean}). The positive coefficient for β_{var} suggests that improved sentiment is associated with increased volatility, while the negative coefficient for β_{mean} suggests that positive sentiment could reduce returns. We may explain this seemingly counterintuitive finding by the inherent comovement between realised returns, variances, and sentiment indicators. Sentiment reflects aspects of past market behaviour.

Furthermore, the results suggest that during periods of positive sentiment, large jumps in returns are corrected the following day, resulting in relatively low daily return variance. Conversely, during periods of negative sentiment, returns tend to be more volatile, leading to higher daily return variance. Moreover, β_{var} represents relative change, compared to the previous day. Thus, even for negative β_{var} expected conditional variance is higher when sentiment is worse (see Equation (2))

The Michigan Consumer Sentiment Index and the ZEW Current Situation Index, both of which gauge perceptions of the current economic situation, significantly affect returns. However, their impact is minimal in emerging markets. The distinct roles of sentiment regarding current and future economic conditions are also evident. The Michigan Consumer Sentiment Index and ZEW Current Situation Index primarily influence returns, while the ZEW Indicator of Economic Sentiment (ZEW-ES) and the German ZEW Indicator, which measure future economic expectations, primarily affect variance. This suggests that current sentiment influences immediate market performance, whereas forward-looking sentiment plays a critical role in shaping future volatility. Notably, the impact of ZEW-ES is evident across all market types, *i.e.*, developed, emerging, and frontier.

The extent of these sentiment effects varies across markets. In developed markets, sentiment effects are primarily driven by major economies, as reflected in the Michigan index and the two ZEW indices from the euro area. In emerging markets, sentiment about the future economy strongly impacts both the mean and volatility of returns (ZEW-ES) and volatility alone (German ZEW Indicator). In frontier markets, which are less integrated with global economic trends, sentiment indicators tied to both major and local economies (such as Germany) significantly influence returns. Among these, the German ZEW Indicator (GER-ES) is particularly impactful, affecting both the mean and volatility of market returns.

The results seem to support our hypotheses. Most sentiment indicators from the major economies affect emerging and frontier markets, as presumed in Hypothesis 1, and the effect is even more pronounced than for the developed markets. According to Hypothesis 3, we notice the significant impact of the US sentiment indicator among developed and frontier markets, although it does not affect the volatility directly. Meanwhile, we tested Hypothesis 2, stating that the impact of sentiment indicators differs by regimes using the TVPMS model in the next section.

Regime-switching Model Results

The AR(1)-GJR-GARCH model provides us with information on the importance of economic sentiment for expected returns and their conditional variances. However, it does not determine whether the variance during periods of strong market turbulence is indeed significantly different from the variance of returns during periods of weak turbulence, nor does it answer the question of when sentiment has the greatest impact on returns. To address these issues, we used a methodology based on switching models. Firstly, we used an HMM to identify two distinct states in which the variance of returns is significantly different. We then applied a regime switching model, where the transition matrix depends on economic sentiment indicators, to determine when sentiment affects the markets – in a high- or low-volatility state.

Hidden Markov Model

We use a fixed probability Hidden Markov Model (HMM) to test for the existence of two distinct states. Table 3 shows the parameter estimates of the HMM model, which we obtained by maximising the likelihood function using the Hamilton filter (Hamilton, 1994). Therefore, the last column of Table 3 (ML) shows the maximum likelihood value. This table also includes the expected market duration in each state: ED_1 for the high volatility state and ED_2 for the low volatility state. We calculated these expected durations as follows:

$$ED_1 = 1/(1 - p_{11}) \text{ and } ED_2 = 1/(1 - p_{22}) \tag{8}$$

Furthermore, we perform a restriction test according to (7) to confirm our conjecture that the states in the HMM model differ mainly in the variances of the return distribution (p-value < 0.001 for all cases). State I is characterised by high variance and negative mean return, while state II is associated with lower variance and positive mean return. The results in the last two columns indicate that the duration in the high volatility state was relatively short compared to the duration in the low volatility state. The pattern of volatility across markets was similar to that shown in Table 1. In both cases,

emerging markets had the highest volatility, while frontier markets had the lowest. On the other hand, emerging markets had the shortest expected duration in the high volatility state, while frontier markets had the longest expected duration in the low volatility state.

Table 3. Estimates of HMM model parameters and expected market duration in high and low volatility states

a_1	b_1	σ_1	a_2	b_2	σ_2	p_{11}	p_{22}	ED_1	ED_2	ML
Developed										
-0.001*	0.030	0.022***	0.001*	-0.035	0.008***	0.956	0.983	23	60	10634.917
(0.040)	(0.290)	(0.000)	(0.016)	(0.139)	(0.000)	–	–	–	–	–
Emerging										
-0.002	0.075*	0.036***	0.000	0.054**	0.011***	0.942	0.986	17	69	9745.576
(0.153)	(0.046)	(0.000)	(0.257)	(0.008)	(0.000)	–	–	–	–	–
Frontier										
-0.002*	0.095***	0.022***	0.001**	0.037.	0.007***	0.954	0.988	22	84	11333.586
(0.027)	(0.000)	(0.000)	(0.003)	(0.063)	(0.000)	–	–	–	–	–

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.
Parameters a_1, b_1 (I state) and a_1, b_1 (II state) are from formula (1).
Source: own study.
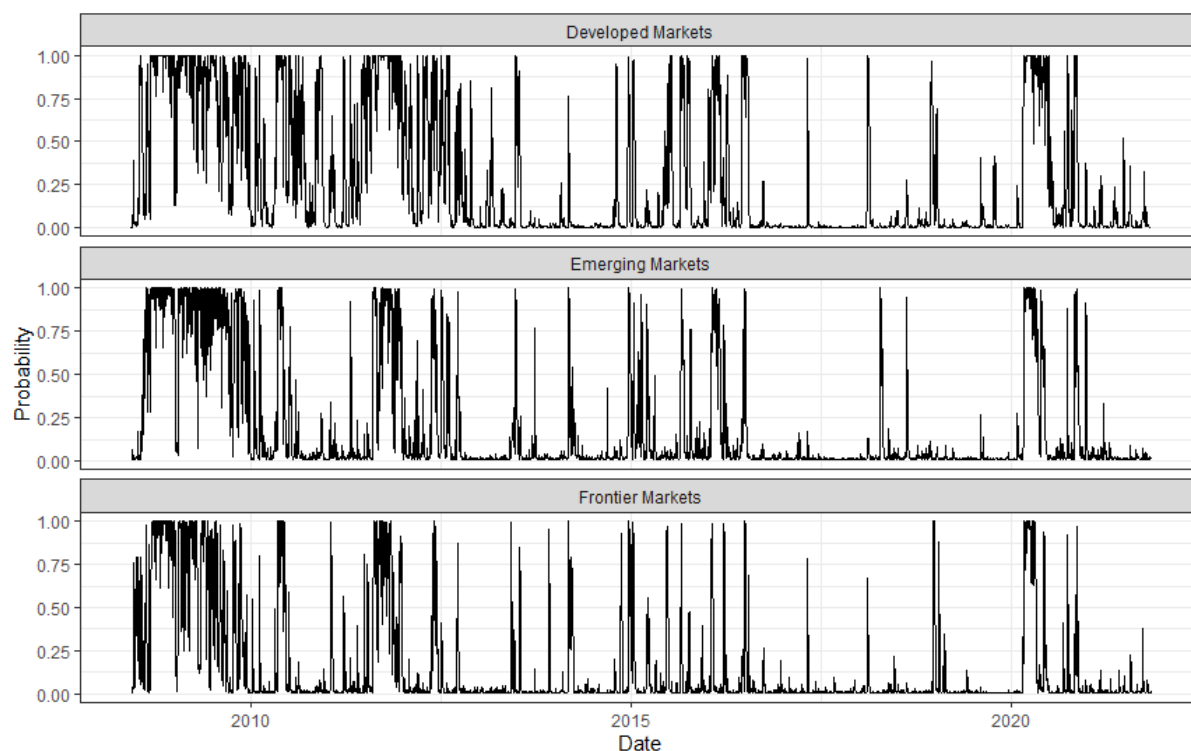
Figure 2. onditional probabilities of remaining in the high volatility regime for developed, emerging, and frontier markets from June 2008 to January 2022
Source: own elaboration.

The significance of the parameters a_1, b_1 (I state) and a_2, b_2 (II state) confirms the conclusions drawn from the analysis using the GARCH family model approach. However, the HMM illustrates the component of AR(1) relationships in two different states. We found that the lagged return parameters in both states were insignificant for developed markets and significant for emerging and frontier markets. This is similar to the results from the GARCH models, where the autoregressive parameters were also significant for emerging and frontier markets, but not for developed markets.

Figure 2 shows the conditional probabilities of being in the high volatility regime. The top panel shows that developed markets are in this regime mainly during periods of index declines. We may observe similar patterns in the middle and lower panels for emerging and frontier markets, respectively. Markets are predominantly in the high volatility regime during the financial crisis of 2007-2008. The probability of this state is also high in the mid-2010s (European debt crisis) and in 2020 (COVID-19 pandemic).

TVPMS Model

In the next step of the analysis, we assumed that the transition matrix in the regime switching model depends on lagged economic sentiment indicators, denoted as x_{t-1}. Since we considered daily market returns together with monthly survey-based sentiment indicators, we had a transition matrix with monthly dynamics. Table 4 shows the parameter estimates for the TVPMS model, with p-values in brackets. Panel A presents the results for developed markets, panel B for emerging markets and panel C for frontier markets. The last column presents the maximum log-likelihood (ML) for the TVPMS model. Comparing the ML values presented in Table 3 and Table 4, we found that the TVPMS model outperformed the HMM model. Furthermore, the TVPMS model was statistically superior to the HMM model according to the LM test performed for all cases (the p-values are less than 0.05). These results can document the fact that economic sentiment impacts market returns.

We noticed that for all market types (developed, emerging, and frontier) there was a negative beta parameter in the high volatility state (State I) and a positive beta parameter in the low volatility state (State II). As sentiment indicators rise, the probability of remaining in a high volatility state decreases, while the probability of remaining in a low volatility state increases. This interpretation is consistent with the findings of the GARCH model, but presented in a different framework, allowing us to directly confirm the Hypothesis 2.

Comparing the ML values in Table 4, we found that US economic sentiment generally has the strongest impact on European markets, in line with Hypothesis 3. The beta parameters in both states (β_1 and β_2) related to the MCSI were significant for all markets. However, sentiment seems to be more influential in the high-volatility regime, where the p-value is close to zero, compared to the low-volatility regime, where the p-values were 0.086 (developed markets), 0.098 (emerging markets), and 0.055 (frontier markets). This result highlights the advantage of the state-dependent framework of the TVPMS model. This distinction was not apparent in the GARCH-based approach, highlighting the value of the regime switching approach for a comprehensive analysis of the impact of sentiment.

The significance of the beta values in relation to the ZEW-ES shows that sentiment about economic expectations for the euro area is important for all markets, but mainly in the high-volatility regime. High economic sentiment reduces return variance not only in developed markets, but also in emerging and frontier markets, confirming Hypothesis 1. The insignificant beta parameters in the low volatility regime suggest that the ZEW-ES has a small impact on markets in stable periods. We obtained the same results for the GER-ES index, but this sentiment had a weaker predictive power compared to the ZEW-ES (lower ML). The beta parameter associated with the GER-ES in the high volatility regime was significant for emerging and frontier markets, but insignificant for developed markets. Similar to the results from the GARCH family model, the impact of German economic sentiment on developed markets is not confirmed.

The ZEW Current Situation Index (ZEW-CS) impacted the returns only in the low-volatility state. The β_2 parameters were significant at the 10% level for all types of markets. Moreover, we confirmed the impact of the ZEW-CS in emerging markets, which the GJR-GARCH approach did not confirm.

To explore the impact of sentiment in more detail, we computed the models for each country separately. The Appendix presents these results. Table A1 presents estimates for developed markets, and Table A2 for emerging and frontier markets. These results confirm our hypotheses, that: H1) major economies' sentiment impacts developing and frontier markets, H2) sentiment's impact differs by state (and the pattern is the same as in the aggregated analysis), and H3) the US sentiment index has a strong influence on European markets (especially developed markets and frontiers).

Table 4. Estimation results of TVPMS model

Sentiment	State	a_i	b_i	σ_i^2	α_i	β_i	ML
		Panel A: Developed markets					
MCSI	I	-0.001 (0.104)	0.029 (0.326)	0.023*** (0.000)	3.080*** (0.000)	**-5.633**** (0.006)	**10658.740**
	II	0.001** (0.001)	-0.067** (0.002)	0.008*** (0.000)	3.997*** (0.000)	**2.851 .** (0.086)	–
ZEW-ES	I	-0.001 . (0.092)	0.031 (0.300)	0.023*** (0.000)	3.408*** (0.000)	**-1.497 .** (0.082)	10655.162
	II	0.001** (0.001)	-0.067** (0.003)	0.008*** (0.000)	4.094*** (0.000)	0.017 (0.986)	–
GER-ES	I	-0.001 (0.066) .	0.038 (0.195)	0.022*** (0.000)	3.454*** (0.000)	-1.116 (0.178)	10653.878
	II	0.001** (0.003)	-0.068** (0.002)	0.008*** (0.000)	4.158*** (0.000)	0.316 (0.744)	–
ZEW-CS	I	-0.001 . (0.090)	0.031 (0.303)	0.023*** (0.000)	2.997*** (0.000)	-0.437 (0.539)	10652.390
	II	0.001) ** (0.001)	-0.061** (0.006)	0.008*** (0.000)	4.282*** (0.000)	**1.008 .** (0.076)	–
		Panel B: Emerging markets					
MCSI	I	-0.002 (0.168)	0.070 . (0.061)	0.036*** (0.000)	5.815*** (0.000)	**-3.877**** (0.001)	**9758.750**
	II	0.001 (0.351)	0.060** (0.003)	0.011*** (0.000)	1.287 (0.451)	**2.933 .** (0.087)	–
ZEW-ES	I	-0.002 (0.151)	0.055 (0.098)	0.036*** (0.000)	3.110*** (0.000)	**-1.685*** (0.016)	9755.232
	II	0.001 (0.399)	0.056** (0.005)	0.011*** (0.000)	4.399*** (0.000)	0.031 (0.969)	–
GER-ES	I	-0.002 (0.132)	0.080* (0.035)	0.036*** (0.000)	3.301*** (0.000)	**--1.423 .** (0.062)	9754.612
	II	0.001 (0.283)	0.057** (0.005)	0.0011*** (0.000)	4.656*** (0.000)	0.055 (0.955)	–
ZEW-CS	I	-0.002 (0.124)	0.074* (0.049)	0.036*** (0.000)	2.883*** (0.000)	-0.076 (0.915)	9754.004
	II	0.001 (0.249)	0.054** (0.008)	0.011*** (0.000)	4.896*** (0.000)	**1.451*** (0.021)	–
		Panel C: Frontier markets					
MCSI	I	-0.003* (0.035)	0.160** (0.001)	0.026*** (0.000)	4.848*** (0.000)	**-4.619**** (0.002)	**11372.944**
	II	0.001 (0.673)	0.047* (0.022)	0.008*** (0.000)	1.530*** (0.344)	3.520 (0.055)	–
ZEW-ES	I	-0.003** (0.028)	0.072 . (0.061)	0.024*** (0.000)	2.199*** (0.000)	**-1.500*** (0.036)	11369.855
	II	0.001 (0.538)	0.040* (0.050)	0.007*** (0.000)	3.743*** (0.000)	0.972 (0.225)	–
GER-ES	I	-0.003** (0.042)	0.073 . (0.062)	0.025*** (0.000)	2.207*** (0.000)	**-1.735*** (0.026)	11368.361
	II	0.001 (0.465)	0.037 . (0.052)	0.007*** (0.000)	3.987*** (0.000)	0.306 (0.762)	–
ZEW-CS	I	-0.004** (0.020)	0.084* (0.041)	0.024*** (0.000)	2.328*** (0.000)	-0.299 (0.915)	11365.970
	II	0.001 (0.673)	0.040* (0.038)	0.007*** (0.000)	4.899*** (0.000)	**1.657 .** (0.077)	–

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Note: α_i and β_i are the parameter from the transition probability matrix, given in the equation (2).

Source: own study.

Consistent Patterns Across Models

The combined results of the AR(1)-GJR-GARCH and TVPMS models show that economic sentiment has a significant impact on European market returns, with different effects depending on market type and sentiment indicator. While the TVPMS model effectively captures the probability of transition between states with different distributions, in particular different volatilities as measured by return variances, the GJR-GARCH model complements these findings by providing nuanced details on daily returns and conditional volatility adjustments of sentiment indices.

This comparative analysis highlights the complementary nature of the two modelling approaches. While the GJR-GARCH model provides insights into the immediate effects of sentiment on returns and volatility, the TVPMS model offers a more nuanced view of how sentiment influences market dynamics across regimes. Together, these models enrich our understanding of the role of sentiment in shaping market behaviour.

Robustness

Figure 1 shows significant fluctuations in returns and economic sentiment indicators around 2020, mainly due to the COVID-19 pandemic. For robustness, we re-estimated both models using only data up to 31 December 2020. Table 5 shows the results for TVPMS model (results for AR(1)-GJR-GARCH are presented in Appendix, Table A3), confirm the initial findings and highlight the persistent impact of economic sentiment on market returns and volatility across market types.

The Michigan consumer sentiment index continues to have a significant effect, especially in the high volatility regime. This is consistent with our hypothesis that the Michigan index has a stronger impact on volatility when markets are more volatile. Similarly, the ZEW Economic Sentiment Index (ZEW-ES) also shows a significant impact, especially in periods of high volatility. This pattern confirms that US and European sentiment about future economic conditions has a stronger impact during periods of market instability.

Furthermore, the comparison of the maximum likelihood values for the ZEW-ES and the GER-ES indices shows that the GER-ES has a weaker impact on market returns compared to the ZEW-ES, in line with our previous findings. In particular, the GER-ES had no significant impact on the frontier markets. The ZEW Current Condition Index (ZEW-CS) retained its significance in the low-volatility state for emerging and frontier markets. For developed markets, the beta parameter associated with the ZEW-CS remained positive, but its significance was marginal (p-value = 0.134).

The results of this robustness check underlined the stability of the results even when excluding the period most affected by the COVID-19 pandemic. This strengthens the argument that economic sentiment indices are important determinants of European stock market returns and volatility.

Discussion

Our results are consistent with the existing literature and extend it in several important ways. Firstly, we confirmed the significant impact of economic sentiment on returns and volatility, supporting the role of sentiment as a predictor in financial markets. They can influence investor decisions across European markets, regardless of the level of market development. Baker *et al*. (2012) and Corredor *et al*. (2015) also observed this 'global' nature of sentiment. The positive influence of survey-based sentiment indicators on markets is consistent with the findings of Homolka and Pavelková (2018) and Rakovská (2021), as well as the impact documented for institutional investor sentiment (Schmeling, 2007). In particular, the influence of the Michigan Consumer Sentiment Index (MCSI) on European markets is consistent with its established role in the US, analysed by Ung *et al*. (2023) for the S&P 500. This relationship highlights the role of US sentiment in shaping expectations and behaviour in European markets, reflecting a broader, interconnected financial environment.

Table 5. Estimation results of TVPMS model (up to 2019)

Sentiment	State	a_i	b_i	σ_i^2	α_i	β_i	ML
		Panel A: Developed markets					
MCSI	I	-0.001 (0.112)	0.028 (0.357)	0.021*** (0.000)	3.287*** (0.000)	**-8.494 .** (0.052)	**9203.765**
	II	0.001** (0.011)	-0.046 . (0.066)	0.008*** (0.000)	3.996*** (0.000)	4.302 (0.397)	–
ZEW-ES	I	-0.001 (0.185)	0.021 (0.485)	0.021*** (0.000)	3.618*** (0.000)	**-1.603**** (0.049)	9202.163
	II	0.001** (0.023)	-0.045 . (0.078)	0.008*** (0.000)	3.961*** (0.000)	0.504 (0.609)	–
GER-ES	I	-0.001 (0.204)	0.029 (0.326)	0.021*** (0.000)	3.548*** (0.000)	-0.815 . (0.327)	9201.228
	II	0.001** (0.045)	-0.034 (0.193)	0.008*** (0.000)	3.985*** (0.000)	0.329 (0.795)	–
ZEW-CS	I	-0.001 (0.117)	0.019 (0.536)	0.021*** (0.000)	3.075*** (0.000)	-0.667 (0.379)	9202.494
	II	0.001 (0.010)	-0.043 . (0.089)	0.008*** (0.000)	4.262*** (0.000)	0.977 (0.138)	–
		Panel B: Emerging markets					
MCSI	I	-0.002 (0.149)	0.094** (0.020)	0.036*** (0.000)	2.901*** (0.000)	**-8.530 .** (0.068)	**845.947**
	II	0.001 (0.390)	0.073*** (0.001)	0.011*** (0.000)	4.538 (0.451)	6.979 (0.311)	–
ZEW-ES	I	-0.002 (0.179)	0.093** (0.021)	0.036*** (0.000)	3..195*** (0.000)	**-1.380**** (0.050)	845.751
	II	0.001 (0.366)	0.073*** (0.001)	0.011*** (0.000)	4.450*** (0.000)	0.016 (0.987)	–
GER-ES	I	-0.002 (0.307)	0.075** (0.065)	0.036*** (0.000)	2.904*** (0.000)	**--1.168 .** (0.073)	8404.093
	II	0.001 (0.672)	0.088*** (0.000)	0.011*** (0.000)	4.370*** (0.000)	0.082 (0.945)	–
ZEW-CS	I	-0.002 (0.149)	0.084** (0.035)	0.036*** (0.000)	2.629*** (0.000)	-0.619 (0.402)	8407.085
	II	0.001 (0.496)	0.072*** (0.001)	0.011*** (0.000)	4.800*** (0.000)	**1.597**** (0.025)	–
		Panel C: Frontier markets					
MCSI	I	-0.002** (0.045)	0.094** (0.014)	0.022*** (0.000)	2.130*** (0.000)	**-9.768**** (0.047)	**9818.311**
	II	0.001 (0.264)	0.031** (0.014)	0.007*** (0.000)	3.911 (0.344)	6.163 (0.244)	–
ZEW-ES	I	-0.004** (0.019)	0.083** (0.027)	0.022*** (0.000)	2.292*** (0.000)	**-1.887**** **(0.026)**	9817.477
	II	0.001 (0.238)	0.022 (0.322)	0.007*** (0.000)	3.733*** (0.000)	0.083 (0.936)	–
GER-ES	I	-0.003** (0.032)	0.096** (0.012)	0.022*** (0.000)	2.732*** (0.000)	-1.109 (0.270)	9816.418
	II	0.001 (0.165)	0.046** (0.012)	0.007*** (0.000)	4.164*** (0.000)	0.277 (0.873)	–
ZEW-CS	I	-0.002** (0.034)	0.087** (0.027)	0.023*** (0.000)	2.044*** (0.000)	-0.205 (0.856)	9815.507
	II	0.001 (0.196)	0.032 (0.143)	0.007*** (0.000)	4.347*** (0.000)	**1.708 .** (0.064)	–

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.
Note: : α_i and β_i are the parameter from the transition probability matrix, given in the equation (2).
Source: own study.

Our study further supports previous research (Gervais & Odean, 2001; Nofsinger, 2005; Li & Luo, 2017) by confirming that investor behaviour varies according to market conditions. Specifically, we found that sentiment on various economic issues can be relevant in different market states: The ZEW Economic Sentiment Indicator (ZEW-ES) and the German Economic Sentiment Indicator (GER-ES) have a significant impact on the markets in periods of high volatility, while the assessment of the current situation (ZEW-CS) has a stronger impact in periods of low volatility.

The added value of our work is the presentation of properties of regime switching models (with a dynamic transition matrix), which are rarely used in practice, compared to the GARCH model family. While the results of the GARCH approach confirm the influence of sentiment on market returns and volatility, the TVPMS approach is able to capture state-dependent transitions between high and low volatility regimes depending on market conditions.

CONCLUSIONS

We examined the impact of economic sentiment in major economies on the average returns and volatility of European stock markets. The analysis used several survey-based indicators of economic sentiment, the two ZEW Economic Sentiment Indices, the ZEW Current Situation Index and the Michigan Consumer Sentiment Index, to focus on sentiment related to the broader economy rather than just investor sentiment. We analysed how sentiment indicators influenced stock market behaviour in developed, emerging, and frontier markets. To examine the role of sentiment in market returns, we considered two models: GARCH-based approach with exogenous factors and a time-varying transition probability Markov switching model, where the probabilities depend on lagged economic sentiment indicators.

Our results show that market returns fluctuate between two states: high and low volatility, as measured by their one-month standard deviation. In the high volatility state, rising positive sentiment increases the probability of leaving that state, while during the low volatility state, rising sentiment increases the probability of staying in that state. The statistical significance of the impact of sentiment depends on the sentiment indicator and the state of the market. The GARCH-approach verified the robustness of the TVPMS results.

MCSI: The Michigan index showed a strong influence in both the GJR-GARCH and TVPMS models, especially for developed and frontier markets. In the GJR-GARCH model, the significant negative coefficients in the mean equation and positive coefficient in the variance equation indicated a stabilising effect on returns and volatility. This is consistent with the TVPMS model, where MCSI was significant in all markets, particularly in high volatility regimes. However, we observed no significant effect of MCSI for emerging markets in either model.

ZEW-ES: Both models confirmed that the ZEW-ES had a significant impact on market volatility, which is measured in different ways. The results of the TVPMS showed that the ZEW-ES had a stronger impact during periods of high volatility in the developed, emerging and frontier markets. This finding underlined the importance of forward-looking sentiment in turbulent times.

ZEW-CS: Both models confirmed that the ZEW-CS had a significant impact on market volatility, which was measured in different ways, but this sentiment had a stronger impact during periods of low volatility in the developed, emerging and frontier markets**.** Moreover, ZEW-CS showed a stronger influence in periods of low volatility for emerging and frontier markets, suggesting that sentiment about the current economic situation was stronger in stable conditions.

GER-ES: The German ZEW index had a weaker impact than the ZEW-ES in both models. In the TVPMS model, the GER-ES had a significant impact on emerging and frontier markets during periods of high volatility, while it had no significant impact on developed markets. These results are consistent with the GJR-GARCH results, which also indicate the insignificance of the GER-ES for developed markets. This discrepancy highlights the regional nature of the impact of German sentiment, which is more relevant for less developed markets.

Overall, our findings suggest that sentiment in major economies had a global reach, affecting not only developed markets but also emerging and frontier markets.

The findings have practical implications for investors and managers. Understanding economic sentiment indicators can help make informed investment decisions. Our results suggest that these indicators can help predict market performance over the next month in terms of returns and volatility. In low-volatility regimes, investors may benefit from focusing on current economic assessments, while in high-volatility regimes, attention should shift to forward-looking sentiment indicators. The US sentiment index (MCSI) is particularly valuable in both regimes, irrespective of the level of market development.

There are some limitations to this study. The frequency of the survey data is monthly, which limits the ability to capture the immediate impact of changes in sentiment. Future research could examine the impact of economic sentiment indicators derived from news and social media, which one can obtain with higher frequency. There is still need for studies analysing the influence of global sentiment on developing and frontier markets outside of Europe and North America.

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Appendix:

Table A1. Estimation results for developed markets

Market		σ_i^2	β_i MCSI	β_i GER-ES	β_i ZEW-ES	β_i ZEW-CS	ML MCSI	GER-ES	ZEW-ES	ZEW-CS
Austria	I	0.035 (0.000)	**-5.675** (0.007)	**-1.151** (0.092)	**-1.749** (0.023)	-0.273 (0.721)	**9368.82**	9366.35	9366.6	9364.04
	II	0.013 (0.000)	3.090 (0.116)	0.262 (0.765)	0.245 (0.779)	**1.167** (0.090)				
Belgiium	I	0.027 (0.000)	**-5.632** (0.002)	**-1.539** (0.025)	**-1.877** (0.007)	0.358 (0.591)	**10185.9**	10179.7	10182.3	10176.0
	II	0.009 (0.000)}	**3.440** (0.039)	0.463 (0.597)	0.769 (0.380)	**1.213** (0.047)				
Denmark	I	0.026 (0.000)	**-3.096** (0.071)	**-1.271** (0.065)	**-1.372** (0.043)	0.069 (0.918)	**10342.2**	10339.7	10341.5	10336.8
	II	0.010 (0.000)	**2.759** (0.064)	0.547 (0.473)	0.424 (0.630)	**0.961** (0.081)				
Finland	I	0.028 (0.000)	**-5.432** (0.026)	**-1.870** (0.045)	**-2.522** (0.008)	-0.830 (0.441)	**9957.2**	9954.3	9956.9	9949.62
	II	0.010 (0.000)	**3.342** (0.021)	0.784 (0.483)	0.295 (0.740)	0.364 (0.682)				
France	I	0.025 (0.000)	**-4.387** (0.026)	**-1.110** (0.084)	**-1.740** (0.019)	-0.227 (0.741)	**10184.6**	10181.5	10183.1	10180.4
	II	0.009 (0.000)	**3.041** (0.038)	0.526 (0.473)	0.174 (0.809)	**1.039** (0.067)				
Germany	I	0.026 (0.000)	**-4.709** (0.015)	**-1.456** (0.031)	**-1.984** (0.009)	-0.183 (0.824)	**10160.7**	10158.3	10160.5	10156.8
	II	0.010 (0.000)	**3.147** (0.049)	0.029 (0.973)	0.130 (0.853)	**1.014** (0.091)				
Ireland	I	0.034 (0.000)	**-5.234** (0.078)	-0.952 (0.372)	**-2.166** (0.033)	-0.395 (0.718)	**9611.72**	9609.06	9611.69	9607.99
	II	0.012 (0.000)	3.246 (0.203)	0.397 (0.786)	0.003 (0.998)	0.242 (0.813)				
Italy	I	0.031 (0.000)	**-3.605** (0.075)	-1.247 (0.111)	**-1.535** (0.041)	0.464 (0.613)	9544.94	9545.27	**9545.75**	9542.84
	II	0.012} (0.000)	1.490 (0.394)	0.493 (0.497)	0.680 (0.313)	**1.320** (0.056)				

Market		σ_i^2	β_i MCSI	β_i GER-ES	β_i ZEW-ES	β_i ZEW-CS		ML MCSI	GER-ES	ZEW-ES	ZEW-CS
Netherland	I	0.022 (0.000)	**-3.957** (0.025)	**-1.634** (0.008)	**-1.771** (0.008)	-0.016 (0.981)		**10383.09**	10374.8	10376.7	10374.4
	II	0.008} (0.000)}	**3.822** (0.012)	0.061 (0.950)	0.020 (0.980)	**1.309** (0.021)					
Norway	I	0.035 (0.000)	**-3.907** (0.064)	-0.966 (0.181)	**-2.141** (0.019)	0.056 (0.936)		**9496.10**	9493.65	9495.34	9492.26
	II	0.012 (0.000)	3.122 (0.108)	0.097 (0.916)	0.168 (0.849)	1.013 (0.103)					
Portugal	I	0.026 (0.000)	-3.326 (0.122)	**-1.691** (0.018)	**-1.674** (0.008)	0.692 (0.369)		9916.08	9920.53	**9922.14**	9920.32
	II	0.011 (0.000)}	2.488 (0.145)	0.176 (0.862)	0.338 (0.621)	**1.424** (0.020)					
Spain	I	0.029 (0.000)	**-4.543** (0.060)	**-2.322** (0.005)	**-3.200** (0.003)	-0.065 (0.937)		9683.22	9685.98	**9687.84**	9684.41
	II	0.011 (0.000)	2.676 (0.150)	0.053 (0.948)	0.468 (0.599)	**1.290** (0.043)					
Sweden	I	0.031 (0.000)	**-5.756** (0.026)	**-1.724** (0.052)	**-1.905** (0.039)	-0.525 (0.617)		**9807.01**	9805.47	9806.12	9802.94
	II	0.011 (0.000)	**4.425** (0.060)	-0.096 (0.924)	0.271 (0.786)	0.267 (0.750)					
Switzerland	I	0.022 (0.000)	**-4.350** (0.037)	**-1.773** (0.022)	**-1.540** (0.035)	-0.022 (0.977)		11207.3	11206.9	**11208.2**	**11204.6**
	II	0.008 (0.000)	3.086 (0.107)	0.272 (0.780)	0.263 (0.762)	1.033 (0.113)					
UK	I	0.024 (0.000)	**-3.971** (0.047)	-1.276 (0.360)	**-2.218** (0.009)	-0.187 (0.776)		10588.4	10591.4	**10592.03**	10588.8
	II	0.008 (0.000)	**3.237** (0.061)	0.543 (0.789)	0.292 (0.257)	**1.116** (0.046)					

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Note: α_i and β_i are the parameter from the transition probability matrix, given in the equation (2) Parameters significant at 10% level and the highest log-likelihood values for a given market are written in bold.

Source: own study.

Table A2. Estimation results for emerging and frontiers markets

Market		σ_i^2	β_i MCSI	β_i GER-ES	β_i ZEW-ES	β_i ZEW-CS		ML MCSI	GER-ES	ZEW-ES	ZEW-CS
Emerging markets											
Czech R.	I	0.036 (0.000)	-4.629 (0.101)	**-1.969** (0.033)	**-1.942** (0.045)	-0.377 (0.729)		10111.63	10112.8	**10113.7**	10108.91
	II	0.011 (0.000)	3.330 (0.187)	0.811 (0.569)	0.971 (0.459)	1.208 (0.178)					
Greece	I	0.044 (0.000)	-1.281 (0.687)	-0.328 (0.597)	-0.802 (0.211)	1.142 (0.377)		8119.86	8120.09	**8120.89**	8115.067
	II	0.017 (0.000)	1.128 (0.440)	0.526 (0.387)	0.191 (0.746)	1.388 (0.412)					
Hungary	I	0.038 (0.000)	**-5.538** (0.022)	**-1.643** (0.087)	**-1.292** (0.085)	-0.072 (0.907)		**9043.59**	9041.49	9041.98	9042.42
	II	0.013 (0.000)	**3.326** (0.056)	0.111 (0.907)	0.419 (0.635)	**1.732** (0.004)					
Poland	I	0.034 (0.000)	**-6.355** (0.013)	**-1.415** (0.076)	**-1.389** (0.091)	0.441 (0.665)		9395.95	9396.34	**9397.33**	9397.17
	II	0.013 (0.000)	2.664 (0.259)	0.052 (0.430)	0.284 (0.778)	**1.527** (0.060)					
Russia	I	0.014 (0.000)	**-4.092** (0.040)	**-1.405** (0.041)	**-1.541** (0.075)	-0.785 (0.267)		9135.76	9131.33	**9138.47**	9136.59
	II	0.044 (0.000)	2.186 (0.302)	0.357 (0.734)	0.232 (0.807)	0.874 (0.186)					
Turkey	I	0.038	-2.129	-0.628	-0.185	-0.005		8805.83	**8808.3**	8807.71	8802.48

Market		σ_i^2	β_i MCSI	β_i GER-ES	β_i ZEW-ES	β_i ZEW-CS	ML	MCSI	GER-ES	ZEW-ES	ZEW-CS
		(0.000)	(0.266)	(0.250)	(0.743)	(0.995)					
	II	0.016 (0.000)	1.084 (0.587)	**1.238** (0.070)	**1.650** (0.014)	0.507 (0.497)					
Frontier markets											
Croatia	I	0.026 (0.000)	**-5.662** (0.009)	**-1.665** (0.018)	**-1.771** (0.015)	-0.065 (0.932)		**11416.55**	11412.8	11412.9	11406.8
	II	0.007 (0.000)	**3.250** (0.096)	0.489 (0.470)	1.098 (0.194)	**1.015** (0.094)					
Estonia	I	0.028 (0.000)	**-3.701** (0.017)	-0.411 (0.333)	-0.712 (0.686)	0.058 (0.928)		**10242.1**	10219.7	10221.2	10217.1
	II	0.008 (0.000)	**3.566** (0.004)	0.181 (0.724)	0.321 (0.501)	**1.111** (0.069)					
Kazakhstan	I	0.032 (0.000)	-0.929 (0.451)	**-0.783** (0.094)	-0.695 (0.110)	-0.092 (0.790)		9212.89	**9215.8**	9215.65	9208.83
	II	0.008 (0.000)	0.761 (0.540)	0.207 (0.664)	0.372 (0.397)	0.450 (0.268)					
Lithuania	I	0.036 (0.000)	**-4.319** (0.047)	-0.126 (0.811)	-0.126 (0.628)	-0.979 (0.139)		**11121.11**	11109.5	11110	11112.4
	II	0.011 (0.000)	**3.979** (0.013)	0.654 (0.316)	**1.121** (0.058)	0.587 (0.332)					
Romania	I	0.033 (0.000)	**-4.002** (0.065)	-0.479 (0.440)	-0.660 (0.296)	-0.353 (0.621)		**9886.94**	9881.17	9882.6	9882.31
	II	0.010 (0.000)	**3.826** (0.013)	0.973 (0.260)	1.033 (0.198)	0.838 (0.187)					
Serbia	I	0.033 (0.000)	**-4.799** (0.003)	**-1.252** (0.017)	**-1.096** (0.038)	-0.227 (0.775)		**10338.9**	10334.2	10336.2	10330.1
	II	0.008 (0.000)	**3.199** (0.012)	**1.399** (0.013)	**1.283** (0.018)	0.971 (0.021)					
Slovenia	I	0.027 (0.000)	**-4.263** (0.016)	**-2.196** (0.000)	**-1.754** (0.041)	-0.133 (0.807)		**10633.51**	10629.3	10632.2	10623.3
	II	0.009 (0.000)	**2.552** (0.093)	0.819 (0.230)	0.720 (0.186)	**0.948** (0.082)					

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Note: α_i and β_i are the parameter from the transition probability matrix, given in the equation (2) Parameters significant at 10% level and the highest log-likelihood values for a given market are written in bold.

Source: own study.

Table A3. Estimation results for AR(1)-GJR-GARCH model (up to 2019)

Sentiment		μ	ϕ	β_{mean}	ω	α	β	γ	β_{var}
Panel A: Developed markets									
MCSI	Estimate	0.001*	0.003	**-0.001***	0.000	0.011	0.900***	0.151***	0.000
	p-value	0.038	0.890	**0.041**	0.257	0.523	0.000	0.000	**0.997**
ZEW-ES	Estimate	0.000	0.002	**0.000**	0.000.	0.020***	0.902***	0.138***	9.63E-09***
	p-value	0.515	0.934	**0.445**	0.086	0.000	0.000	0.000	**0.000**
ZEW-CS	Estimate	0.000	0.001	**-0.001***	0.000	0.015**	0.901***	0.145***	**0.000**
	p-value	0.624	0.945	**0.016**	0.110	0.007	0.000	0.000	**0.996**
GER-ES	Estimate	0.001.	0.005	**-0.001.**	0.000	0.026**	0.888***	0.137***	**0.000**
	p-value	0.063	0.228	**0.081**	0.166	0.006	0.000	0.000	**0.973**
Panel B: Emerging markets									
MCSI	Estimate	0.000	0.058**	**0.000**	0.000	0.012.	0.939***	0.080***	**0.000**
	p-value	0.604	0.002	**0.305**	0.120	0.062	0.000	0.000	**0.951**
ZEW-ES	Estimate	0.000	0.059**	**0.000**	0.000	0.015	0.938***	0.079***	1.26E-08***
	p-value	0.955	0.002	**0.291**	0.479	0.427	0.000	0.000	**0.000**
ZEW-CS	Estimate	0.000	0.059***	**0.000**	0.000	0.014*	0.939***	0.079***	**0.000**
	p-value	0.783	0.001	**0.896**	0.145	0.034	0.000	0.000	**0.978**
GER-ES	Estimate	0.000	0.056**	**0.000**	0.000.	0.000	0.956***	0.068***	1.11E-08***
	p-value	0.599	0.007	**0.487**	0.081	0.994	0.000	0.000	**0.000**

Sentiment		μ	ϕ	β_{mean}	ω	α	β	γ	β_{var}
Panel C: Frontier markets									
MCSI	Estimate	0.000	0.036.	**0.000**	0.000.	0.034***	0.911***	0.061***	**0.000**
	Estimate	0.442	0.061	**0.613**	0.052	0.000	0.000	0.000	**0.997**
ZEW-ES	Estimate	0.000	0.036.	**0.000**	0.000*	0.035***	0.911***	0.060***	**1.07E-08*****
	p-value	0.537	0.064	**0.758**	0.017	0.000	0.000	0.000	**0.000**
ZEW-CS	Estimate	0.000	0.037.	**0.000**	0.000*	0.035***	0.911***	0.060***	**0.000**
	p-value	0.832	0.061	**0.480**	0.027	0.000	0.000	0.000	**0.999**
GER-ES	Estimate	0.000	0.033	**0.000**	0.000***	0.001	0.934***	0.058***	**0.97E-08*****
	p-value	0.257	0.115	**0.369**	0.000	0.397	0.000	0.000	**0.000**

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.
Source: own study.

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Contribution share: Czapkiewicz – 30%: conceptualisation, literature review, calculations, writing, Choczyńska – 40%: conceptualisation, literature review, calculations, writing, Machno – 30%: calculations, writing.

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Use of Artificial Intelligence

Authors declare the use of AI tools DeepL Write and ChatGPT for proofreading the manuscript.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Lecturers' pathways to integrating artificial intelligence in business and economics curricula

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A B S T R A C T
Objective: This article aims to identify the factors affecting business and economics lecturers' inclusion of artificial intelligence (AI) in the curricula.
Research Design & Methods: We applied a quantitative approach to test a research model based on the theory of planned behaviour. We used partial least squares structural equation modelling to verify hypotheses using a sample of 133 university lecturers from business and economics.
Findings: The study reveals that key background factors, including prior AI education and prior AI use, indirectly contribute to the inclusion of AI in the curricula. AI education contributed by enhancing lecturers' cognitive attitudes and self-efficacy and AI use only contributed through self-efficacy. Contrary to expectations, previous instances of AI integration in teaching have had an insignificant influence on the inclusion of AI into the curriculum.
Implications & Recommendations: The inclusion of AI in business and economics university teaching is a precondition for equipping graduates with skills expected in the job market. Based on the findings of this study, two paths seem to be particularly helpful in achieving this objective: improving lecturers' attitudes via AI education and improving their self-efficacy through personal AI use.
Contribution & Value Added: The contribution of this study consists of identifying the factors that influence lecturers' intentions to incorporate AI into their curricula. Shedding light on these determinants can guide higher education policies and support the development of strategies to promote the effective incorporation of AI into current teaching programmes.
Article type:	research article
Keywords:	artificial intelligence; higher education; curriculum; theory of planned behaviour; business education
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INTRODUCTION

Artificial intelligence (AI) is a field that combines the science and engineering of creating intelligent systems and machines (Sarker, 2022). These systems are designed to perform intricate human cognitive tasks, including problem-solving, pattern recognition, language understanding, and decision-making (Hassani *et al.*, 2020). The recent rise in interest in AI was fueled by the introduction of large language models like Generative Pre-trained Transformer (ChatGPT), sparking fears of AI replacing human labour. The challenge of substituting human work with information and communication technologies is not new, though, as it has already taken place in less creative industries (Zhang *et al.*, 2023). That said, Usabiaga *et al.* (2022) argue that the risk of automation is lower for non-routine jobs, yet these are most likely to require Information and Communication Technology (ICT) skills. Therefore, we may assume that managers will soon expect employees to possess AI skills (Ratten, 2024), making those who possess such skills more competitive in the labour market and less likely

to be substituted by technology. This phenomenon is not limited to the ICT sector but extends to other areas, notably higher education. Hence, it is reasonable to ask if higher education institutions (HEIs) are ready to meet this challenge and adopt AI courses in their offering.

According to Bewersdorff *et al.* (2023), learners display numerous misconceptions about AI, potentially leading to limited use. Therefore, developing AI literacy programmes is indispensable (Kong *et al.*, 2023). Notwithstanding the need for such a general cognitive AI literacy, Hornberger *et al.* (2023) highlight the heterogeneous nature of students' needs in terms of AI education and recommend developing AI education that would respond to these diverse needs. This is further supported by Nyale *et al.* (2024), whose review on the alignment between AI higher education programmes underscores the role of digital skills for graduates' employability. In this study, we considered the issue of introducing AI education at the university level, specifically for the fields of business and economics.

Although some understanding of the technical background of AI is undoubtedly of value irrespective of the student's background, linking AI teaching with specific applications in business requires an understanding of business and economics topics. Artificial intelligence is a transdisciplinary topic (Tsao *et al.*, 2024), although its inclusion in curricula cannot be limited to the common core. Therefore, the implementation of AI education tailored to the needs of business/economics students requires that at least part of this education is undertaken by lecturers with subject expertise. Here, it is important to understand pathways that lead business/economics lecturers to offer AI-oriented courses or implement AI topics in business/economics curricula.

The theory of planned behaviour (TPB) (Ajzen, 1991) provides a theoretical framework for explaining this problem, where its three explanatory variables, attitude towards the behaviour, subjective norms, and perceived control, are extended by prior knowledge and exposure of lecturers to AI. The aim of this study is to explore the factors that lead business/economics lecturers to develop intentions towards implementing AI-oriented courses or topics into business/economics curricula. Despite the increasing interest in AI applications in education (O'Dea, 2024), research is yet to fully uncover the adoption of more advanced deep learning technologies within educational contexts (Roy *et al.*, 2022). Hmoud *et al.* (2023) noted the slow pace of technological innovation adoption in higher education contexts (unlike other sectors) and called for more studies exploring potential triggers. Chatterjee and Bhattacharjee (2020) raised the need for further research on AI adoption at the individual level, where students, educators, and administrators are key stakeholders. Mohd Rahim *et al.* (2022) added that attempts to tackle AI adoption at the individual level should draw on information system theories. While the issue of AI adoption, even if understudied, has been the subject of empirical studies, including quantitative approaches, the question of integrating AI into university teaching curricula has received much less attention. Therefore, the focus on educators as a primary stakeholder and their inclusion of AI topics in the curriculum constitutes an important contribution of this article, as most prior works focused on general AI adoption as a tool. Furthermore, this study contributes by taking a quantitative approach informed by a solid theoretical background, while extant studies on the topic tend to rely on specific cases, such as that of the University of Florida, which embarked on integrating AI into its curricula (Southworth *et al.*, 2023). The contribution of this study consists in uncovering the triggers of lecturers' behavioural intentions to integrate AI into their teaching content. This can inform higher education policies and help develop adequate support measures, fostering the integration of AI into existing teaching programmes.

The article is organised in the following way. First, the theoretical framework provides an overview of the theory of planned behaviour, followed by formulated hypotheses. The next section presents methods. Finally, we present and discuss the survey results conducted among university lecturers of business /economics.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The TPB (Ajzen, 1991) is among the most prominent theories explaining and predicting human behaviour. Its primary purpose is to predict human behaviour by linking behaviour with its intentions and deriving intentions from an individual's beliefs about the behaviour, namely attitude towards the be-

haviour, subjective norms, and perceived behavioural control. TPB is rooted in a socio-cognitive approach to human behaviour whereby personal cognition and social pressure contribute to human behaviour. The model has been applied in various contexts, including health-related decisions, technology adoption, sexual behaviour, or physical exercise (Ajzen, 2020). Scholars have also applied it in education-related studies (Knauder & Koschmieder, 2019), including ones dealing with the adoption of technology in learning-related situations either by teachers (Watson & Rockinson-Szapkiw, 2021) or, more frequently, by students (Budhathoki *et al.*, 2024; Strzelecki, 2024). Although other theoretical frameworks, such as technology acceptance model (Davis *et al.*, 1989) and unified theory of acceptance and use of technology UTAUT (Venkatesh *et al.*, 2003) have been more popular than TPB in the context of technology adoption, they seem less relevant for our context where the outcome involved inclusion of AI into curricula rather than AI's adoption.

The basic premise of TPB concerns the relationship between an individual's beliefs and behaviour, mediated by behavioural intentions. The explanatory variables involve attitude (positive or negative evaluation) towards the behaviour, subjective norms 'perceived social pressure to perform or not to perform a behaviour' and perceived behavioural control (PBC), which 'refers to the perceived ease or difficulty of performing the behaviour' (Ajzen, 1991, p. 188). More importantly, the model assumes the presence of antecedents of these beliefs, known as background variables, which shape behavioural intentions via the three core constructs (Ajzen, 2020). The inclusion of such relevant background factors can deepen our understanding of the behaviour and its drivers (Ajzen & Fishbein, 2005, p. 197). While the extant literature often overlooks these factors (Onjewu *et al.*, 2022), Ajzen (2011) urged scholars to recognise the important role of background factors in forming the intention and leading to subsequent behaviour. In studies linked to technology and AI, background factors include basic knowledge of the technology (Sanusi *et al.*, 2024), access to professional development (training and education), perceived usefulness, and ease of use (Foulger *et al.*, 2021). In this study, we did not include perceived usefulness and ease of use as background variables since self-efficacy and attitudes, treated as core constructs, overlap with these constructs. As for access to professional development, it was captured through AI-related education and self-education, which capture different forms of professional learning. Regarding basic knowledge, this is captured through participants' prior experience using AI, which provides a good proxy for their basic understanding of the technology. We discuss the selection of background factors in the corresponding section.

Furthermore, the integration of implementation intentions into the TPB framework offers a valuable perspective in understanding the transition from intentions to actions, a critical aspect in the context of adopting AI in business curricula. Implementation intentions involve specific plans about when, where, and how to perform a behaviour (Gollwitzer, 1999). By formulating concrete action plans, academicians can bridge the gap between their intention to integrate AI into their teaching and the actual execution of this integration. This approach is especially crucial in educational settings where the successful adoption of new technologies like AI requires not only positive attitudes and perceived social support but also clear, actionable strategies to implement these technologies effectively.

The Core Predictors of AI Inclusion

According to the TPB, behavioural intentions are determined by attitudes towards the behaviour, subjective norms, and perceived behavioural control, in our case, proxied by self-efficacy, which is considered as largely overlapping in meaning with PBC (Newman *et al.*, 2019). Positive links between these antecedents and behavioural intentions have been widely confirmed in various studies, including those from the field of education. For example, Lenski *et al.* (2019) reported positive and significant relationships between intentions and all three antecedents in the context of a competency-based approach to instruction, demonstrating that PBC plays the most significant role. Lee *et al.* (2010) found the TPB antecedents to be significant predictors of the intention to use educational technology, while Knabe (2012) found the TPB to explain the intention to teach public relations online. Dunn *et al.* (2018) noted a significant relationship between the TPB antecedents and teachers' intention to engage in professional learning supporting math teaching standards.

Furthermore, a few studies demonstrate the applicability of TPB in explaining the introduction of both methods and content in teaching practice, although with varied outcomes. Sadaf and Gezer (2020) found that attitude towards the behaviour, but not subjective norms or perceived behavioural control, explains teachers' intention to include digital literacy in their teaching. Foulger *et al.* (2021) reported that the TPB factors predicted teachers' candidates' intentions to integrate technology into classroom instructions. Similar findings were obtained by Habibi *et al.* (2023), who applied a modified TPB model to study technology integration for teaching practice among pre-service teachers. They demonstrated that out of the three core TPB antecedents, all of which were significant, PBC showed the highest effect size. Based on a student sample from Korea, Jo (2023) found a positive impact of attitudes and subjective norms, yet a surprisingly trivial role of PBC in shaping the intention to apply AI-related tools. In turn, Lenart *et al.* (2025), based on a Polish student sample, found a positive role of Attitudes for AI use intentions.

Overall, the empirical evidence suggests that TPB is well-suited both in the context of AI and to explain lecturers' intentions concerning integrating new methods and new content in teaching. Therefore, we expected that such antecedents would explain the intentions of university lecturers to include AI in their teaching curricula. Based on this, we hypothesised:

H1(a): A positive attitude towards AI enhances lecturers' intention to include AI in the curricula.

H1(b): Subjective norms vis-à-vis AI enhance lecturers' intention to include AI in the curricula.

H1(c): Lecturers' self-efficacy for AI enhances lecturers' intention to include AI in the curricula.

The Role of Background Factors in Driving AI Adoption

The theory of planned behaviour assumes the presence of background factors that may affect behavioural intention via the three core TPB antecedents. Background factors may include, among others, demographic variables (including education), individual personality (including emotions), and societal variables (including political and economic situation). The relevance of background factors may depend on particular circumstances and behaviours. In this regard, Bae *et al.* (2020) found that prior knowledge about sports had a positive impact on attitude towards sports participation and intention to participate in sports. In a business context, it has been shown that education about behaviour, such as entrepreneurship behaviour, contributes to developing behavioural intentions via TPB antecedents, such as self-efficacy (Nowiński *et al.*, 2019).

Regarding technology-related behaviours, prior knowledge is a background factor that has a positive influence on attitude and behavioural control. Rejali *et al.* (2023) found that prior knowledge concerning fully automated vehicles increased positive attitudes and behavioural control regarding such vehicles. As for educational settings, Tschannen-Moran and Hoy (2007) argued that teachers' self-efficacy beliefs were linked with mastery experiences (satisfaction with past teaching success) for experienced teachers and other factors like teaching resources and interpersonal support being more prominent among less experienced teachers. Habibi *et al.* (2023) linked behavioural intentions to integrate technology into teaching practice with technological pedagogical content knowledge. Technology perceptions related to familiarity with the technology were regarded as contributing factors to attitudes towards including technology in teaching (Shiau & Chau, 2016; Foulger *et al.*, 2021). In the context of AI and teaching practice, Sanusi *et al.* (2024) investigated factors affecting pre-service teachers' intentions to learn AI. They found that having basic knowledge about AI had a positive effect on their self-efficacy perceptions. Kohnke *et al.* (2023) found that familiarity with AI and AI-related training can be important for integrating AI into teaching practice.

Based on the above, it becomes apparent that background factors related to knowledge and learning about the behaviour have relevance for the behaviour, and this can occur via TPB antecedents. Here, we argue that prior AI-related education can positively affect behavioural intentions via two of the three TPB antecedents, namely, attitude towards the behaviour and self-efficacy. This is important because lecturers may feel overwhelmed, not having sufficient knowledge about AI technologies (Walter, 2024). We also argue that prior experience of using AI would serve as a source of experiential education for the lecturers, increasing their AI-related knowledge and positively affecting their attitudes towards the inclu-

sion of AI in the business curricula and their respective self-efficacy perceptions. Furthermore, it is widely accepted that past behaviours affect future behaviours, which is at least partially mediated via TPB antecedents (Ajzen, 2002). Various studies have shown such a link between prior exposure to certain behaviour and intentions to adopt that behaviour. For example, scholars found that prior work in a family business positively affects future entrepreneurial intentions by shaping their TPB antecedents (Carr & Sequeira, 2007; Onjewu *et al.*, 2022). Thus, it is reasonable to expect that prior experience with AI-related teaching would positively affect implementation intentions to include AI in the business curricula. Against this backdrop, it was reasonable for us to hypothesise the following:

H2(a): Prior experience with teaching involving AI enhances lecturers' intention to include AI in the curricula, via enhancing their positive attitudes and self-efficacy.

H2(b): Prior use of AI tools enhances lecturers' intention to include AI in the curricula, via enhancing their positive attitudes and self-efficacy.

H2(c): Education (including self-education) about AI enhances lecturers' intention to include AI in the curricula, via enhancing their positive attitudes and self-efficacy.

Figure 1 summarises the hypotheses.
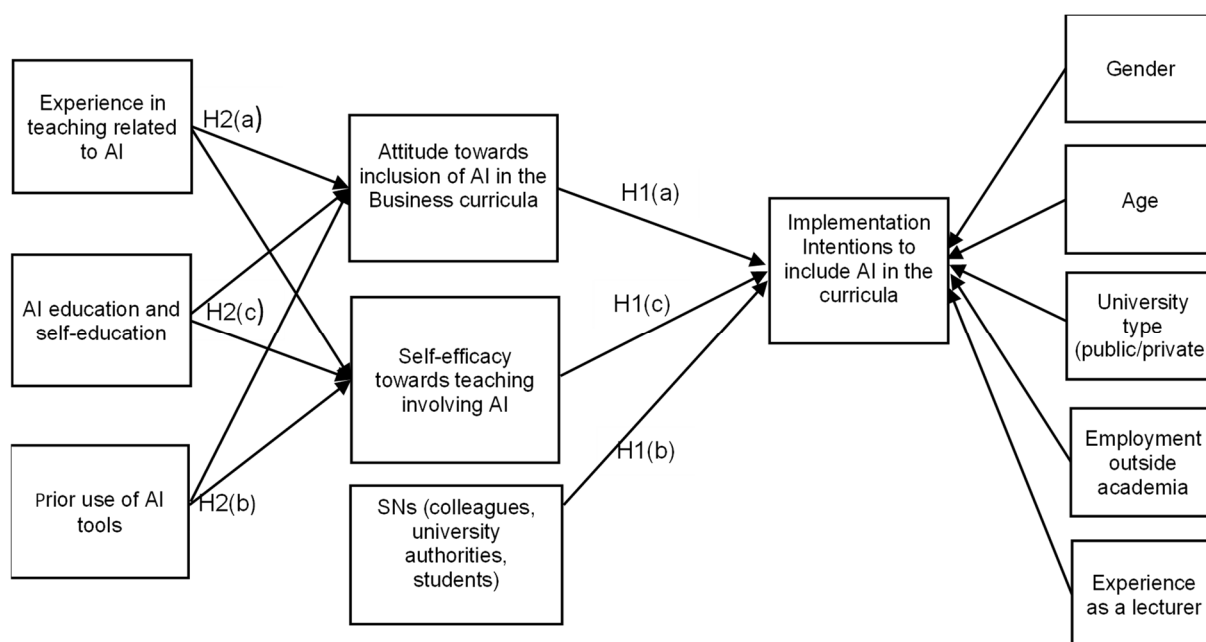
Figure 1. Theoretical framework
Source: own elaboration.

RESEARCH METHODOLOGY

Data Collection

Over the period spanning from June 2023 to September 2023, we collected a cumulative dataset comprising 136 responses from business and economics lecturers, conducted via an online survey using KoBoToolbox (Harvard Humanitarian Initiative, n.d.). We distributed the survey via email to university lecturers. We sent invitations to email addresses available on the Internet. We considered the sample size adequate according to Cohen's (1992) power table, a standard reference in partial least squares structural equation modelling (PLS-SEM) studies for determining the minimum sample size needed based on model complexity, desired statistical power, and significance level. In this case, since the current model comprises three variables affecting a construct, a minimum sample size of 124 is necessary to detect an R^2 of at least 0.10 with a power level of 0.80 and a significance level of 5%. The main focus was on business/economics lecturers from Central and Eastern Europe, including Poland, the Czech Republic, Slovakia, and Hungary, and we undertook efforts to include lecturers from at least two

universities per country. Three respondents indicated a different country than the four mentioned Visegrad countries, which we could explain by temporary employment in the region. We excluded these three respondents, leaving 133 respondents in the analysed sample. The predominant part of the sample consisted of participants located in Poland, constituting 87 responses (65.4%), followed by 25 respondents from the Czech Republic (18.8%), which was related both to the size of the business/economics lecturer community and to access to email addresses in these countries. Although we made efforts to target lecturers from different universities and fields in the business/economics realm, we must be cautious regarding their representativeness. In total, 90% of the respondents were employed in public universities or business schools. Only a minority, approximately 28%, had teaching experience in subjects related to AI or in areas incorporating AI elements. Table 1 presents further details about the demographics of the respondents, their expertise in AI, and their relevant experience.

Measures

One can apply TPB across diverse contexts (Ajzen, 2020) where individuals make decisions. Nonetheless, to remain valid, individual constructs need to be adapted to a given behaviour. Therefore, in this study, the attitudes (measured with two items) refer to the positive or negative sentiments held by business and economics lecturers towards AI as a topic for business/economics education. Subjective norms (measured with three items) represent the degree of approval from close peers for a decision to incorporate AI-oriented courses or topics into business/economics curricula. We measured self-efficacy (akin to perceived behavioural control) with three items. It refers to business/economics lecturers' perception of their capacity to incorporate AI-oriented courses or topics into business/economics curricula. We measured implementation intentions with two items reflecting planning and activities towards the inclusion of AI in the curricula. Learning (education) around the topic of AI was measured with three items. We measured all items of the above-mentioned constructs on a 5-point Likert scale. The rest of the variables were single items, either binary (gender, experience in AI-related teaching, university type) or used an ordinal scale (age, teaching experience). As for the exposure to AI tools it was conceptualised as a formative construct and measured with four items. The appendix presents a complete list of items.

RESULTS AND DISCUSSION

To test the study hypotheses, we adopted a PLS-SEM approach through the Smart PLS 4 software (Ringle *et al.*, 2022). We deemed this variance-based approach suitable for this study due to the complexity of the tested model and the greater predictive power in comparison to covariance methods (Hair *et al.*, 2017). Our model is inherently complex due to the presence of multiple indirect relationships involving mediating variables across seven constructs. This complexity makes PLS-SEM an appropriate technique as it is suitable for handling intricate models with multiple layers of relationships, particularly when theory is still developing or evolving, as is the case with AI integration in education. Moreover, the PLS-SEM is particularly advantageous for the study purpose, because it focuses on maximising explained variance in the dependent variable. This approach aligns well with our aim to predict the drivers of academics' intention to adopt AI in curricula. Two steps exist in PLS-SEM, namely measurement and structural models. The former refers to the relationships between the latent constructs and their items, whereas the latter captures the relationships between the latent constructs.

Measurement Model

We assessed reliability and validity in the measurement model as per Hair *et al.'s* (2016) guidance. For reflective variables, reliability is checked through two indicators, composite reliability (CR) and Cronbach's alpha (α). Here, the variables should exhibit a score greater than 0.7. Validity comprises two types, convergent and discriminant. Convergent validity is assessed through the items' loadings and the average variance extracted (AVE). Both should be 0.5 or higher. As for discriminant validity, it is inspected through the square roots of AVE (Table 3). Following Fornell and Larcker's (1981) criterion, those values should be higher than the ones on the diagonal. Moreover, collinearity should be checked to ensure no major issues in this regard. This is inspected through the variance inflation

factor (VIF), which should be less than 5. Table 2 showcases the findings for reliability and validity. Regarding collinearity, all VIF values were less than 5.

Table 1. Research sample characteristics

Control variables	Response	N	%
Country of residence	Poland	87	65.4
	Czech Republic	25	18.8
	Hungary	12	9.0
	Slovakia	9	6.8
Field of Teaching	Finance	15	11.3
	Economics	47	35.3
	Marketing	21	15.8
	HR management	4	3.0
	Logistics and production	9	6.8
	Management	37	27.8
Gender	Male	75	56.4
	Female	56	42.1
Age range	20-30 years	4	3.0
	31-40 years	39	29.3
	41-50 years	53	39.8
	51-60 years	18	13.5
	61 years or older	19	14.3
Work	Public university	120	90.2
	Private university	13	9.8
Job title	A full-time lecturer focused on teaching	9	6.8
	A full-time lecturer – both teaching and doing research	117	88.0
	A part-time lecturer	7	5.3
Years of teaching experience at university	Less than 5 years	9	6.8
	5-10 years	24	18.0
	11-15 years	22	16.5
	More than 15 years	78	58.6
Are you currently employed outside academia?	No	90	67.7
	Yes, I run my own business	18	13.5
	Yes, I am employed in business	4	3.0
	Yes, I am employed in public/local administration	13	9.8
	Yes, other	9	6.8
Previous teaching experience related to AI	Yes	37	27.8
	No	96	72.2
Previous exposure (application) of AI tools (in education or elsewhere)			
Chatbot	Yes	55	41.4
	No	78	58.6
ChatGPT	Yes	90	67.7
	No	43	32.3
Automatic translators	Yes	111	83.5
	No	22	16.5

Source: own study.

Table 2. CR, α, AVE, and VIF

Indicator	Previous AI Teaching	AI Education	Prior AI Use	SE	ATT	SNs	AI Implementation Intention
CR	Single Item	0.879	Formative	0.940	0.854	0.896	0.945
α	Single Item	0.795	Formative	0.904	0.660	0.836	0.884
AVE	Single Item	0.711	Formative	0.841	0.747	0.747	0.897

Note: SE – self-efficacy (towards teaching involving AI); ATT – attitude (towards the inclusion of AI in the Business curricula); SNs – subjective norms.
Source: own study in Smart PLS 4.0.

Table 3. Square roots of AVE

Variables	AI_E	Age	Att	Exper.	Gender	IIs	P_AI_T	E_o_A	SE	SNs	Univ.
AI education	0.843										
Age	0.033	1									
Attitude	0.516	-0.079	0.865								
Experience	-0.171	0.533	-0.138	1							
Gender	-0.111	-0.201	0.059	-0.135	1						
IIs	0.696	-0.032	0.545	-0.101	-0.013	0.947					
Previous AI teaching	0.545	0.004	0.239	-0.103	-0.028	0.428	1				
Empl. outside academia	0.278	-0.086	0.219	-0.031	-0.143	0.174	0.134	1			
SE	0.724	-0.073	0.394	-0.116	-0.197	0.631	0.437	0.168	0.917		
SNs	0.254	-0.163	0.384	-0.125	0.021	0.291	0.156	0.014	0.196	0.869	
Univ.	0.111	0.281	-0.008	0.141	-0.183	0.021	0.078	0.145	0.114	0.203	1

Note: IIs – implementation intentions [to include AI in the curricula]; SE – self-efficacy; SNs – subjective norms; Univ. – University; P_AI_T – Previous AI teaching [experience]; E_o_A – Employment outside academia.
Source: own study in Smart PLS 4.0.

Structural Model

Table 4 illustrates the results of the structural model, which captures the hypothesised links. To begin

Table 4. Structural model results and indirect effects

Direct Effects	Sample mean (M)	P values
AI education -> Attitude	0.541	0.000
AI education -> SE	0.519	0.000
AI use -> Attitude	0.058	0.889
AI use -> SE	0.709	0.000
Age -> IIs	0.090	0.255
Attitude -> IIs	0.292	0.001
Experience -> IIs	-0.014	0.831
Gender -> IIs	0.156	0.220
Previous AI teaching -> Attitude	-0.140	0.459
Previous AI teaching -> SE	0.163	0.207
Empl. outside academia -> IIs	0.112	0.475
SE -> IIs	0.514	0.000
SNs -> IIs	0.108	0.206
University type ->IIs	-0.251	0.265
Indirect effects	**Sample mean (M)**	**P values**
AI education -> Attitude -> IIs	0.159	0.007
AI education -> SE -> IIs	0.268	0.000
AI use -> Attitude -> IIs	0.017	0.896
Previous AI teaching -> Attitude -> IIs	-0.040	0.484
AI use -> SE -> IIs	0.365	0.000
Previous AI teaching -> SE -> IIs	0.083	0.204

Source: own study in Smart PLS 4.0.

with, the path analysis reveals that SE is driven by AI Education (β = 0.519, P ≤ 0.01) and AI Prior Use (β = 0.709, P ≤ 0.01), whereas ATT is influenced by AI Education only (β = 0.541, P ≤ 0.01). In turn, both ATT and SE hold a positive and significant influence on AI Implementation Intention (β = 0.292, 0.514, P ≤ 0.01), but SNs do not. None of the control variables had a significant relationship with Implementation Intention.

As for the indirect effects, AI Education held a positive and significant indirect effect on AI Implementation Intention through both SE and ATT (β = 0.268, 0.159, P ≤ 0.01). As for Prior AI use, it had a positive, significant indirect effect on AI Implementation Intention through SE only (β = 0.365, P ≤ 0.01) and not ATT. In contrast, the indirect influence of Previous AI teaching on AI Implementation Intention failed to materialise. Therefore, we found support for H1a and H1c but not for H1b. Moreover, we rejected H2a, found partial support for H2b, and support for H2c. Overall, the model explains 52.3% of AI Implementation Intention.

Discussion

This study has uncovered the mechanism underlying business lecturers' inclusion of AI in university curricula. While extant works have explored the adoption of AI in various contexts as a tool, scholars have overlooked its inclusion into the higher education curricula. Responding to calls for a better understanding of AI applications in education (Roy *et al.*, 2022; Fernández-Batanero *et al.*, 2023; Hmoud *et al.*, 2023), this study offers novel insights on the factors triggering business lecturers' inclusion of AI in their teaching content. Leveraging the TPB framework, this study uncovered the important role of background factors, including prior AI use and prior AI education. Self-efficacy is driven by AI education and AI prior use, whereas Attitude is influenced by AI education only. Surprisingly, we found that previous teaching with AI tools plays a non-significant role, while subjective norms did not lead to AI inclusion.

Findings on the role of TPB factors are consistent with prior research on the adoption and integration of technology in teaching. Shiau and Chau (2016) reported significant effects of attitudes and PBC (akin to self-efficacy) on the intention to use cloud computing classrooms. Similarly, PBC (Habibi *et al.*, 2023) and self-efficacy (Wang *et al.*, 2021) were reported to play a significant role in explaining intentions to integrate technology into teaching practice. However, unlike earlier studies (Habibi *et al.*, 2023; Sadaf & Gezer, 2020; Shiau & Chau, 2016), our findings found subjective norms to play a trivial role. This is interesting, especially since AI has recently received significant attention in the media, and anecdotal evidence suggests that it has become a subject of intense discussion among university faculty and university governing bodies. Nonetheless, it seems that the influence of close peers does not directly affect implementation intentions. Perhaps, this is because the attention of higher education institutions has focused on regulatory issues (Korseberg & Elken, 2024) and not so much on embedding AI in the curricula. The observed trivial effect of subjective norms might also be, to some extent, explained by a very strong effect of self-efficacy. According to La Barbera and Ajzen (2020), the effect of subjective norms often becomes less pronounced and even insignificant at high levels of PBC/SE. The impact of cultural environment might also play a role, as subjective norms may have a more pronounced role in technology adoption in collectivistic societies (Zhao *et al.*, 2020).

Interestingly, the results diverge from what was found in the context of university students' use of AI. In this regard, Jo (2023) showed a surprisingly trivial role of perceived behavioural control. Thus, it seems that while students are prone to experimenting with AI tools even when their self-efficacy concerning AI tools is low, the faculty, especially when teaching is concerned, perceive their AI skills as much more important. It suggests that both the sample and the context in which AI implementation is studied may have important consequences for the obtained results.

Moving forward to the effect of background factors, the extant findings reveal that the prior use of AI tools has a strong positive impact on self-efficacy but not on attitude towards the inclusion of AI in teaching. This is consistent with Horowitz Kahn *et al.'s* (2023) findings concerning the impact of familiarity

with AI on the acceptance and willingness to use this technology. However, the observed lack of significant impact on attitude towards including AI in the curricula is not entirely consistent with those studies that combine TPB with the technology acceptance model (TAM), where perceived utility (PU) and perceived ease of use (PEOU) are regarded as antecedents of both positive attitudes towards the behaviour and PBC/self-efficacy (Shiau & Chau, 2016; Teo *et al.*, 2016). Simultaneously, our results provide support for qualitative findings on the preparedness of language instructors for AI (Kohnke *et al.*, 2023), highlighting the relevance of familiarity with AI tools in identifying ways to employ them in teaching.

Surprisingly, prior experience in teaching involving AI does not have a positive impact on self-efficacy or attitude. Here, we may provide two potential explanations. On the one hand, prior coverage of AI applications in business may not affect lecturers' self-efficacy due to the pace at which the field of AI is expanding. On the other hand, self-efficacy is a perceptual measure of personal skills and thus may be subject to over-optimism biases when new technologies are concerned. Such over-optimism is particularly likely among those with limited exposure to the topic.

Lastly, prior AI education has a positive influence on both self-efficacy and attitudes. This finding aligns with some prior studies that show educational efforts aimed at teachers to increase their technology-related self-efficacy. Specifically, Lee and Lee (2014) demonstrated that pre-service teachers' self-efficacy beliefs for technology integration increased after completion of the technology course. Similarly, prior studies based on the TPB framework, although in a different context, indicated that context-specific education significantly affects behavioural intentions via its impact on self-efficacy (Nowiński *et al.*, 2019). We may also compare the current findings to those of Aslan and Zhu (2016), who found a significant effect of both perceived ICT competence and perceived competence in integrating ICT into lessons on the actual integration of ICT into teaching practices. It is also consistent with a recent study of Chai *et al.* (2024), who uncovered the instrumental role of AI knowledge in AI teaching intentions in Chinese primary and secondary schools.

On a general level, our findings concur with research indicating the importance of teacher ICT education for incorporating ICT in the educational process (Tondeur *et al.*, 2018). However, when considering practical implications, we should also note contextual differences. While in the case of general ICT skills, these can be provided by means of fairly standard training, training opportunities in such a dynamic field as AI are less available. Therefore, the inclusion of AI in the curricula may require much more personal involvement on behalf of the lecturers and more contextualised training (Luckin *et al.*, 2022) than with more mature technologies.

CONCLUSIONS

This study provides probably the first assessment of university teachers' intentions to implement AI in their teaching curricula. Based on the theoretical foundations of TPB, it sheds light on the antecedents of the inclusion of AI in teaching, demonstrating that context-specific self-efficacy perceptions and attitudes towards the behaviour are significantly related to the implementation intentions. Surprisingly, despite substantial attention paid to AI, a trivial role of subjective norms is found. At the same time, the study reveals background factors that contribute to self-efficacy and attitudes, with the role of prior teacher education and the use of AI tools being related to self-efficacy, as well as a significant role of education for attitudes. Interestingly, the prior inclusion of AI in teaching did not contribute to self-efficacy or attitudes.

The study's theoretical implications concern TPB's applicability for future research on integrating emerging technologies into business and economics education. In terms of practical implications, the study points to the importance of the lecturer's self-efficacy shaped by technology education and technology use. Given the rapid rise of AI and the urgent need for student education in this respect, implementing train-the-trainer programmes should occur as soon as possible to prepare students entering the workforce for the AI revolution (Walter, 2024). Moreover, the dynamic nature of technological advancement calls for stronger and mutual ties between academia and business (Schaeffer *et al.*, 2021), which could help university lecturers stay current with their field-specific AI

developments. This would enable them to offer more relevant, context-specific AI instruction, particularly crucial when the focus is on AI application rather than its technical development. To conclude, in light of growing concerns about AI's impact on employment, we cannot overstate the importance of embedding field-specific AI education in university curricula.

Lastly, this study is not without limitations. First and foremost, the sample was not representative and limited to business and economics university lecturers from Central and Eastern Europe. While non-probability sampling and a limited number of respondents constitute an important limitation, it is worthwhile to note that few studies addressing technology in (higher) education have relied on active lecturers due to challenges related to data collection. To overcome this limitation in the future, we recommend involving important external stakeholders in the data collection process, such as the Ministry responsible for Higher Education, which could encourage broader participation in future surveys. As for the theoretical model and construct measures being applied, future studies could use more elaborate measures of lecturer education and familiarity with AI. Lastly, an extension of this research into other contexts, such as other education levels and fields other than business economics, would certainly be welcome. Finally, it is important to highlight that our model indicates more than 45% unexplained variance. We may attribute this to possible omitted variables, including institutional policies and external technological pressures. Thus, we call for future research to incorporate additional variables at both organisational and environmental levels to enhance explained variance.

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Appendix:

Table A. Construct operationalisation

TPB Construct	Item/ Survey Question
Attitude towards the inclusion of AI in the business curricula	Artificial intelligence is an important topic for business education.
	It is not possible to teach students who major in business studies without referring to artificial intelligence.
Self-efficacy towards teaching involving artificial intelligence	I have sufficient knowledge about artificial intelligence to include artificial intelligence in my courses.
	I could handle adding artificial intelligence-related content to my courses without much effort.
	I am knowledgeable enough about artificial intelligence applications to discuss these issues with my students.
Subjective Norms	A decision to include artificial intelligence in my teaching would have been approved by my university colleagues.
	A decision to include artificial intelligence in my teaching would have been approved by my university authorities/managers.
	A decision to include artificial intelligence in my teaching would have been approved by my university students.
AI-related education and self-education	I have been regularly following publications on artificial intelligence applications in business.
	I have attended workshops or seminars to increase my knowledge about artificial intelligence and its applications in business.
	I have devoted significant time to learning about artificial intelligence and its business applications.
Implementation Intentions to include AI in the curricula	I have started planning the inclusion of artificial intelligence content in my courses.
	I have started collecting teaching materials concerning artificial intelligence applications.
Prior AI experience	Have you ever taught any courses related to artificial intelligence, or that included a component related to artificial intelligence?
Prior AI use	Have you ever applied the following artificial intelligence tools (in education or elsewhere)? Chatbot, Chat GPT, Automatic translators, other AI

Source: own study.

Authors

The contribution share of the authors was as follows:

Witold Nowiński (40%) – conceptualization, methodology, investigation, formal analysis, writing – the original draft, review and editing, Mohamed Yacine Haddoud (35%) – conceptualization, methodology, formal analysis, writing – the original draft, review, and editing, Julien Issa (25%) – conceptualization, data curation, formal analysis, writing – the original draft

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Generation Y entrepreneurial competitiveness: An empirical analysis of determining factors

Bilal Khalid, Singha Chaveesuk, Wornchanok Chaiyasoonthorn

A B S T R A C T
Objective: The research aimed to identify the determining factors that influence Generation Y entrepreneurial competitiveness. The study was motivated by this Generation's significant impact on the global economy, as they comprise a quarter of the global population, and the fact that they grew up in a period of technological advancement.
Research Design & Methods: We used a quantitative survey research design to empirically collect primary data from Gen Y entrepreneurs, using a sample size of 384 respondents. The model had six independent variables, i.e., personal traits, entrepreneurial self-efficacy, networking skills, digital capabilities, fear of failure, and growth mindset. The mediating variable was entrepreneurial orientation, while the dependent variable was entrepreneurial competitiveness. We evaluated the model using confirmatory factor analysis (CFA), and we tested the hypotheses using structural equation modelling (SEM).
Findings: We found that entrepreneurial self-efficacy, digital capabilities, networking skills, and growth mindset significantly enhance Gen Y competitiveness, while personal traits showed no significant effect. Fear of failure had an unexpected positive impact. Entrepreneurial orientation did not mediate these relationships. Innovation and adaptability were key drivers, but digital transformation emerged as the strongest predictor of Gen Y entrepreneurial success in competitive markets.
Implications & Recommendations: The study recommended Gen Y entrepreneurs and policymakers entrepreneurial training and education to enhance their entrepreneurial capabilities; networking strategies and skills, which are vital in nurturing a diverse workforce; and digital transformation for small businesses as a strategy to achieve entrepreneurial competitiveness.
Contribution & Value Added: Our research advances entrepreneurial research by identifying key drivers of Gen Y competitiveness: digital capabilities, self-efficacy, and networking, while challenging conventional assumptions about personal traits and fear of failure. It bridges gaps in generational entrepreneurship literature by empirically validating technology's pivotal role. The findings offer a refined framework for policymakers and educators to cultivate adaptive, digitally fluent entrepreneurs, enhancing competitiveness in evolving markets. This work enriches theoretical discourse and provides actionable strategies for fostering Gen Y entrepreneurial success by integrating psychological and technological perspectives.

Article type:	research article
Keywords:	generation Y; entrepreneurial competitiveness; entrepreneurial orientation; entrepreneurial self-efficacy; digital capabilities
JEL codes:	J24, L26, M13

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INTRODUCTION

Generation Y entrepreneurs represent the unusually strong combination of exceptional technological competence with the largest segment of the global workforce. Therefore, understanding the psycho-digital drivers-behavioural patterns and digital uniqueness of future entrepreneurs for competition will

be extremely vital for adaptation to the future business dynamics. Born between 1981 and 1996, Gen Y has significantly contributed to reshaping the entrepreneurial landscape and the general global economy (Črešnar & Nedelko, 2020; Heiberg, 2024). Singh *et al.* (2023) inform that Gen Y comprise up to 40% of the current global labour force and could rise to 75% by the year 2025. Moreover, individuals from Generation Y grew up in a period of technological advancements. Hence, they continue to be influenced by technology in the global economy, including the use of social media and other technologies in business to enhance their competitiveness. Like individuals in other demographic categorisations, Generation Y presents various unique characteristics significant to the global economy. For instance, scholars consider Generation Y to be highly tech-savvy and deliberate in sharing information and finding solutions to their problems online (Nguyen, 2020).

Competitiveness in business entails the ability to gain an advantage and succeed in the market, resulting in increased productivity (Farida & Setiawan, 2022). Therefore, entrepreneurial competitiveness refers to an entrepreneur's ability to create more opportunities in business (Hu *et al.*, 2022). For instance, entrepreneurs can enhance their competitiveness by acquiring and maintaining a competitive advantage (Somwethee *et al.*, 2023). Entrepreneurs can gain a competitive advantage by hiring quality staff with the right skills and innovative characteristics, successfully differentiating their products, having low-cost suppliers, employing different business strategies, and having target niches (Farida & Setiawan, 2022). According to the literature, there is a knowledge gap about the elements that drive entrepreneurial competitiveness among Generation Y. Despite changes in the corporate environment and technological innovation, the literature continues to focus on human attributes. Technology and economic aspects remain underexplored. For instance, a study by Neumann (2021) explains how entrepreneurship affects welfare, but his study fails to extend its analysis into social and environmental welfare.

Past research demonstrates that Gen X shows different entrepreneurial patterns as compared to Gen Y. As such, it introduces the belief that Millennials display reduced entrepreneurial inclinations. Research examining entrepreneurial competitiveness through multiple factors remains scarce in the literature. The literature lacks studies about identity factors which affect Generation Y entrepreneurial competitiveness levels. The marketplace that Generation Y must contend with is very competitive. Entrepreneurial self-efficacy, digital skills, fear of failure, growth mentality, and entrepreneurial orientation are some psychological qualities that contribute to their entrepreneurial competitiveness. We aimed to close the knowledge gap by examining the factors and their impacts on the entrepreneurial behaviour associated with Generation Y.

To bridge this research gap, we addressed the following research objectives: (1) to identify and measure the impact of key psychological and technological factors (entrepreneurial self-efficacy, digital capabilities, networking skills, growth mindset, fear of failure, and personal traits) on Generation Y entrepreneurial competitiveness; and (2) to find out the factors influencing the entrepreneurial competitiveness of Generation Y entrepreneurs. This research makes three key contributions: (1) it shifts the theoretical focus from static traits to dynamic psychological and technological factors critical for Gen Y; (2) it identifies and empirically validates the specific mediating pathways, especially the pivotal role of digital capabilities and growth mindset, that enhance competitiveness in this generation; and (3) it provides actionable insights for developing targeted interventions, such as specialized training in sector-specific digital tools and resilience-building programs to cultivate a more competitive Generation Y entrepreneurial ecosystem.

The remainder of this article is structured as follows. Section 2 presents a literature review and develops the research hypotheses. Section 3 details the research methodology, including the sample, data collection, and analytical techniques. Section 4 presents the results of the empirical analysis and discusses the key findings. Finally, Section 5 concludes the article by outlining the theoretical and practical implications, acknowledging the study's limitations, and suggesting future research directions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Evaluating Generation Y Entrepreneurship

Literature search revealed the existence of prior studies to discern the inherent characteristics and motivations of Generation Y entrepreneurs, by comparing them to other demographic categorisations (Liu *et al.*, 2019). Srivastava and Banerjee (2016) found that Generation Y entrepreneurs base their decisions on making meaningful differences when studying their motivations compared to Generation X (group born 1965-1980, bridging analogue traditions and digital innovation), who value preserving a work-life balance. People from Generation Y, with their solid educational foundation, seek positive feedback and numerous achievements in their professional work as their motivational drivers. Gen Y individuals gain their entrepreneurial motivation from creativity and innovation due to their upbringing in the technological era (Nalluri, 2019). Consequently, technology plays a vital role in their entrepreneurial activities. Business Millennials depend on Facebook and X (formerly Twitter) to maintain networks with critical stakeholders, according to Alhabash and Ma (2017). The digital proficiency of Gen Y entrepreneurs allows them to use trend understanding and analytical data and performance metrics to enhance their performance outcomes.

The Generation Y Competitive Structures

The Generation Y competitive structure is defined by their unique capacity to leverage digital globalisation for opportunity creation, yet challenged by intense market competition, particularly from resource-entrenched Gen X, who may perceive them as inexperienced (Hershatter & Epstein, 2010). To escape this duality, the Gen Y entrepreneurs take recourse in business model innovation strategies to competitively reconfigure value propositions and capture emerging markets with technological agility (Cui *et al.,* 2024; Nayak *et al.*, 2023). We identified the following as two major industrial advantages for this cohort: speed of assimilating disruptive technology within the core infrastructure of the industry and collaborative networking ecosystems. We decided to combine thus identified features to create a certain competitive architecture through which Gen Y will be able to convert its fluency with digital into a market advantage without antagonism among generations.

Theoretical Frameworks of Entrepreneurship

Schumpeter's innovation theory of entrepreneurship describes entrepreneurs as innovative through technological invention but also through their application to business processes and production methods (Mihalcea *et al.*, 2012). It is fundamental to Schumpeter's framework that it delineates competitive advantage by the normatively new application of innovations. This is ever relevant when assessing the ability of Generation Y to deploy and embed digital technologies into business operations and offerings. Young Generation business entrepreneurs develop competitive edges by taking risks and showing innovation combined with tolerance (Kraus *et al.*, 2021; Tai *et al.*, 2021; Nayak *et al.*, 2023). Gen Y entrepreneurs should use Schumpeter's theory of entrepreneurship to develop approaches for how they will embed different technologies into their business operations and manufacturing processes. The theory possesses limited effectiveness since technological innovations serve alone as insufficient to develop competitive advantages in the market. The psychological theory of entrepreneurship finds suitable application when examining different traits present in entrepreneurs. The theory has limitations since particular characteristics, including excessive optimism, produce incorrect assumptions about future expectations (Ben Fatma *et al.*, 2024). The theories here provide the analytical dimension to suggest how such digital fluency of Gen Y relates in tandem with defining psychological dispositions to entrepreneurial competitiveness.

Determining Factors of Generation Y Entrepreneurial Competitiveness Personality Traits

Scholars have identified that personality traits influence decisions made by people in different circumstances, both personal and business. Moreover, scholars have discerned that the big five personality traits play a critical role in entrepreneurial performance and success for business ventures

(Nayak *et al.*, 2023). According to Batool *et al.* (2023), the big-five model demonstrates that action-oriented traits such as innovativeness and competitiveness, together with risk-taking, facilitate the development of Gen Y entrepreneurial competitiveness in people. Caliendo *et al.* (2023) support the assertion that people who possess characteristics of innovativeness and high achievement needs, together with self-efficacy along risk tolerance capabilities, better recognise growth opportunities and develop competitive advantages. According to Awwad *et al.* (2021), trait variables demonstrate a positive impact on the entrepreneurs' achievement.

Since the success of entrepreneurial enterprises depends on the owner's human capital, Gen Y's high entrepreneurial score on trait variables is vital in developing a competitive advantage. In this context, we formulated the following hypothesis:

H1: The Big Five personal traits positively affect Generation Y entrepreneurial competitiveness.

Entrepreneurial Self-efficacy

Entrepreneurial self-efficacy is a personality trait. It is the belief an entrepreneur has in their proficiency to execute goals that are performance-oriented (Khalid, 2024). Often, small and medium-sized enterprises and Gen Y start-ups do not survive or experience growth. The element of entrepreneurial self-efficacy is of vital importance in the decisions made by new entrepreneurs regarding entry, as well as in assisting such entrepreneurs' survival and growth, asserts Sitinjak (2019). Again, in supporting this statement, Caliendo and his colleagues indicate that self-efficacy in Gen Y entrepreneurs encompasses self-belief in the ability to conduct challenging tasks to achieve success (2023). Having a self-efficacy trait plays a critical role in not only ensuring start-up survival but also increasing entrepreneurial income and competitiveness. Consequently, researchers proposed the following hypothesis:

H2: Entrepreneurial self-efficacy positively affects Generation Y entrepreneurial competitiveness.

Networking Skills

Scholars consider networking a critical skill in achieving entrepreneurial success. This is because the development of a strong network of contacts eases access to business partners, new customers, and mentors (Delias *et al.*, 2023; Wasim *et al.*, 2023). According to Dhameria *et al.* (2021), the networking abilities of entrepreneurs strongly affect competitive advantage development in entrepreneurial marketing contexts. Gen Y's networking ability directly affects the marketing effectiveness of business enterprises, which leads to enhanced business success rates. According to Anwar *et al.* (2021), different business networking systems, such as business networking and political networking alongside financial networking, have an essential impact on venture performance. A company achieves new market access and venture success by developing all possible business networks. Researchers formed the following hypothesis through this study.

H3: Networking skills positively affect Generation Y's entrepreneurial competitiveness.

Digital Capabilities

Scholars have identified digital business capabilities as disruptive elements that have a positive impact on start-up initiatives through an introspective examination of the literature (Dabbous *et al.*, 2023; Galindo-Martín *et al.*, 2023). They achieve this while simultaneously maintaining a commanding market position and a competitive edge (Dabbous *et al.*, 2023). According to Dabbous *et al.* (2023), digital business methods affect entrepreneurial competitiveness through three major operational areas involving internet use and digital integration, along with connectivity functions. Zhang *et al.* (2023) establish that digital enterprise transformation establishes fundamental importance for core business performance improvement. Gen Y grew up in an age of technological advancement, and incorporating digital capabilities into business will be critical in areas such as management capabilities, which will lead to competitive advantage (Prakasa & Jumani, 2024). Thus, we hypothesised:

H4: Digital capabilities positively affect Generation Y entrepreneurial competitiveness.

Fear of Failure

Entrepreneurs have turned the fear of business failure into a motivator, which could have positive as well as negative outcomes (Dutta & Sobel, 2020; Hunter *et al.*, 2021). Societal discrimination against business failure generates the fear of failure as a psychological trait which restrains business development, according to Halim *et al.*'s (2023) research. Business success is prone to suffer when failure occurs at high levels, as this negatively affects both entrepreneurial risk-taking and business competitiveness; this prompted Hunter and colleagues (2021) to claim that entrepreneurs' fear of failure impacts their decision-making, increasing risk and also negatively affecting competitiveness. The discussion from the literature founded the next hypothesis:

H5: Generation Y's entrepreneurial competitiveness directly influences their fear of failing.

Growth Mindset

When discussing entrepreneurship, a growth mindset refers to a positive outlook on events irrespective of barriers and adversaries, as well as persistence in seeking growth and improvement in the face of adversity (Billingsley *et al.*, 2021). According to Li *et al.* (2023), the likelihood of entrepreneurs engaging in entrepreneurship when confronted with less demanding business contexts increases rather than when confronted with difficult problems. In buttressing this view, Jemal (2020) avers that a growth mindset, which includes variables like creativity, innovation, pro-activeness, and risk-taking, among other traits, has all positively influenced the performance of small and medium ventures, whilst increasing competitiveness (Chatzoglou *et al.*, 2022). These views were the basis for proposing the following hypothesis:

H6: Growth mindset has a positive effect on the entrepreneurial competitiveness of Generation Y.

Entrepreneurial Orientation

Entrepreneurial orientation in business refers to entrepreneurs' risk-taking, innovativeness, pro-activeness, competitive aggressiveness, and autonomy (Lumpkin & Dess, 1996). Entrepreneurs can improve their business competitiveness by leveraging various dimensions, including risk-taking, to venture into new opportunities that larger organisations may not exploit (Feng *et al.*, 2024; Wales *et al.*, 2013). Similarly, by addressing the dimension of competitive advantage, entrepreneurs can improve the relationship between business entrepreneurial orientation and venture performance (Badruddin *et al.*, 2019). Exploiting the various dimensions of business entrepreneurial orientation will help entrepreneurs improve their business competitiveness. Therefore, we proposed the following hypothesis:

H7: Entrepreneurial orientation significantly mediates the effects of determining factors on generation Y entrepreneurial competitiveness.

Conceptual Framework

From the above critical review of literature, and the hypothesis proposed, we developed the following conceptual framework. The model comprised six independent variables, namely personal traits, entrepreneurial self-efficacy, networking skills, digital capabilities, fear of failure, and growth mindset. The mediating variable was entrepreneurial orientation, while the independent variable was entrepreneurial competitiveness. Figure 1 presents them both.

RESEARCH METHODOLOGY

The study opted for a quantitative survey design, which involved gathering primary data from the study target population (Gen Y entrepreneurs in Thailand), allowing for the analysis of multiple variables. The study considered all types of businesses, whether large or small, as well as different business sectors. The large size of the population led to the selection of a representative sample. We selected a large representative sample to minimise the sample size and results bias. Assuming an unlimited population, we determined the sample size using the following formula:

$$n = \frac{z^2 \times \hat{p}\,(1 - \hat{p}\,)}{\varepsilon^2} \tag{1}$$

in which:

    n - sample size;

    z - the z score;

    ε - the margin of error;
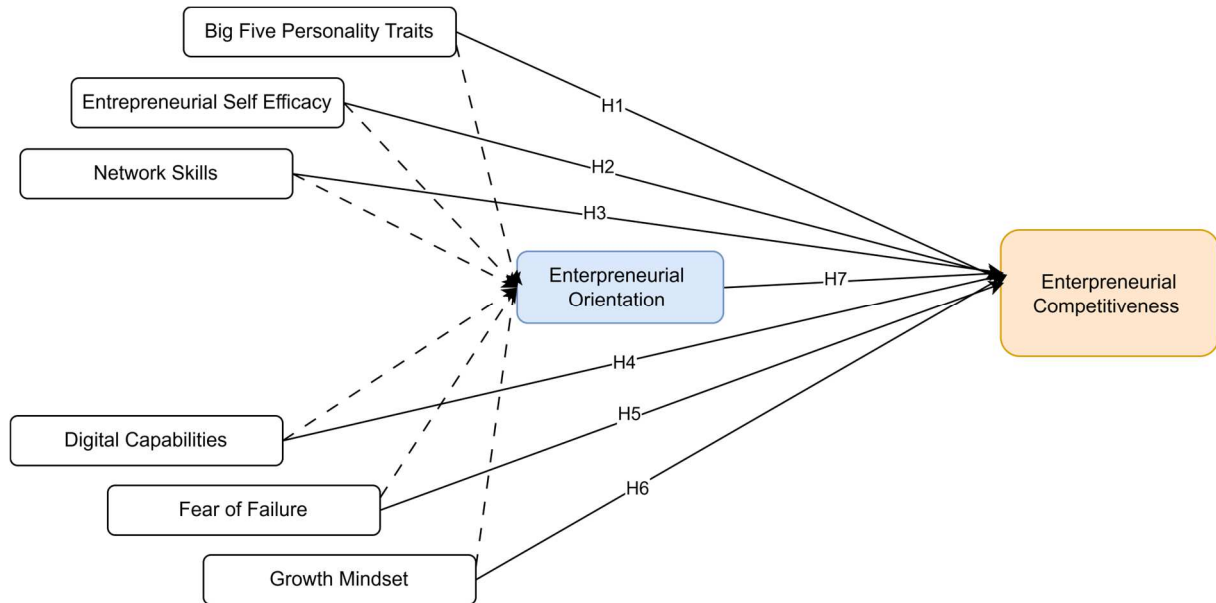
    $\hat{p}$ **-** the population proportion.

Figure 1. The study's conceptual framework
Source: own elaboration.

We computed the following sample using a 50% percentage, a 95% confidence level, and a 5% margin of error for a two-tailed test as outlined:

$$n = \frac{1.96^2 * 0.5(1 - 0.5)}{0.05^2} = 384 \tag{2}$$

Therefore, we determined the minimum size to be 384 respondents.

We adopted the non-probability sampling method and convenience sampling technique to recruit the respondents who satisfied the required inclusion criteria. To mitigate convenience sampling bias, we enhanced representativeness through strategic diversification: targeting key industries (see Table 1), recruiting nationwide based on the population spread (Bangkok: 17%, Central including East: 33%, North: 18%, Northeast: 33%, South: 14%), and including ventures from micro to medium sizes with varied founder experience levels. To collect the data, we developed a structured self-administered online questionnaire adopting a 5-point Likert scale, where 1=strongly disagree and 5 = strongly agree. We developed and administered the survey using Google Forms. We invited the respondents through links to the Google Form-hosted questionnaire to participate in the survey. We shared the questionnaire on Thailand social entrepreneur groups on the Line app. We collected data between November 2024 and January 2025. We received 412 responses (51.2% response rate), with 384 valid for analysis after data cleaning (48.0% valid response rate). This aligns with response rates for entrepreneurial surveys and ensures geographic/industry diversity across our target cohort.

We investigated the relationship between the different variables and the hypotheses using SEM, after we evaluated the proposed model for validity, reliability, and goodness of fit. We ensured the validity of combining scales from different sources through conceptual alignment, pilot testing, and psychometric validation (CFA), confirming reliability and measurement model fit for the integrated scales.

The big five personality traits had five observed variables, each having two items adopted from Salmony and Kanbach (2022) and Nayak *et al.* (2023). Five observed variables, adapted from Ferreira-Neto *et al.* (2023) and Caliendo *et al.* (2023), measured entrepreneurial self-efficacy. Udimal *et al.* (2021) and Wasim *et al.* (2023) provided the five observed variables used to evaluate networking skills. We measured digital capabilities by four observed variables obtained from Dabbous *et al.* (2023) and Prakasa and Jumani (2023). Dutta and Sobel (2020) and Gao *et al.* (2024) provided five observed variables to measure the fear of failure. We measured growth mindset using three observed variables obtained from Dweck (2009) and Kapasi and Pei (2021). We measured entrepreneurship orientation using three observed variables, each having three items obtained from Covin *et al.* (2020) and Bolton and Lane (2012). We used three variables to assess entrepreneurial competitiveness, with each of them having three items adapted based on the studies of Lawal *et al.* (2018) and Cullen and Adendorff (2014).

RESULTS AND DISCUSSION

Demographic Characteristics

We conducted descriptive statistics to evaluate the respondents' characteristics. The gender variable results indicated that the majority of respondents were women (52.6%), while a significant proportion (8.3%) indicated that they belonged to the 'others' gender category. For the age variable, the majority were those born between 1986 and 1990 (44.01%), followed by those who were born between 1991 and 1996 (36.46%). The rest of the Table addresses the education, industry of operations, and their years of experience.

Table 1. Descriptive statistics

Variables	Categories	Frequency	Percent
Gender	Male	150	39.1
	Female	202	52.6
	Others	32	8.3
	Total	384	100
Age	1981-1985	75	19.53
	1986-1990	169	44.01
	1991-1996	140	36.46
	Total	384	100
Education	Junior high school or lower	34	8.9
	High school / Diploma	96	25
	Bachelor's degree	215	56
	Master's degree	34	8.85
	Doctorate degree	5	1.3
	Total	384	100
Industry	E-commerce and retail	70	18.2
	Finance/Professional services	31	8.1
	Technology and innovation	48	12.5
	Education and training	69	18
	Healthcare and wellness	48	12.5
	Media and entertainment	33	8.6
	Arts and crafts	36	9.4
	Hospitality and tourism	49	12.8
	Total	384	100
Enterprise Age	< 1 year	39	10.2
	1-5 Years	165	43
	6-10 Years	119	31
	Over 10 Years	61	15.9
	Total	384	100

Source: own study.

Model Evaluation

The first analysis was an evaluation of the model's fitness. We conducted the model fitness using CFA. The results summarised in Table 2 indicate that all the fitness indices evaluated satisfied the required criteria. This supported the requirement that the data used in the analysis effectively fit the model.

Table 2. Evaluation of model fitness

Reference index	x^2/df	RMR	GFI	TLI	IFI	CFI	RMSEA
Evaluation criterion	1—3	<0.08	>0.8	>0.9	>0.9	>0.9	<0.08
Statistical values	2.462	0.027	0.829	0.907	0.917	0.917	0.062
Model fitness level	Fit	Fit	Fit	Fit	Fit	Fit	Fit

Note: Robust fit indices (CFI > 0.90; RMSEA < 0.08) provide secondary evidence against substantial common method variance.

Source: own study.

We evaluated common method bias (CMB) using multiple approaches. Firstly, Harman's single-factor test indicated that a single factor accounted for only 24.7% of the total variance, suggesting that common method variance was unlikely to be a major concern. Secondly, we applied the confirmatory factor analysis (CFA) marker variable technique using an unrelated construct (an environmental marker) according to Lindell and Whitney's (2001) recommendations. The marker variable showed no significant method-related covariance ($\lambda = 0.08$, $p = 0.41$), further supporting the absence of substantial CMB. Finally, the measurement model demonstrated a strong overall fit (Table 2), consistent with conditions of minimal common method bias (Williams *et al*., 2010). The other analysis conducted was the evaluation of the reliability (Cronbach's alpha and composite reliability (CR)) and validity analysis (factor loadings and average variance extracted (AVE)); Table 3 summarises the results. The required threshold for standardised factor loadings and average variance extracted (AVE) was 0.5 (Afthanorhan *et al*., 2020; Brandstätter, 2011; Obschonka *et al*., 2012), and the required threshold for composite reliability and Cronbach's alpha was 0.70 (Sujati & Akhyar, 2020). From the results, the standardised factor loadings ranged from 0.53 to 0.898, while the average variance extracted (AVE) ranged from 0.52 to 0.781, which satisfied the required threshold. In assessing the study reliability data, the values for CR ranged from 0.653 to 0.914, while those for Cronbach's alpha were from 0.821 to 0.915. These satisfied the required threshold and thus confirmed that the required reliability and validity levels were satisfactory, hence giving the go-ahead for SEM analysis.

From the correlation analysis presented in Table 4, the correlation between the dependent variable, entrepreneurial competitiveness (EC), with other variables was strong, positive, and significant. Correlation with entrepreneurial self-efficacy (ESE) ($r = 0.833$, $p < 0.001$); with networking skills (NS) ($r = 0.832$, $p < 0.001$); with digital capabilities (DC) ($r = 0.835$, $p < 0.001$); with fear of failure (FF) ($r = 0.841$, $p < 0.001$); with growth mindset (GM) ($r = 0.798$, $p < 0.001$); and with entrepreneurial orientation (EO) ($r = 0.822$, $p < 0.001$). Entrepreneurial competitiveness (EC) also had a moderate and significant and moderate correlation with personality traits (PT) ($r = 0.742$, $p < 0.001$). Therefore, these factors showed that they had a significant role in Gen Y competitiveness. The results meant that a positive change in these variables resulted in a positive change in Gen Y entrepreneurial competitiveness.

We explored the relationship between the independent latent variables on the dependent variable of entrepreneurial competitiveness. The first analysis on hypothesis one indicated that the big five personal traits have a positive and insignificant influence on entrepreneur competitiveness ($\beta = 0.086$, $p = 0.111$). Since the effect was insignificant, we rejected hypothesis one. The second hypothesis was on the effect of entrepreneurial self-efficacy. The results indicated that entrepreneurial self-efficacy had a positive and significant influence on entrepreneurial competitiveness ($\beta = 0.098$, $p = 0.009$). Thus, we accepted this hypothesis. The third hypothesis was on the effect of network skills. The statistics showed that network skills have a positive and significant influence on Gen Y entrepreneurial competitiveness ($\beta = 0.215$, $p = 0.000$). Hence, we did not reject hypothesis three. Hypothesis four concerned

the effect of digital capabilities. We found that they have a positive and significant influence on entrepreneurial competitiveness ($\beta = 0.234$, $p = 0.000$). As such, we accepted this hypothesis. We also accepted the fifth hypothesis. This is because we found that the relationship between fear of failure and entrepreneurial competitiveness was positive and significant ($\beta = 0.165$, $p = 0.000$). The fifth hypothesis investigated the effect of a growth mindset. The study indicated a positive and significant relationship with entrepreneurial competitiveness ($\beta = 0.106$, $p = 0.000$). Hence, we accepted this hypothesis. The last hypothesis six indicated that entrepreneurial orientation had a positive and significant influence on entrepreneurial competitiveness ($\beta = 0.272$, $p = 0.046$). This led to accepting this hypothesis. Table 5 summarises the direct relationship path.

Table 3. Reliability and validity analysis

Latent variables	Observed variables	Standardized factors	CR	AVE	Cronbach's alpha
DC	dig1	0.53	0.842	0.520	0.857
	dig2	0.738			
	dig3	0.784			
	dig4	0.73			
	dig5	0.793			
EC	Compe	0.898	0.914	0.781	0.915
	Mark	0.877			
	RiskT	0.876			
EO	Innov	0.762	0.837	0.631	0.839
	Proact	0.8			
	Risk	0.82			
ESE	esf1	0.789	0.826	0.591	0.843
	esf2	0.725			
	esf3	0.766			
	esf4	0.52			
	esf5	0.672			
FF	fof1	0.681	0.819	0.676	0.821
	fof2	0.738			
	fof3	0.666			
	fof4	0.661			
	fof5	0.7			
GM	grow1	0.685	0.653	0.538	0.856
	grow2	0.736			
	grow3	0.778			
	grow4	0.726			
	grow5	0.741			
NS	net1	0.7	0.846	0.524	0.848
	net2	0.762			
	net3	0.722			
	net4	0.688			
	net5	0.746			
PT	Agre	0.807	0.879	0.592	0.881
	Con	0.744			
	Extra	0.787			
	Neu	0.734			
	Open	0.774			

Note: PT = personality traits; ESE = entrepreneurial self-efficacy; NS = networking skills; DC = digital capabilities; FF = fear of failure; GM = growth mindset; EO = entrepreneurial orientation; EC = entrepreneurial competitiveness.
Source: own study.

Table 4. Pearson correlation matrix of latent variables

Variable	ESE	NS	DC	FF	GM	EO	EC	PT
ESE	1.00							
NS	0.825**	1.00						
DC	0.824**	0.765**	1.00					
FF	0.818**	0.812**	0.795**	1.00				
GM	0.783**	0.761**	0.762**	0.779**	1.00			
EO	0.798**	0.757**	0.766**	0.769**	0.734**	1.00		
EC	0.833**	0.832**	0.835**	0.841**	0.798**	0.822**	1.00	
PT	0.728**	0.680**	0.731**	0.674**	0.659**	0.748**	0.742**	1.00

Note: *p < 0.05, ** p < 0.001*
Source: own study.

Table 5. Direct relationship: Empirical results

Hypothesis	Paths	Estimate	S.E.	C.R.	p-value	Confirmed?
H1	PT→EC	0.086	0.054	1.593	0.111	No
H2	ESE→EC	0.098	0.038	2.601	0.009	Yes
H3	NS→EC	0.215	0.036	5.891	***	Yes
H4	DC→EC	0.234	0.035	6.617	***	Yes
H5	FF→EC	0.165	0.033	5.088	***	No
H6	GM→EC	0.106	0.028	3.793	***	Yes
H7	EO→EC	0.272	0.137	1.992	0.046	Yes

EC = entrepreneur competitiveness, EO = entrepreneurial orientation, PT = personal trait, ESE = entrepreneurial self-effi-cacy, NS = network skills, DC = digital capabilities, FF = fear of failure, GM = growth mindset.
Source: own study.
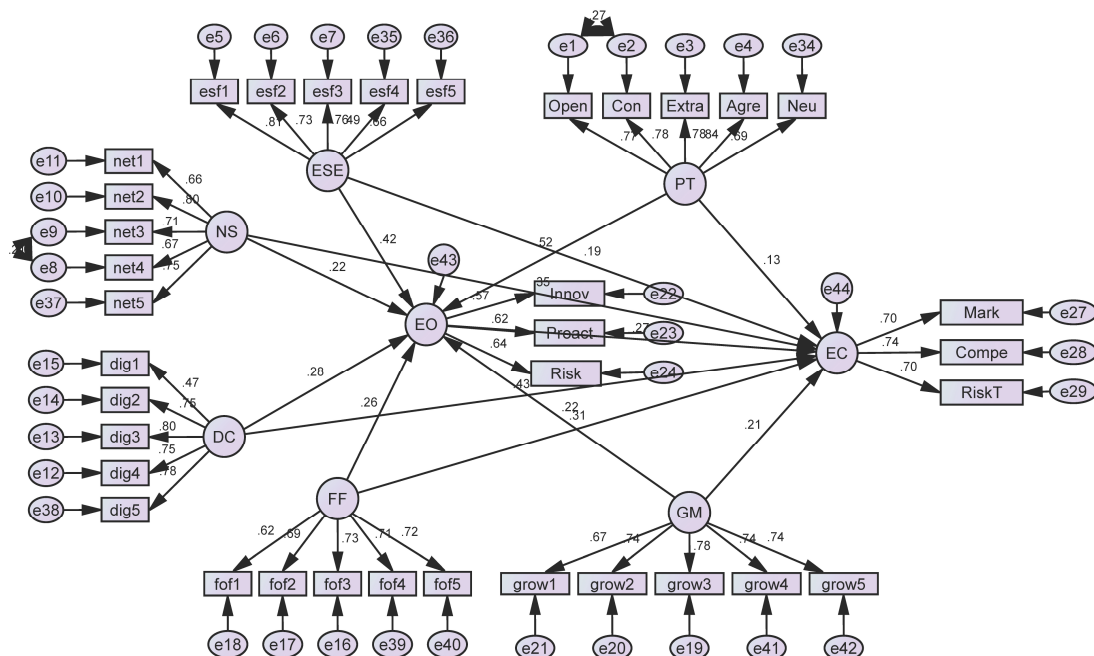
Figure 2. Empirical results
Note: Latent variable (observed variables) – DC (dig1 dig2, dig3, dig4, dig5); EC (Compe, Mark, RiskT); EO (Innov, Proact, Risk); ESE (esf1, esf2, esf3, esf4, esf5); FF (fof1, fof2, fof3, fof4, fof5); GM (grow1, grow2, grow3, grow4, grow5); NS (net1, net2, net3, net4, net5); PT (Agre, Con, Extra, Neu, Open)
Source: own elaboration.

Furthermore, we evaluated the indirect influence by analysing the mediating effect of entrepreneurial orientation on the effect of independent variables (personal traits, entrepreneurial self-efficacy, networking skills, digital capabilities, fear of failure, and growth mindset) on entrepreneurial competitiveness. We conducted the analysis using the SEM bootstrapping method. Table 6 summarises the results. The results indicated that entrepreneurial orientation did not have a significant mediation effect, as none of the indirect paths were significant.

Table 6. Indirect relationship empirical results

Indirect Paths	Total	Direct	Indirect
GM --> EO -->EC	0.137**	0.106**	0.031
FF --> EO -->EC	0.202**	0.165**	0.037
DC --> EO -->EC	0.276**	0.234**	0.042
NS --> EO -->EC	0.251**	0.215	0.037
ESE --> EO -->EC	0.156**	0.098	0.058
PT --> EO -->EC	0.175	0.086	0.090

Source: own study.

Invariably, the understanding from the findings includes that several personal and environmental factors contribute to the entrepreneurial competitiveness and successes of Gen Y entrepreneurs. We can also deduce from the results that entrepreneurial self-efficacy significantly influences the entrepreneurial competitiveness of the Gen Y population. Thus, we can highlight that the investigated elements of self-efficacy include being confident in the ability to recognise and assess business opportunities to spot their potential, and having the requisite knowledge and skills to successfully run a sustainable business enterprise, as well as being able to overcome entry barriers and encumbrances that are tied to running a startup enterprise. Based on our findings, we think that these aspects are vital in shaping the entrepreneurial abilities of Gen Y entrepreneurs. This view can find validation from the research of Sitinjak (2019), who is of the view that people confident enough to carry out entrepreneurial tasks and functions are more likely to decisively make decisions needed to successfully run any business enterprise, regardless minding those who may be affected by their decisions. They also tend to be resilient when faced with business impasses, and in the end, can achieve favourable business results. McGee and Peterson (2019) claim that entrepreneurs with strong self-efficacy succeed at acquiring resources and resolving crucial issues to maintain a sustainable business during its startup phase.

Our findings align with Schumpeter's innovation theory: digital capabilities (the strongest predictor) embody 'creative destruction,' enabling Gen Y to disrupt markets (Zhang *et al*., 2023). Conversely, psychological theory explains self-efficacy's impact (McGee & Peterson, 2019) but fails to predict the non-significance of traits or fear of failure's positive role; resource-based logic (Barney, 1991) further contextualises networking's value (Hoyos-Ruperto *et al*., 2013). We also found that the digital capabilities of entrepreneurs influence their entrepreneurial performance because effective digital technology users maintain their position at the frontiers enabled by technological progress. Corporations are forced to move to online platforms because their clients have shifted their operations to the internet. Thus, businesses have to keep up with the trends. Most significant among the findings was the important position of technological awareness and the adaptability role factor in Gen Y entrepreneurs.

The research backs this up. Zhang *et al.* (2023) explain that digital technology serves as a vital innovation driver and efficiency accelerator that boosts new business scalability. Young entrepreneurs view the mastery of digital marketing tools, along with online business promotional strategies and data analysis tools that track business operations to enhance operational efficiency, as vital components of their digital capabilities. Gen Y entrepreneurs possess two main digital skills: they automate business operations with digital technologies, and they excel at finding and making use of online information resources. According to Von Arnim and Mrozewski (2020), Generation Y entrepreneurs are very adept with their digital tools; they are excellent in spotting good opportunities in business where many see challenges, and they would probably work well in pushing omnichannels to engage their clientele and entice the online window shoppers into offline/storefront customers.

This paradigm has come to stand as an iconic variable that Gen Y entrepreneurs are to understand its damn minutiae-gravity significance. The very essence of this theory is beneficial to entrepreneurs who have developed the ability to adapt whenever challenges arise. Entrepreneurs who survived the business obstacles from COVID-19 lockdowns demonstrated success because they made their products or services operationally efficient for digital platforms. The education sector and logistics sector experienced exceptional growth during this period because people required online learning and logistics services. Burnette *et al.* (2019) demonstrate that entrepreneurs who believe strongly in themselves can transform their business ventures using diligence and determination, which both match entrepreneurial achievement objectives. The characteristics of a growth mindset include developing abilities through hard labour and turning challenges and business failures into opportunities for data collection and business growth. Prudent Gen Y entrepreneurs dedicate themselves to lifelong learning efforts that enable them to develop business-advancing competencies.

The research finds that although entrepreneurial orientation makes a very minimal impact when compared to the other studied variables, it is vital in decision making within Gen Y business owners that have implications towards the performance of the firm. Cho and Lee (2018) acknowledge the importance of this concept while explaining that it provides Gen Y entrepreneurs with superior innovative abilities to exploit opportunities better than competitors. A positive entrepreneurial mindset connected to relationship-building helps Gen Y entrepreneurs handle business development challenges in the twenty-first century. Networking skills represent a fundamental element for entrepreneurial achievement, because they grant business individuals the ability to obtain beneficial information as well as necessary resources, along with supportive contacts.

Hoyos-Ruperto *et al.* (2013) reaffirm that effective networking enhances opportunity recognition, facilitates access to funding, and fosters the formation of strategic partnerships, all of which collectively constitute a competitive advantage crucial to Gen Y's enterprising skills. Central to the theoretical hypotheses, this study found that inherent personal traits may not have a significant influence on determining entrepreneurial success. We found that fear of failure positively affects Gen Y entrepreneurial competitiveness. Very unlike the assumptions they had formulated and percepts in literary sources, the observation proved dissonant. However, the fear of failure prevents many people from putting their lives on the line, since innovation and risk-taking play quite vital roles in entrepreneurship.

CONCLUSIONS

Recommendations, Practical and Theoretical Implications

This study shifts entrepreneurial focus from traditional traits to technology-driven factors like digital capabilities, adaptability, and self-assessment. To build Gen Y competitiveness, implementing specific actions is required: finance/professional services should adopt cloud accounting (*e.g.*, QuickBooks Online) and analytics tools (*e.g.*, Tableau); technology & innovation must utilize development platforms (*e.g.*, GitHub) and cloud infrastructure (*e.g.*, AWS/Azure); education & training requires integrating LMS (*e.g.*, Canvas) with AI tutors; healthcare & wellness needs EHR systems (*e.g.*, Epic) and telehealth platforms; media & entertainment should leverage video tools (*e.g.*, Adobe Premiere Pro) and social analytics (*e.g.*, Hootsuite); arts & crafts can utilize e-commerce platforms (*e.g.*, Etsy, Shopify) and design software; Hospitality & Tourism must deploy booking systems (*e.g.*, Resy) and reputation management tools (*e.g.*, Revinate). Provide sector-specific bootcamps and workshops on these tools to enhance digital skills and entrepreneurial self-perception. Theoretically, this study's advances include: (1) a digital-psychological synergy framework for Gen Y; (2) Schumpeterian innovation theory refinement (digital > invention); (3) boundary conditions for psychological theory and entrepreneurial orientation.

Limitations and Future Studies

The research has been able to investigate the factors with characteristics to augment entrepreneurial competitiveness of Generation Y, taking into cognisance the increasing competition brought about by technological expansion and development. The study limitations include the use of convenience sampling, which may have affected generalisability and by its cross-sectional design, which restricts causal

interpretation of the examined variables, as well as the non-application of the demographic data in the discussion. Future studies could consider incorporating demographic moderating effects on entrepreneurial competitiveness to extend the findings of this study.

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Use of Artificial Intelligence

The manuscript is free of AI/GAI usage.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Entrepreneurial strategies for national large language models: A comparative study of Bielik and PLLuM in advancing Poland's digital sovereignty

Łukasz Sułkowski, Roksana Ulatowska

A B S T R A C T
Objective: In the framework of digital sovereignty, the article aims to investigate and assess the entrepreneurial models supporting the evolution of Poland's two national large language models (LLM), i.e., Bielik (community-driven Polish LLM) and PLLuM (Polish Large Universal Model, a consortium-based initiative).
Research Design & Methods: Using a qualitative research methodology, this work focuses on two national LLMs in a case study. Contextual data were obtained through in-depth, semi-structured interviews, document analysis, and scenario-based model testing. These data were subsequently thematically analysed with the support of NVivo systematic coding software.
Findings: The results show that both institutional and agile approaches to entrepreneurship are necessary for national digital sovereignty to be ensured. A comparative analysisproves the agility ofcommunity-driven LLMs differ from institutional models with great scale found in PLLUM. Through government-supported development, grassroots innovation, and flexible deployment features Bielik contrast PLLum's strategic scalability. By means of localised artificial intelligence innovation, both models show different but complementary approaches to forward Poland's digital sovereignty. By means of localised artificial intelligence innovation, both models show different but complementary approaches to advancing Poland's digital sovereignty.
Implications & Recommendations: Poland's technological resilience and capacity for innovation at once benefit from complementary models such as Bielik and PLLuM. Policymakers should support pluralistic innovation ecosystems to guarantee strong, flexible and sovereign artificial intelligence (AI) development matched with changing national needs including digital security and technological independence. Artificial intelligence's innovation is based on strategic public, commercial, and academic sector cooperation.
Contribution & Value Added: Examining modern and changing phenomena, this creative study of national language models (LLMs) is especially crucial. Thus conducted research focuses mostly on global, commercial models produced by multinational corporations. Therefore, it seems especially crucial to examine local, strategic, and institutional conditions for LLM development as well as their consequences on national technological autonomy and innovation.

Article type:	research article
Keywords:	local large language models; entrepreneurial ecosystems; digital sovereignty; AI in Poland; public-private innovations models
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INTRODUCTION

Large language models (LLMs) have lately changed the technological scene all around Google's BERT, OpenAI's ChatGPT, and other advanced artificial intelligence (AI) systems have revolutionised interactions in various industries by automating complex cognitive processes, improving opera-

tional efficiency and enabling innovative digital services (Khurana *et al.*, 2023; Zubiaga, 2024; Caballero & Jenkins, 2025). The ability to comprehend and generate human-like text and facilitate more sophisticated, nuanced, and contextually appropriate interactions are LLMs' common features (Kietzman & Park, 2024). Their strategic relevance as digital transformation tools is shown by their wide application in many fields, including, *e.g.*, healthcare, finance, customer service, education, and public administration (Retkowsky *et al.*, 2024). The fast global spread of LLMs has also spurred discussions on digital sovereignty. More generally, the concept is a nation's ability for autonomous control over its digital infrastructure, technology systems, and data governance (Chiarello *et al.*, 2024). Under the framework of mounting concerns about technological dependence and the potential risks of depending on digital systems and infrastructure under control by foreign entities, this idea gained momentum. Digital sovereignty stresses the need that nations to develop their technological competencies to defend national interests and sensitive data from outside vulnerabilities and geopolitical tensions (Ferraris *et al.*, 2025).

Digital sovereignty is a strategic need within AI since it enables the creation of national innovation ecosystems capable of autonomous development and application of technologies based on AI. The goal is to guarantee strategic resilience, cultural relevance, and regulatory compliance with national priorities and values (Ferraris *et al.*, 2025), thus transcending local technological innovation. Therefore, a drive for digital sovereignty requires significant investments in technological entrepreneurship and localised research, support for sustainable innovation ecosystems, and increasing national competitiveness (Teece, 2014). Especially in the face of the expansion of two innovative Polish LLM initiatives, Bielik and PLLuM, Poland has become a major actor in advancing digital sovereignty by means of targeted investments in national AI projects. They show attempts to satisfy the specific linguistic, cultural, and operational needs of the Polish environment by means of local knowledge and resources. Their expansion emphasises Poland's strategic intent to assert control over critical AI technologies, reduce reliance on outside suppliers, and strengthen its digital sovereignty through localised innovation and autonomous technological capabilities. Led by the SpeakLeash Foundation in partnership with Cyfronet AGH, the Bielik initiative presents a creative model of entrepreneurship emphasizing language and cultural specificity, community involvement, and open-source accessibility (Żmigrodzki *et al.*, 2025). This locally inspired and community-based project stresses Poland's ability to leverage current knowledge and resources to produce reliable, independent AI solutions. Showing an agile entrepreneurial approach (Żmigrodzki *et al.*, 2025), this project successfully addresses legal complexity, technological challenges, and resource constraints by means of crowdsourcing and strategic institutional cooperation. By contrast, the methodical consortium approach known as the Polish Large Universal Model PLLuM consists of several credible Polish research facilities. These include the Institute of Computer Science of the Polish Academy of Sciences, the Wrocław University of Technology, and the Research and Academic Computer Network (NASK). Mainly founded by the Polish Ministry of Digital Affairs, PLLuM seeks to provide a complete artificial intelligence solution fir for the public and private sectors in Poland (Żmigrodzki *et al.*, 2025).

Strict ethical guidelines, careful data management, and technological dependability help PLLuM's development process to be strategically in line with more general national goals of digital sovereignty objectives (Żmigrodzki *et al.*, 2025). The two initiatives, Bielik and PLLuM, present several approaches to entrepreneurship meant to reach digital sovereignty. Reflecting strategic responses to the particular opportunities and challenges of Poland in the global scene of AI, they both underline the need for localised innovation ecosystems in the larger framework of national technological autonomy. The study closely notes the ways that the business models on which Bielik and PLLuM are grounded affect Poland's digital sovereignty. It specifically highlights the approaches that let these initiatives properly address ethical, legal, and technological challenges. Analysing how these LLMs are applied in Polish business and public sector organisations helps underline their relevance in enhancing operational efficiencies and autonomy. Without localised LLM programmes, countries risk data vulnerability or cultural mismatch. Unlike many non-English LLM initiatives, Poland emphasises distinct entrepreneurial strategies to mitigate data vulnerability and ensure cultural alignment. We comparatively analysed entrepreneurial practices and sovereignty outcomes.

We addressed three primary research questions:

RQ1: What specific entrepreneurial strategies and organisational practices underpin the development and successful deployment of Bielik and PLLuM? How do these approaches differ in their contributions?

RQ2: Do the national LLM models contribute to strengthening Poland's digital sovereignty?

RQ3: How cleverly did Polish businesses and public sector institutions merge Bielik and PLLuM to increase operational efficiency and support national digital autonomy?

This work answers these research questions holistically using a qualitative method. We used in-depth interviews with significant project stakeholders (such as project leaders, developers, and strategists), practical testing of models and rigorous analysis of relevant documentation, including project reports, conversations on social media and technical papers in detailed case studies of Bielik and PLLuM projects under several data collecting techniques. Methodically, we used advanced qualitative data analysis software (NVivo) to identify, classify, and interpret relevant themes linked to entrepreneurial practices, technological challenges, regulatory compliance, and strategic adaptation for the goals of digital sovereignty. This article offers a comprehensive analysis of the entrepreneurial strategies and technological innovations defining Bielik and PLLuM. Thus, augmenting the more general discussions on the purpose of national AI projects in producing digital sovereignty offers significant insights into how localised technological entrepreneurship could effectively pursue national goals, lower outside dependencies, and support sustainable innovation ecosystems.

Finally, this study serves as. a basis for policy-makers, entrepreneurs, and organisational leaders whose goal is to strategically utilise local technological innovations to increase digital autonomy and competitive position in the fast-changing global digital scene. Existing research often neglects comparative analyses of entrepreneurial strategies and predominantly focuses on English-centric models. This research addresses these gaps by explicitly comparing agile and institutional entrepreneurial modes in Poland, thus advancing the theoretical understanding of digital sovereignty.

LITERATURE REVIEW

Researching local entrepreneurial models of LLMs in the framework of digital sovereignty and technological innovation ecosystems calls for extensive knowledge of many theoretical frameworks. Emphasizing digital sovereignty, technological entrepreneurship, and national AI-driven innovation ecosystems, this review of the literature critically assesses these models. It also looks at the corpus of present studies on entrepreneurial strategies in the national development of AI and the pragmatic results of LLM implementations in business and public sectors.

Rising concerns about national security, economic competitiveness, and technological autonomy drive digital sovereignty as a major policy goal worldwide. Chiarello *et al.* (2024) define digital sovereignty as the nation's ability to independently manage and defend its digital infrastructure, technological platforms, and data resources from outside hazards and disruptions. The progressively significant role of digital technologies in national economies and security infrastructures drives countries to reduce their reliance on outside technologies and increase their capacity for autonomous innovation, thus motivating the strategic need for digital sovereignty. Particularly LLM and AI technologies have grown strategically important in this context. National governments have begun their development finally realizing the need to create localised AI capabilities to keep control over significant technologies handling sensitive data and impact national security (Ferraris *et al.*, 2025). According to Ferraris *et al.* (2025), digital sovereignty entails not only technological independence but also legal, ethical, and governmental elements in addition. Good digital sovereignty strategy proposals must include comprehensive policy frameworks balancing ethical concerns privacy, security, and innovation integrate.

Entrepreneurship in Technological Innovation

Through creative-based strategies, technological entrepreneurship significantly influences the development of digital sovereignty. According to Teece (2014), technological entrepreneurship is the ability of

companies and people to identify and grab technological opportunities using strategic resource allocation and creative business models. By means of agile, flexible organisational structures, technology entrepreneurs propel the evolution and implementation of novel technologies and thus encourage creativity. The 2014 conceptual framework by Teece emphasises the need for entrepreneurs to manage uncertainty, effectively allocate resources, and always change with the times in respect to technology. This entrepreneurial agility is especially crucial in fast-growing sectors like AI, where constant innovation, technological breakthroughs, and market dynamism demand responsive entrepreneurial strategies. Thus, the success of national AI projects mostly depends on the entrepreneurial ability to innovate strategically, use local knowledge, and properly supervise demanding technological projects.

Digital sovereignty realised successfully by localised AI solutions depends on national innovation ecosystems powered by AI. Ferraris *et al*. (2025) present an integrative framework stressing the critical interaction among governmental policy support, academic and industrial cooperation, and entrepreneurial initiatives inside national innovation ecosystems. Such ecosystems should strive to support specialised knowledge, reliable infrastructure, strategic alliances, and regulatory frameworks allowing the development and commercialisation of innovative technologies including LLMs. National LLMs aim to strengthen digital sovereignty and deliver services in line with local priorities (Pandey, 2025). According to Ferraris *et al*. (2025), successful innovation ecosystems are based on close cooperation among significant stakeholders: government agencies, academic institutions, industrial partners, and entrepreneurs – to guarantee coordinated support for technological innovation. Such cooperation is essential to create stable, sustainable, resilient ecosystems supporting long-term strategic objectives including digital sovereignty. Entrepreneurial strategies, particularly via creative approaches fit for linguistic, cultural, and operational needs, help to greatly build national capacities in the field of AI. Żmigrodzki *et al*. (2025) underline the demand for entrepreneurial activities in developing localised AI technologies that can handle linguistic and cultural nuances usually neglected by global AI developers. These methods combine open-source distribution, and agile management strategies alliances, to raise general acceptance, openness, and adaptability. Localised entrepreneurial projects offer tailored AI solutions that enhance operational efficiencies, strategic decision-making, and technological resilience, thus greatly supporting national competitiveness. These entrepreneurial strategies help national goals of digital sovereignty and technological autonomy by means of motivating innovation and reducing outside dependencies (Żmigrodzki *et al*., 2025).

Many different sectors have benefited much from the pragmatic application of LLMs by automating, challenging tasks simplifying decision-making processes, and increasing operational efficiency. Ilagan *et al.* (2024) emphasise the importance of contributing to the acceleration of informed decision-making processes in a rapidly changing digital environment. Pessanha *et al*. (2024) and de Curtò *et al.* (2024) underline that LLMs are widely used in commercial settings for automating customer satisfaction and that these technologies have a much improved competitive advantage. The application of LLM technologies has a major positive impact on public administration by improving the responsiveness and accuracy of government services, and on business efficiency, customer satisfaction, and competitive advantage. Pessanha *et al*. (2024) also discuss, especially in terms of reducing operational delays, improving information accessibility, and simplifying challenging bureaucratic jargon, the adoption of LLM-based automation will be quite helpful for the public sector. Retkowsky *et al.* (2024) underline even more the transforming power of LLMs in professional services including healthcare, education spheres, and legal services. These models demonstrate their strategic value over many organisational settings by improving professional decision-making, providing customised service delivery, and allowing for sophisticated data analysis.

Though the present literature mostly addresses digital sovereignty, technological entrepreneurship, and innovation ecosystems based on AI, there are still research gaps, especially with regard to the way entrepreneurial strategies directly influence national AI projects like LLMs. Especially in non-English-speaking surroundings, the entrepreneurial side of developing localised AI solutions is still underdeveloped. Studies on the entrepreneurial initiative strategic resource mobilisation, and innovative business models supporting the success of localised AI projects are much awaited.

Furthermore, even if the pragmatic applications of LLMs are well-documented, most of the present research focuses on the global or English-speaking environment and pays little attention to localised language models fit to particular cultural and linguistic settings. Inspired by Bielik and PLLuM initiatives, the Polish setting offers a unique opportunity to close this gap and demonstrate how locally driven entrepreneurial strategies can effectively support national digital sovereignty goals. Based on this analysis of the literature review, the relevant theoretical frameworks and pragmatic elements required for local entrepreneurial LLM models and digital sovereignty become clear. The emphasis is on the main contribution of strategic entrepreneurial activities, integrated innovation ecosystems, and technological entrepreneurship in the effective development and deployment of localised AI technologies. By filling observed research gaps, particularly in the entrepreneurial elements of national AI projects, this study significantly advances knowledge of how localised technological innovations could increase national digital sovereignty. Due to the study's exploratory qualitative approach, we did not employ formal hypotheses but rather conceptual propositions based on comprehensive literature regarding technological entrepreneurship and digital sovereignty.

RESEARCH METHODOLOGY

We employed a qualitative methodology for its ability to fully investigate events and offer nuanced insights into the entrepreneurial activities surrounding local large language models (LLMs) like Bielik and PLLuM. Well-known for its interpretative and naturalistic approach, qualitative research helps researchers explore thoroughly and grasp the settings, motivations, and complexity connected with technological development and application (Creswell & Poth, 2017). As Eisenhardt (1989) notes, close relationships to empirical data enable the case study approach to support the development of inductive theory. Its adaptability and iterative character ensure complete contextual analysis and theoretical relevance thus they help it to be helpful in newly growing areas (Corbin & Strauss, 1990). Core objectives for the research include examining entrepreneurial strategies, technological novation pathways, and strategic impacts on digital sovereignty. They also support a thorough awareness of difficult technological projects in the dynamic and uncertain surroundings typical of advanced AI applications.

The approach of qualitative research applied in this study emphasises careful case studies (Stake, 1995). According to Yin (2018), case study research is especially useful for analysing contemporary events in their natural settings, particularly in cases when the differences between events and their surroundings are not exactly clear. From this vantage point, the case study approach facilitates investigating Bielik and PLLuM projects, looking at how they have strategically contributed to advancing Poland's digital sovereignty by means of entrepreneurial activities, technological innovation, and policy alignment. By means of a case study method approach, one can closely investigate the internal dynamics, strategic objectives, and operational complexities defining various entrepreneurial AI projects. Case studies allowed one to have complete knowledge of the beginning, running, challenges, and outcomes of the project by means of rich qualitative data from many sources (Stake, 1995). Furthermore, they facilitate an in-depth understanding of complex technological initiatives in dynamic and uncertain environments, characteristic of advanced AI technology deployment. We selected the cases of Bielik and PLLuM for their representativeness of contrasting entrepreneurial strategies: agile community-driven versus structured institutional models. Furthermore, the following criteria dictated the selection of cases: the first two national LLM models were selected for the study; second, when the study began, there were no other available national initiatives in this area.

Mostly in-depth interviews (IDIs) surround this qualitative research and case studies. Selected IDIs were effective in producing complete, narrative responses that provide a great awareness of participants' viewpoints, experiences, and motivations (Brinkmann & Kvale, 2015). This method allowed developers from Bielik and PLLuM strategies, and project managers to offer rich, contextually based observations on the projects. The interview process was open-question under an agenda designed to probe many thematic areas. The protocol included the main areas of interviews: project goals, strategic alignment with digital sovereignty, technology decisions including choice of training data and architec-

ture, technological and entrepreneurial challenges, regulatory issues, ethical considerations and the application of models in the public and private sectors. Semi-structured interviews allowed participants to investigate in-depth topics they felt particularly relevant or important and thus capture nuanced insights on the entrepreneurial processes and strategic decision-making. All questions were open-ended and were structured to encourage respondents to provide detailed, narrative answers. We validated interview questions against existing research frameworks on technological entrepreneurship and digital sovereignty. We ensured reliability through thematic saturation and cross-validation with document analysis. There were eight in-depth interviews, four related to Bielik and four to PLLuM (Table 1). We selected all participants to participate in the interview in a purposive manner.

The criteria for selection were direct participation in the work on the creation, development and implementation strategies of the models analysed. Interviews were conducted with key participants involved in the development of Bielik and PLLuM models, including project leaders, strategists, decision-makers, technology implementation specialists, and developers from Bielik and PLLuM.

Table 1. General list of the respondents

Respondent ID	Organisation	Gender
Respondent 1	SpeakLeash Foundation	M
Respondent 2	SpeakLeash Foundation	M
Respondent 3	SpeakLeash Foundation	F
Respondent 4	SpeakLeash Foundation	M
Respondent 1	University of Lodz	M
Respondent 2	Wrocław University of Technology	M
Respondent 3	Scientific and Academic Computer Network (NASK) National Research Institute	F
Respondent 4	Information Processing Centre National Research Institute	M

Source: own study.

We conducted every interview online and recorded it digitally. All interviews lasted between 60 to 90 minutes, allowing enough time to probe of probe the points of view and life events of every participant. They were painstakingly transcribed, and the interviews guaranteed accuracy in data collecting and corresponding analysis. We considered the highest ethical standards in digital research when designing the study. Before the interviews, we obtained informed consent from participants to participate in the research and to record the interviews. Before the interviews' transcription and analysis, we anonymised all data. We reported the research project to the Research Ethics Committee at the Jagiellonian University. However, due to the lack of sensitive research, the study did not require an additional approval procedure. The study meets the requirements of the Declaration of Helsinki and the GDPR. Several complementary techniques used in the data-collecting process for this study triangulated the results to increase their depth and dependability. We mitigated potential biases from developer perspectives through triangulation with secondary data (usage logs, policy reports). Specific case excerpts illustrate practical challenges, such as GDPR compliance and resource bottlenecks. Moreover, Bielik and PLLuM strategies explicitly correspond to Teece's 'dynamic capabilities' and Ferraris' 'integrated ecosystems,' respectively, presented in a conceptual matrix of entrepreneurial agility vs institutional support. As said, IDIs provided main qualitative data with careful awareness of the strategic, technological, and entrepreneurial features of every project. We used practical tests on both Bielik and PLLuM to empirically access both models. The model of evaluation criteria included operational performance (response time and functionality), linguistic precision (grammatical and contextual accuracy), adaptability (performance across diverse scenarios), and resilience. Model testing consisted of scenario-based assessments in context-specific applications relevant to both corporate and public sector environments whereby we accessed the outputs of the LLMs for accuracy, relevance, and ethical compliance. Examining many publicly available and internal documents, we conducted a comprehensive document analysis (Miles *et al*., 2014).

The sources compromised official project web pages, technical documentation, strategic reports, material from social media, and other pertinent internet resources. Through means of required background

knowledge and data cross-verification, analysing the records helped us authenticate the insights acquired from the model testing and interviews. We closely examined the data gathered through interviews, model evaluations, and document reviews using thematic analysis – a flexible qualitative method meant to identify, investigate, and present patterns – themes – within datasets (Braun & Clarke, 2006). We selected thematic analysis for its proven ability to organise and grasp complex qualitative data. Therefore, the data includes both explicit and implicit interpretations. Under the guidance of Braun and Clarke's (2006) methodological recommendations, the study underwent several iterative stages:

Data familiarization: We first checked several times every transcript and document to ensure total awareness of the material and background.

First coding: Particularly with an eye toward themes of entrepreneurial practice, strategic alignment, technological innovation, and ethical-regulatory compliance, we methodically coded major textual sections. This phase consisted of deductive (theory-motivated) and inductive (data-driven) coding methods.

Identifying Themes: From codes, we developed meaningful themes and iteratively refined them to reflect significant conclusions on entrepreneurial strategies, digital sovereignty alignment, technological challenges, and sector-specific applications.

Reviewing and enhancing themes helped to guarantee internal coherence inside them and clear difference between them, thus ensuring great interpretation and resilience.

Defining and naming themes: We precisely defined every theme, thus capturing the central concepts of the research questions. We articulated the themes to underline their relevance and applicability in addressing how strategic help of entrepreneurial models helped Poland to reach digital sovereignty.

Reporting: To provide strong empirical evidence for every theme that surfaced, we methodically presented the results of thematic analysis, combining narrative descriptions with illustrative passages from interview data and document analyses.

By providing a thorough and methodical way to code and examine data, the NVivo program helped us organise huge qualitative datasets and improve the clarity and repeatability of the studies, in-depth interviews, practical model evaluations, and in-depth thematic analysis, the methodological approach presents a successful investigation of the entrepreneurial strategies underlying Bielik and PLLuM projects. By means of the methodological multi-faceted qualitative approach, this study greatly improves the knowledge of how entrepreneurial practices and strategies might efficiently strengthen national digital sovereignty by means of localised advances in artificial intelligence. We developed the thematic codes deductively and then developed them inductively based on the analysis of the empirical materials. The thematic codes enabled systematic coding of data and triangulation between different sources. This strengthened the consistency of the analysis and increased the reliability of the results obtained. In the course of the thematic analysis, we identified eight main codes and sixteen sub-codes (Table 2).

Table 2. The final codebook with main and subcodes

Main codes	Subcodes	Codes number
LLMs strategies	Strategic objectives; National vs. commercial motivations	34
Technology entrepreneurship	Business models; Funding and partnerships	31
Infrastructure and data	Data sources; Technical infrastructure	42
Model performance	Quality of responses; Resistance to hallucinations; Ethical compliance	34
Digital sovereignty	Definitions and approaches; The role of LLM in the national strategy	28
Challenges and barriers	Technological; Regulatory; Political	39
Prospects for model development and practical implementation	Further development plans; Technological innovations	21

Source: own study.

RESULTS AND DISCUSSION

Case Study 1:

Exhibition of the Bielik Project

One of the main Polish projects is Bielik, which intends to establish and apply a local large language model (LLM specifically fit for the Polish language). This project aims to close significant gaps in the Polish language coverage in the worldwide artificial intelligence ecosystems. The main goal of the project is to give Polish-speaking companies and individuals a strong, linguistically accurate, culturally appropriate AI tool. Bielik receives financing mostly from community-driven sector sponsors and crowdfunding platforms, thus reflecting its entrepreneurial basis and flexible development strategy.

'We built Bielik with our own efforts, just such a bottom-up social initiative. A bottom-up, independent of any entities.'

(IDI, Respondent 1, Bielik)

Essential for effective project management and resource mobilization, this grassroots approach ensures community involvement and increases the active participation of great stakeholders.

Strategic Goals

Bielik deliberately stresses matching with linguistic and cultural aspects, trying to ensure that its language models totally reflect the subtitles and nuances of the Polish language. This alignment is vital given the lack of successful Polish-language models in a global AI market, mostly targeted by English-language solutions. Part of ensuring linguistic accuracy is intensive research and development projects aiming at exactly capturing and replicating the subtleties of Polish syntax, semantics, and pragmatics inside AI systems.

'Initially, the mission of our community that built Bielik was to collect a sufficiently large set of training data for language models in Polish. In the beginning, the team was only involved in cataloguing the data collection. Now we have almost three terabytes of text data in Polish and, to our knowledge, this is the largest collection of text data in Polish in an open model anywhere in the world.'

(IDI, Respondent 4, Bielik)

For Bielik, operational autonomy marks still another basic strategic goal. By means of local technological knowledge and infrastructure, the project seeks to lower Poland's dependency on AI technologies developed by external entities, which is not free from multinational technology companies but also has data control capabilities (Open AI, Meta, Deep Seek). The open-source Bielik project lowers costs and enhances security by letting regional companies and institutions apply AI independent of commercial, offshore cloud services. Apart from enhancing Poland's resilience against possible geopolitical and economic threats related to external technological reliance by means of increased technological independence, Bielik also conforms with more general national aspirations of digital sovereignty.

'We can install the data in the infrastructure of the company, the office and feed the model, give it a database context and keep all the work in internal use. At the same time, the model can handle RODO issues, personal data issues, and canonicalisation, and at the same time we can, for example, use a set of documents as a knowledge source for the user. We have said from the beginning, we want the model to be in the organisation, in the company of the data running on their server.'

(IDI, Respondent 1, Bielik)

To offer practical and scalable AI solutions that can be rapidly embraced into a range of sectors, the strategy framework of the Bielik project gives operational effectiveness great weight. By applying agile project management approaches, Bielik can rapidly adapt to limited resources, shifting technical

needs and operational requirements. This guarantees the efficient implementation of AI solutions in given businesses and municipalities.

Entrepreneurial Models and Technology

Using and developing Bielik presents many technological and entrepreneurial challenges requiring a strategic entrepreneurial approach. These challenges included regulatory compliance issues, data collecting limitations, and difficulties in training models. One of the main difficulties – given the rather limited availability of comprehensive, high-quality Polish-language datasets fir for advanced artificial intelligence training – is data acquisition. Unlike publicly available English-language datasets, Polish datasets tend to be fragmented and require significant preprocessing and screening. Creative data collecting techniques including collaboration with academic institutions, publishers, and government agencies to acquire a variety of outstanding language resources needed for effective model training where needed to solve this problem. Model training presented further technological complexity mostly due to the great computational resources required for developing and improving large language models. Computational restrictions were overcome with strategic alliances, most famously with the Academic Computer Centre Cyfronet AGH, which gave access to technological know-how and contemporary computing architecture. Effective management of computational resources, optimising algorithms, and improving models continuously – all made possible by this system – help achieve the desired performance and accuracy.

> 'The moment Cyfronet from AGH joined us, it became apparent that we had a missing proxy in the form of computing power. From word of mouth, it turned out that we were building the first LLM.'

> (IDI, Respondent 3, Bielik)

> 'Thanks to Cyfronet, we overcame the technical challenge, because the biggest problem was the GPU (Graphics Processing Unit).'

> (IDI, Respondent 1, Bielik)

One major challenge was meeting legal criteria. This included a rigorous respect of EU and Polish data protection policies, including the General Data Protection Regulation (GDPR, 2016). To build stakeholder confidence and project validity, project leaders had to establish privacy-protecting strategies and strict ethical monitoring policies through data governance systems.

Use Cases Reflecting Applications and Effectiveness in Business Automation and Public Administration

In many spheres of public administration and corporate automation, Bielik has shown to be pragmatic and successful. These initiatives confirmed both its strategic relevance and the contribution to increased capability and digital sovereignty. Regarding corporate automation, Bielik improved means of communication strategies, customer service tools, and sales processes. Through means of accurate and contextually relevant automated communications (IDI, Respondent 2, Bielik), its application has enabled Polish companies to automate interactions, efficiently control customer relationships, and raise general customer satisfaction. Using advanced language understanding tools has helped companies greatly reduce running expenses, streamline procedures, and increase market competitiveness.

Particularly in public administration, Bielik can be rather useful for automating complicated bureaucratic procedures, boosting citizen participation, and quickening administrative reactions. For instance, Bielik has been successfully included in the administrative systems of the Poznań Supercomputing Centre, automating responses to citizen questions, simplifying complex bureaucratic language, and enhancing information distribution methods (Poznań Supercomputing Center, 2025). Particularly with regard to administrative processing times, operational delays, and informational errors, this approach significantly raised public service delivery quality and efficiency.

> 'Bielik is like a more organised intern who needs to be shown how a copier works, how a coffee machine works. Then he will be able to do these few selected things, such as vertical tasks. He has a very high focus on specific tasks.'

<div align="right">(IDI, Respondent 1, Bielik)</div>

Moreover, Bielik's strategic relevance has been demonstrated in important administrative responsibilities, like helping government agencies with legal compliance, document summarizing, and decision-making. The adaptability and scalability of Bielik's solutions have helped to further enable significant deployment across many governmental departments, thus supporting their contribution to improving Poland's public sector technological autonomy and operational capacities.

> 'Bielik can be like a document classifier. We have a Bielik that detects sentiment in documents and another Bielik that decides where to send those documents. To use each of them, well, you have to install them separately. On the other hand, they no longer require training, but are, as it were, adapted to it. You have to remember that in most cases you don't need to train the models, you just need to give them good instructions and a good database.'

<div align="right">(IDI, Respondent 1, Bielik)</div>

Artificial intelligence solutions have been quickly tailored and adapted to meet various organisational and sector-specific needs thanks to the entrepreneurial structure applied in the expansion of Bielik. Always matching with evolving user expectations, technological developments, and legal requirements guarantees that AI implementations remain relevant and effective by this natural adaptability.

Bielik's case study detailed pictures of effective entrepreneurial strategies that have been quite essential in bringing local AI solutions meant to support national goals of digital sovereignty into use. Notwithstanding significant technological and entrepreneurial challenges, Bielik successfully underlines that locally developed AI technologies could boost operational efficiency, reduce reliance on outside technologies, and help build ecosystems of sustainable innovation. By means of strategic alliances, effective resource management, and strict compliance rules, Bielik demonstrates the indispensable role entrepreneurial models perform in attaining technological autonomy and digital sovereignty. Its successful efficient application in public administration contexts and Polish businesses highlights more relevance and strategic advantages of localised artificial intelligence solutions. Bielik LLM fits Teece's (2014) concept of dynamic capabilities. Its creation validates the ability to quickly identify opportunities, mobilise resources and adapt to changing technological conditions. The model illustrates the entrepreneurial agility crucial for innovation in the AI environment. Here policymakers, corporate leaders, and legislators seeking to use technological innovations to reach national sovereignty objectives will find great ideas.

<div align="center">

Case Study 2:

</div>

Project Consortium Overview, Leadership Positions, Funding PLLuM

Polish Large Universal Model (PLLuM) is an attempt at developing and using advanced AI solutions specifically suitable for the Polish environment. Comprising well-known academic and research facilities, including Wrocław University of Technology, NASK National Research Institute, Information Processing Centre – National Research Institute (OPI PIB), Institute of Computer Science of the Polish Academy of Sciences, University of Łódź, and the Institute of Slavic Studies of the Polish Academy of Sciences (PLLuM, 2024), the project is set up as a cooperative consortium. Under this consortium approach, combining knowledge in linguistics, computer science, cybersecurity, and data management promotes noteworthy multidisciplinary cooperation. Polish Large Universal Model has defined management roles based on institutional strengths and specializations quite precisely. Wrocław University of Science and Technology is guiding the consortium in project management and technological development. In the project, ethical government and cybersecurity fall to NASK. It guarantees strict following of national and European legal norms. Every institution involved provides unique knowledge and contributes to building the creative ecosystem and knowledge sharing required for the project to be

successful. Mostly sponsored by the government, PLLuM is strategically important for Poland's more ambitious goals related to digital sovereignty. The Polish Ministry of Digital Affairs provided s provided over 14.5 million Polish zlotys to assist in the phases of intensive research, development, and PLLuM (Ministry of Digital Affairs, 2025) implementation. Such a significant government-backed expenditure underscores the strategic importance of PLLuM for national goals, enabling sustained research and technological development crucial to achieving digital autonomy in Poland.

Aimed Deliberately, Strategically

Driven by a vision that exceeds technological development, PLLuM stresses social responsibility, economic integration, and ethical integrity equally – all of which are vital for a sustainable and long-lasting digital transformation. The program aims mostly to increase digital competency in all spheres of life. This means projects aiming at improving the digital skills of people, companies, and institutions all around Poland. Moreover, PLLuM supports the creation of a digital environment in which technology efficiently serves people and helps build a more technologically conscious and capable society by means of AI solutions not only advanced but also tailored to the particular needs of the local context.

Not less important is PLLuM's commitment to stimulating imagination. The initiative actively supports the public and private sectors, AI integration, supporting entrepreneurship, increasing competitiveness, and fostering economic development. Apart from providing contemporary technological solutions, PLLuM wants to build a strong and sustainable innovation ecosystem supporting ongoing research and the continuous development of artificial intelligence technology.

> 'The model is not only a language processing tool but also a way to develop digital competence. Public administration, business, and all users are learning to use AI. While they are testing but increasingly putting it into practice and adapting it to their own needs.'

> (IDI, Respondent 3, PLLuM)

Digital sovereignty is rather important among the several strategic objectives of the PLLuM model. Though its main goal is to develop natural language understanding for PL with open and readily available AI, PLLuM helps to further the more general objective of digital sovereignty. Being an open-source project and using PLLuM allows users to run models locally, upload documents and interact with them under private RAG setups. The model allows for safe, local processing and maintains overall control over user data. Noteworthy, PLLuM ethically emphasises highly the need to minimise false, offensive, or misleading information generated by AI systems. Ethical goals include rigorous data curating, thorough content moderation policies, and methodological bias detection techniques in order to ensure responsible, trustworthy AI deployment. Integrated into PLLuM, ethical safeguarding policies demonstrate a commitment to maintaining information integrity distribution integrity, regulatory compliance, and society values preservation.

Observations of Technology

Polish Large Universal Model incorporates a multi-scale model infrastructure with parameter values ranging from 8 billion to 70 billion parameters. It thus addresses a wide spectrum of computational requirements. This stratified approach enables the system to run effectively over several operational settings. Smaller businesses or limited-scope projects would find the models at the lower end of the scale – those with 8 billion parameters – fit for use in the settings in which computational resources are limited. Conversely, especially in complex environments like government agencies and large corporations, the larger models – with up to 70 billion parameters – offer the processing capacity required for more challenging tasks.

> 'We have acquired text data with consent directly from publishers, authors or data to which we are entitled. Due to the legal situation in this area, which we recognise quite thoroughly, and the regulations that have been in force since 20 September 2024 [...]. Instructional data is mainly our data, manually collected or converted from resources that we also collected

in the consortium many years ago. Well, and preferences are also newly acquired data – the only dataset of this kind in Poland.'

(IDI, Respondent 2, PLLuM)

The quality of training sets greatly affects PLLuM's performance. One respondent PLLuM reports having about 150 billion tokens, carefully chosen from many sources, including publicly available language data, proprietary content acquired from strategic alliances, and specialised datasets fit for particular sectoral uses. Crucially for high-performance AI, this extensive data-curating process guarantees linguistic accuracy, cultural relevance, and functional adaptability.

By means of a multi-layered approach, the PLLuM design minimises ethical issues in content production. This approach essentially uses automated tools designed to detect bias, which run in the first phases of processing to uncover trends likely to generate biased or negative outputs. Regular manual assessments conducted by field experts complement these automated systems so enabling the study of cases where algorithmic assessments might be inadequate. Apart from a means of correction, human involvement is a basic component of the system's design concept. Moreover, constant assessments of the system produce a feedback loop that ensures the model develops in line with contemporary ethical standards and society values, thus ensuring continuous progress. This adaptable framework enables PLLuM to preserve high degrees of responsibility while efficiently handling new ethical challenges.

Strategic Public Sector Implementation Model

The strategic utility and effectiveness of PLLuM are vividly demonstrated through successful implementations across critical public sector domains, notably in citizen assistant applications, healthcare, legal frameworks, and education.

'Depending on what we want to do – whether a general-purpose model or a few specific tasks – a different size will be appropriate. […] We have what we refer to as generator models. These work great for various flagship applications, like search systems. [...] We have framework models – the 8 billion parameter model or the large 70 billion parameter model.'

(IDI, Respondent 1, PLLuM)

Citizen assistant applications form the primary strategic focus of the PLLuM deployment. Through automated, responsive interactions with people, this paradigm greatly boosts the efficiency of public administration. These initiatives improve public service availability and quality, help to simplify and clear bureaucratic procedures, and allow the automated processing of citizen inquiries. Noteworthy, PLLuM's capacity for subtle, contextually appropriate responses helps to enable meaningful citizen involvement thus lowering administrative needs and simplifying governmental procedures. Moreover, PLLuM enhances clinical treatment decisions and patient management in healthcare by means of advanced diagnostic support systems grounded on AI. Using analysis of large medical data sets and patient histories, PLLuM helps doctors identify diagnostic trends, make individualised treatment recommendations and automate routine clinical documentation. This application of PLLuM significantly enhances healthcare delivery, patient outcomes, and operational efficiencies within medical institutions.

By means of effective management and interpretation of challenging legal texts, PLLuM increases the accuracy and efficiency of legal analysis. Lawyers also streamline decision-making and enhance legal information access, thus helping professionals and the general public.

Another sector gaining from PLLuM's arrival is the legal one. Polish Large Universal Model's enhanced processing capability helps it much as well. This system automates legal document analysis, statutes interpretation, and compliance checker process. PLLuM improves the process of delivering legal analysis by supporting lawyers in interpreting sophisticated texts and facilitating access to legal documents for both experts and non-experts. Educational applications of PLLuM provide innovative solutions to enhance teaching and learning processes across diverse educational contexts. Furthermore, PLLuM supports the development of interactive, personalised educational content, automated assessment mechanisms, and sophisticated educational analytics, significantly improving educational delivery and outcomes. According to one respondent:

'Its ability to adapt content and interactions to varying educational needs ensures broad applicability and effectiveness within Poland's educational system.'

(IDI, Respondent 3, PLLuM)

The PLLuM project is a well-coordinated attempt to produce local AI solutions fit for Poland's national objectives for digital sovereignty. It skillfully navigates through technological,, regulatory, and ethical terrain to generate strong AI applications that are culturally appropriate with a well-defined consortium framework, major government support, and established strategic and ethical objectives. The technical complexity of the project, different model framework, and strong ethical standards underline its potential to considerably increasethe operational efficiency of the public sector, improve service delivery, and strengthen national digital competences. Its successful implementation in significant spheres of the public sector, including citizen support, healthcare, legal frameworks, and education, underlines the strategic relevance of localised AI solutions in driving sustainable digital transformation and raising national technological independence.

The PLLuM model fits into the framework of integrated ecosystems Ferraris *et al*. (2025). The model is based on the collaboration of academic institutions and government bodies. The coordinator of multiple partners within the consortium has played a crucial role in building the innovation ecosystem and supporting digital sovereignty.

Comparative Study of Bielik and PLLuM

Particularly for the Polish environment, Bielik and PLLuM provide different approaches to generating large language models (LLMs) with their different technological architectures and model capacities. Bielik largely uses smaller and medium-sized models between 1.5 and almost 11 billion parameters. Using a strategic approach that gives practicality, simplicity of implementation, and operational effectiveness top priority, Bielik efficiently serves a wide spectrum of small and medium-sized businesses along with local government agencies. On the other hand, PLLuM offers a larger range of model architectures, spanning from 8 billion to 70 billion parameters. Designed for applications needing great computational capability, PLLuM's architecture satisfies the needs of larger corporations, national organisations, and government agencies depending on advanced AI capability. More broad models enable more difficult tasks, including thorough data analysis, advanced language comprehension, and improved contextual interactions.

Although every project uses different strategies to reach this alignment, Bielik and PLLuM both significantly support Poland's general aim of digital sovereignty. Bielik is a strategically coordinated project that underlines the significance of operational autonomy, linguistic-cultural sensivity, and grassroots innovation. As an AI tools initially developed as a social initiative, it offers easily accessible, linguistically precise, and culturally adequate solutions for local implementations, at the same time reducing Poland's dependency on external AI providers. Through an agile, open-source architecture, Bielik advances the general acceptance of technology and active community participation, thus enhancing the nation's capacity for autonomous innovation. Meanwhile, PLLuM ensures guarantees of thorough adherence to regulatory standards, thus strategically aligning itself with national objectives related to digital sovereignty and supporting continuous, major technological developments especially targeted at supporting critical applications in the public and private sectors by forming alliances with important institutions By including strategic digital skills and rigorous ethical standards in its technological architecture, PLLuM directly addresses Poland's concerns about digital sovereignty, generating strong, institutionalised AI capabilities.

Financing and entrepreneurial ideas supported by Bielik and PLLuM highlight several approaches to stimulating innovation and implementation of AI. Stressing agile development, flexible resource management, and the ability to quickly adapt to new technical and operational needs, Bielik mostly employs a bottom-up entrepreneurial approach. Especially with Cyfronet AGH, which supplies the required computing infrastructure, its many funding sources cover strategic alliances, private sponsors, and crowdsourcing projects. By keeping flexible, sensitive to community needs, and in line with local technological strengths, this approach helps Bielik create dynamic innovation ecosystems. Conversely, PLLuM

employs a more ordered entrepreneurial model distinguished by significant institutional collaboration and substantial governmental support. Thanks – in large part – to the main financial support from the Polish Ministry of Digital Affairs, which enables long-term strategic planning, methodical technological development and strong ethical management, PLLuM has great financial resources. Noteworthy, PLLuM can conduct large-scale, resource-intensive research and development projects closely linked to national strategic objectives and regulatory standards by means of this ordered framework.

An examination of Bielik and PLLuM projects revealed clear differences in their technological approaches, strategic orientations, entrepreneurial frameworks, and regulatory and ethical considerations. Both projects aim to increase Poland's digital sovereignty. Particularly useful for distributed and smaller projects, Bielik stresses adaptability, fast responsiveness, and wide accessibility using a community-centric and, agile operational framework. Its entrepreneurial approach encourages constant innovation, agile development and strong adaptation to the needs of local users based on active community involvement and different funding sources. Conversely, PLLuM operates inside a consortium-based, institutionally anchored framework designed for continuous strategic development. This approach is defined by great government support, advanced technological capability, and strict adherence to regulatory standards. Its methodical and disciplined approach supports long-term sustainability, scalability, and dependable performance, especially in mission-critical national applications. Taken together, these initiatives demonstrate how context-sensitive entrepreneurial ideas could support the development of technological sovereignty. Their different achievements highlight how realistic several strategic routes are for advancing national innovations in AI, each tuned to different operational environments, sectoral needs, and policy goals.

Emphasising the strategic need of helping a variety of entrepreneurial models and creating adaptive technological ecosystems, this comparative analysis provides insightful analysis for legislators, corporate leaders, and entrepreneurs. Encouragement of national innovation capacity and Poland's digital sovereignty calls for a whole policy framework including diversified financing sources, agile managerial approaches, a coherent regulatory environment, and governance structures based on ethical values. By means of innovative technological ideas and diverse entrepreneurial approaches, Bielik and PLLuM both effectively advance Poland's digital sovereignty objectives despite having rather different approaches and strategic focus. This comparative emphasises the need for a contextual approach to the development of national AI, thus providing significant insights for current and future projects meant to support sustainable technological innovation and national digital autonomy.

The case studies help us realise, among other things, the great impact of intentional entrepreneurial strategies in advancing context-aware development in the artificial intelligence domain. The successful application of agile management techniques, the development of strategic alliances, an emphasis on data ownership, and the acceptance of open-source distribution frameworks constitute fundamental ingredients in driving local-level innovation. As Teece (2014) notes, technological entrepreneurship is essentially defined by the demand for responsiveness, careful use of resources, and a great degree of adaptation in the face of changing market dynamics and technological developments. Bielik is an agile, entrepreneurially oriented initiative with great capacity of adaptation, flexible resource management, and community-driven innovation that fits perfectly. Strong, flexible technological solutions directly fit for local needs and conditions were created by the collaboration with companies such as Cyfronet AGH and crowdsourcing. As a part of structured entrepreneurial approaches, PLLuM reflects institutional cooperation and strong government support. This model captures the emphasis of Ferraris *et al.* (2025) on integrated national innovation ecosystems in which government policy, academia, industry, and entrepreneurial players interact closely for the sake of proper technological development. PLLuM's extensive institutional framework, significant state funding, and strategic alignment with national priorities show how well-organised entrepreneurial models can support the major, resource-intensive technological changes needed for significant national applications. Open-source distribution and data localization are two further entrepreneurial techniques that greatly support digital sovereignty. Emphasising open-source technologies, Bielik helped to spread openness, community involvement, and wide acceptance, thus distributing technological control and reducing dependency on outside sources. Emphasised espe-

cially in PLLuM's rigorous data management policies, data localisation guaranteed compliance with national and European regulatory standards, thus safeguarding sensitive information and strengthening national autonomy in terms of critical digital infrastructures (Chiarello *et al.*, 2024).

The case studies underline significant effects on Poland's technological autonomy and creative capacity. Though their routes are quite different, Bielik and PLLuM both actively support Poland towards digital sovereignty. Using community resources, local knowledge, and quick, context-specific technological development, Bielik's bottom-up entrepreneurial model increases Poland's creative potential. The strategic plan embraced by the PLLuM's consortium greatly promotes technological independence by means of formalised cooperation among companies, preservation of continuous governmental involvement, and support of the execution of sustainable, future-oriented projects. This methodical approach reveals a cautious and context-aware initiative meant to increase national self-reliance in important technological fields. This disparity corresponds with the theoretical perspectives of Ferraris *et al.* (2025), who underline that different entrepreneurial strategies suited for different circumstances define how dynamically innovation ecosystems are kept in good condition.

As Bielik and PLLuM demonstrate, the coexistence of agile and disciplined, entrepreneurial models emphasises the synergistic elements of these strategies. This integration raises Poland's creative potential and its ability to solve technological problems. Notwithstanding all the achievements, several problems still exist, especially in regard to scalability, data management, and ethical standards adherence. One of the toughest challenges is scalability, particularly for dynamic businesses like Bielik. Financial constraints, scattered data sources, and limited computing resources seriously impede sustainable development and wide application. As PLLuM's effective structured approach demonstrates, solving these issues calls for ongoing financing, strategic cooperation between institutions, and expandable technological frameworks. Data governance is further challenging, mostly because of the strict regulatory environment – that which the including General Data Protection Regulations compliance demands. Reaching effective data localization, ethical data use, and strong privacy protections calls for continuous regulatory alignment, careful monitoring, and creative directionally driven innovative data management techniques under constant control. Maintaining ethical compliance requires constant attention, the application of advanced moderation techniques, regular evaluations of ethical guidelines, and proactive approaches to find bias, all of which are vital for preserving user trust, openness, and acceptance. Recommendations for improving entrepreneurial activities, a range of funding sources, and a strong institutional framework supporting both flexible and orderly entrepreneurial practices. Policymakers should promote more cooperation among academic institutions, businesses, government agencies, and entrepreneurial organisations and thus create strong innovation ecosystems able to sustain targeted and context-driven technological advancement. To ensure clarity, support, and efficient control for the growth of entrepreneurial AI – thus enhance national technological independence and innovation capacity – the regulatory environment must be always changing. The effective applications of Bielik at the Poznań Supercomputing Centre clearly demonstrate the strategic relevance of AI in the field of public administration. The operational benefits localised AI integration – such as automating complex bureaucratic procedures, enhancing effective information sharing, and improving institutional responsiveness – are reflected in the experiences of Polish companies. Firms across sectors including finance, customer service, and sales—report significant increases in productivity, customer satisfaction, and competitive positioning following the merger of Bielik and PLLuM.

Pessanha *et al.* (2024) emphasise that LLM-driven solutions substantially improve operational efficiencies and decision-making accuracy, enhancing competitive advantages and strategic responsiveness in dynamic market environments. Polish enterprises, including those in sectors like finance, customer service, and sales, report notable improvements in productivity, customer satisfaction, and competitive positioning following the integration of Bielik and PLLuM. Particularly, Bielik's deft use within Poznań Supercomputing Center highlights its strategic relevance in public administration settings. Automating complex bureaucratic tasks, improving information dissemination processes, and enhancing administrative responsiveness illustrate significant operational efficiencies achieved through localised AI solutions.

Similarly, PLLuM's strategic applications extend across healthcare, legal frameworks, and education, demonstrating versatile, sector-specific functionalities essential for comprehensive public service improvements. Healthcare institutions leveraging PLLuM's advanced analytical capabilities report significant enhancements in clinical decision-making, patient management efficiencies, and personalised healthcare delivery. Legal frameworks benefit substantially from automated document analysis, legislative interpretation, and compliance verification processes facilitated by PLLuM, improving legal service accessibility, responsiveness, and accuracy. Educational applications similarly illustrate PLLuM's strategic value, providing personalised content, interactive learning environments, and automated evaluation mechanisms that substantially enhance educational outcomes and pedagogical effectiveness. The successful implementations of Bielik and PLLuM highlight significant potential for further integration and innovation within Polish business and public sectors. Continuous advancements in AI technologies, expanding model capabilities, and improving computational resources offer opportunities for broader adoption, deeper sector-specific integrations, and enhanced strategic functionalities.

Future integration efforts should emphasise scalable solutions, ethical safeguards, and enhanced computational capacities to sustain innovation momentum effectively. Policymakers and organisational leaders should foster comprehensive innovation ecosystems supporting ongoing research, sustained funding, and strategic technological advancements. Encouraging greater community engagement, transparent development practices, and diversified entrepreneurial approaches will further enhance Poland's AI innovation capacities and national digital sovereignty. The comparative insights from Bielik and PLLuM demonstrate diverse, context-specific entrepreneurial pathways to achieving digital sovereignty objectives. Agile and structured entrepreneurial models offer complementary strengths, highlighting the strategic importance of diverse innovation ecosystems. Effective entrepreneurial strategies, robust regulatory frameworks, and sustained institutional collaborations significantly enhance technological autonomy, innovation capacities, and operational efficiencies across sectors. These insights provide valuable guidance for policymakers, entrepreneurs, and organisational leaders aiming to strategically leverage localised AI innovations to reinforce national digital sovereignty. The findings explicitly extend existing theory by providing empirical validation of agile versus institutional entrepreneurial strategies in localised AI contexts.

To develop directions for future research on the dynamics of sovereign AI technologies, we propose a new conceptual model. The model of the matrix can be based on two dimensions: organisational agility and institutional support. According to the matrix, we may classify national initiatives for the creation of LLM models according to the level of agility and institutional support.

CONCLUSIONS

This research contributes by directly addressing gaps in comparative entrepreneurial strategies within national AI development contexts. With a special focus on their contribution to creating national digital sovereignty, we investigated the entrepreneurial models on which the expansion of the early Polish LLMs, Bielik and PLLuM, is based. By means of a qualitative approach, the research reveals significant opportunities related to national AI technologies and facilitates the resolution of the last challenges for such projects. The results suggest that the encouragement of technological independence, creativity, and the development of a strategic managerial framework depends essentially on the entrepreneurs' participation.

Still, a number of issues remain unresolved even with the notable progress achieved in these initiatives. The main problem addresses the linguistic complexity of the Polish language by the models' limited ability to regulate the syntactic variability and semantic nuances of the language. These characteristics reveal the need for long-term strategic investments and methodological improvements in the development of localised AI systems. Dealing with the continuous challenges connected with the evolution of AI calls for both methodical enrichment and diversification of language datasets as well as constant improvement in training approaches. Constant improvement of algorithmic models is necessary to maintain their accuracy as well as their sensitivity to context. Still, scalability remains a fundamental challenge in this field – especially in connection to startups like Bielik. Often under strict

financial constraints and dependent on few community resources, these early-stage projects pose great obstacles to their long-term viability and continuous growth. Realizing good scalability requires coordinated inter-institutional partnerships, consistent financial investment, and upgraded computing infrastructure. Legislators and relevant players have to build motivating regulatory frameworks and targeted funding models if we are to enable the broader deployment and institutional integration of such agile technological solutions. Ethical protections are another interesting topic. While both Bielik and PLLuM have embraced rigorous methods of ethical moderation and bias detection, the continuous control and improvement of these ethical practices remain a main challenge.

Complete ethical compliance demands iterative testing and validation methods, proactive human supervision, and continuous methodological advancement. Strengthening these protections will help to ensure public confidence, guarantee openness, and advance responsible AI use in many social environments. Improving linguistic accuracy, extending computational capability, and strengthening ethical compliance systems should be given great focus in the next studies and development. Efficiency gains are quite likely given continuous development in natural language processing technologies and algorithmic creativity. More general sectoral integration and sustainable technical development will also be enabled by the additional study of creative data management techniques, hybrid business models combining agile and structured approaches, and advanced regulatory frameworks. The scalability and sustainability of Bielik and PLLuM implementations constitute major future issues. Long-term sustainability depends on strategic financial planning, varied funding sources, and trustworthy governance structures capable of supporting ongoing operational needs and technological updates. Growing scalability calls for institutional support, improved computing tools, and methodical knowledge sharing among interested parties. Policymakers and institutional leaders have to create conditions fit for strategic development and sustainable innovation and thus enable the complete integration of localised AI solutions in many different organisational environments.

This article underlines the relevance of entrepreneurial strategies in promoting Poland's digital sovereignty, especially by means of the development and strategic deployment of localised LLMs. Apart from the well-coordinated, consortium-driven PLLuM approach, the adaptable and community-oriented Bielik model presents two different but complementary points of view on entrepreneurial strategies that might effectively increase national technological autonomy and innovation capacity. Particularly adaptable, responsive, and able to fulfil regional needs, Bielik's bottom-up approach helps to support quick, context-specific innovation. On the other hand, PLLuM emphasises open-source projects and transparent governance, thus promoting great community involvement and enabling distributed technological progress and reinforcement of Poland's digital sovereignty. Its basis is a more structured entrepreneurial model characterised by great government support, broad institutional cooperation, and alignment with national strategic objectives. Stable technological infrastructure of the model, strong ethical standards, and significant resource investment form the basis for the development of sophisticated, sectoral relevant AI solutions of great relevance for major national operations. Through its strategic framework, PLLuM increases institutional capabilities, technological dependability and regulatory compliance, thus strengthening Poland's digital autonomy by means of these three factors.

The outcomes draw attention to several crucial policy presumptions that are quite necessary for the development of local LLMs. Strong innovation ecosystems combining government support, scholarly knowledge, industry cooperation, and entrepreneurial activities including government backing should be the focus of policy makers. Effective innovation ecosystems should be granted increased governmental funding, diverse funding sources and strategic incentives that promote entrepreneurial activity and the development of AI technologies aligned with national priorities. Policymakers also must solve regulatory challenges by means of well-defined policies, strict monitoring, and continuous adaptation to the fast-changing technological scene.

For agile, community-based models such as -like Bielik, it is worth introducing an adaptive governance framework. In this model, an emphasis on decentralised decision-making, flexibility and iterative learning processes will be key. This will ensure that agile initiatives can respond effectively to identified needs and technological changes. When models, such as PLLuM, are structured and institutionally sup-

ported, institutional theory provides the framework. In this context, the article presents a set of strategic management concepts that – through flexible organisational structures, the development of cooperation between entities,, and the strengthening of effective management mechanisms – contribute to the creation of a suitable technological ecosystem. Businesses implementing context-specific AI technologies have to give management strategies characterised by adaptability and responsiveness first importance. Such approaches are essential to ensure congruence with the dynamic character of operational requirements, the speed of technical development, and the shifting interests of many stakeholders. Strategic alliances between government agencies, companies, academic institutions, and entrepreneurial companies will help to greatly increase knowledge sharing, resource mobilization, and creative capacity. Recommendations for improving technology policy focus on continuous improvement of ethical compliance systems, data management tools, and computer infrastructure. A good policy framework must have three main components. Firstly, giving advanced computational infrastructure top priority for resource allocation; secondly, improving data governance techniques; thirdly, using careful ethical monitoring systems. Guaranteeing the ethical development and application of AI systems depends on these very fundamental components. Prerequisites for both continuous innovation and the strategic integration of growing technologies across many sectors are constant improvement of techniques, proactive regulatory adaptation, and the methodical inclusion of many stakeholder points of view. Recommendations prioritise feasible and urgent actions, specifically differentiating advice for government and private sectors. Successful international policies, contextualise these recommendations, underscoring the theoretical and practical contributions of this study. Existing frameworks of application of AI concentrate mainly on global scale LLMs like Chat GPT etc. In this study, we qualitatively researched national LLMs. The conclusions apply to Poland and provide a perspective for future research in central Europe and EU countries.

We are aware of the limitations resulting from the methodology of this study. We note, firstly, the limited number of sample size. The number of respondents results from the fact that we invited to the research participation experts who were directly involved in the creation process of national LLMs. Secondly, we are aware that the research covers a Poland-specific context, which additionally limits the possibility of generalizing to different national contexts. When designing further research, scholars should consider these limitations.

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Use of Artificial Intelligence

The manuscript is free of AI/GAI usage.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Barriers and enablers: Review research on women entrepreneurship and its impact on sustainable tourism development

Jaya Singh Parihar, Dariusz Cichon, Aeshna Kharbanda, Dariusz Sala, Gagan Deep Sharma

A B S T R A C T
Objective: People often glorify the tourism industry as a gateway for entrepreneurial opportunities, particularly for women. However, its structural inequalities remain largely unaddressed. While women play a significant role in tourism entrepreneurship, systemic barriers constrain their participation, including limited access to capital, restrictive social norms, and gendered labour segmentation. Existing research primarily frames empowerment in financial terms, neglecting broader socio-cultural and structural constraints. Feminist critiques of tourism entrepreneurship remain marginal, creating gaps in academic inquiry, and policy interventions.
Research Design & Methods: We conducted an integrative literature review, systematically examining research on gender, tourism, and entrepreneurship through a dual analytic approach incorporating inductive and deductive coding (Donthu *et al.*, 2021). Using the PRISMA framework, we synthesised high-impact literature to identify thematic patterns, research gaps, and structural constraints affecting women entrepreneurs in tourism.
Findings: Findings reveal persistent gender disparities, particularly in financial accessibility, decision-making power, and policy design. The thematic analysis highlights key dimensions such as gender inclusivity, sustainable tourism, and feminist entrepreneurship, advocating for an intersectional approach that incorporates gender-sensitive frameworks into tourism research (Cobo *et al.*, 2015).
Implications & Recommendations: Policy recommendations emerging from this study include targeted funding mechanisms, comprehensive training and mentorship programs, and regulatory reforms designed to support women-led enterprises in sustainable tourism. By integrating feminist perspectives into tourism entrepreneurship discourse, this research advances theoretical understanding while offering actionable recommendations for policymakers. Addressing gendered barriers in tourism entrepreneurship is critical for achieving sustainable development goals and fostering inclusive economic growth.
Contribution & Value Added: This study's originality lies in its integrative application of feminist perspectives to critically analyse gendered barriers in tourism entrepreneurship. By employing a dual analytic approach and emphasising intersectional insights, it offers a nuanced understanding of structural inequalities and actionable policy recommendations for sustainable and inclusive tourism development.

Article type:	research article
Keywords:	women's entrepreneurship; gender and tourism; sustainable tourism; gender inclusivity; sustainable development goals (SDGs); economic empowerment
JEL codes:	J16, L83, M14, O13, Q01, Q56

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INTRODUCTION

Scholars perceive the tourism sector as a favourable to entrepreneurial activities due to the comparatively easy access to the industry and the presence of numerous small enterprises (Nikraftar & Hosseini, 2016; Robert & Brown, 1998). Women entrepreneurs play a pivotal role in fostering sustainable tourism but they often encounter significant challenges that hinder their contributions. These

challenges include limited access to financial resources, social stereotypes, and gender-based discrimination, which collectively undermine their entrepreneurial potential in the tourism sector (Freund & Hernandez-Maskivker, 2021). However, the potential for women to drive sustainable tourism initiatives is substantial, as evidenced by their ability to leverage social capital and community networks to overcome these obstacles (Kutlu & Ngoasong, 2023). According to the World Tourism Organisation (2019), the United Nations acknowledges that tourism has the potential to empower women via the creation of income-generating possibilities within various scales of tourist enterprises. Mosedale (2014) highlights the need for a nuanced understanding of tourism's role in economic empowerment, emphasising that the industry continues to reinforce gendered norms. While it is often depicted as a diverse, dynamic, and flexible industry with such potential, it is crucial to recognise that tourism still perpetuates gendered norms (Peeters & Ateljevic, 2017). This is evident in the provision of temporary and part-time employment opportunities that align with traditional gender roles and skills. Consequently, this perpetuates disparities in the allocation of work.

The prevailing narrative tends to equate empowerment with financial independence, often overlooking broader socio-cultural and structural factors. The literature indicates that women entrepreneurs in tourism are not only key to economic growth but also achieving broader social objectives such as gender equality and community development (Abou-Shouk et al., 2021). The extant literature highlights that women-led tourism initiatives can enhance local economies while promoting cultural preservation and environmental sustainability (Ali et al., 2024). The role of social entrepreneurship is particularly significant, as it emphasises the integration of social goals with business practices, thereby aligning with sustainable tourism principles (Aquino et al., 2018). The concept of tourism entrepreneurship requires reframing to move beyond a masculinist economic perspective that overlooks the complexities of women's experiences in the industry. According to Cole (2018), adopting this approach will enhance comprehension of how entrepreneurs see and navigate the opportunities and limitations associated with entrepreneurship, going beyond the conventional narratives of globalisation and capitalism. In a broader context, the significant promise and potential impact of tourism entrepreneurship are widely acknowledged. However, feminist theoretical critiques, which aim to challenge the subordinate status of women entrepreneurs to their male counterparts, have not been adequately incorporated into the field of tourism research, despite their emergence within the broader entrepreneurial scholarship.

Within the extensive body of literature on entrepreneurship, scholars observed that the presence of a gendered bias permeates discussions around entrepreneurship. This prejudice manifests in the perception of women entrepreneurs as being of lesser importance and lacking in contrast to their male counterparts. The existence of a hierarchical gendered structure has given rise to several research and policy initiatives that seek to address the perceived limitations faced by women in their abilities to participate in entrepreneurial activities and contribute to innovation and wealth generation (Ahl & Marlow, 2012). In the context of tourism entrepreneurship, male entrepreneurs outperform their female counterparts (Henry et al., 2016; Swail & Marlow, 2018). Hence, it is imperative to provide support and aid to women to fully harness the transformative capabilities of entrepreneurship. As a result, the scholarly debate on tourism entrepreneurship has failed to critically examine the fundamental assumptions regarding gender, while simultaneously highlighting the possibilities for empowerment that entrepreneurship offers to women.

In addition to the persistent gender biases within tourism entrepreneurship, several critical research gaps hinder a comprehensive understanding of the barriers and enablers affecting women entrepreneurs and their role in sustainable tourism development. While women's role in sustainable tourism is increasingly acknowledged, existing research often focuses narrowly on economic empowerment, overlooking structural and socio-cultural barriers. Moreover, feminist and intersectional perspectives remain underutilised in tourism entrepreneurship studies. This review addresses these gaps by critically examining the barriers and enablers shaping women's entrepreneurial participation through a gender-informed lens. Despite the recognition of gender disparities, structural factors, such as literacy and education, have received inadequate attention, despite their substantial influence on the entrepreneurial engagement of women (Gebbels et al., 2020). The capacity of women to secure employment and effectively manage tourism-related enterprises is often hindered by illiteracy and low educational attain-

ment, which frequently arise from familial responsibilities (Ali *et al.*, 2024). Moreover, the sector's diversity of occupational opportunities is restricted by cultural stereotypes that perpetuate traditional gender roles. This is particularly true in environments where male-dominated norms discourage women from participating in entrepreneurial activities, as the absence of comprehensive support systems, both within professional networks and societal structures, exacerbates these challenges. Financial constraints continue to be a significant obstacle, as women encounter challenges in obtaining the credit, financing, and investment opportunities that are essential for the expansion of their businesses (Dutta & Mallick, 2023). Furthermore, despite the introduction of gender-based policies to encourage women's entrepreneurship, there is a scarcity of research that assesses their practical efficacy. Another underexplored area is the transformative potential of technology as an enabler for women entrepreneurs, particularly in terms of how digital tools can improve market access and business scalability (Swartz *et al.*, 2022). Moreover, the research on tourism entrepreneurship has not sufficiently incorporated intersectionality, which refers to the compounded effects of socioeconomic status, ethnicity, and geographic location. Finally, the relationship between environmental sustainability and women's entrepreneurship is a developing research frontier, as few studies investigate how women contribute to sustainable tourism practices (Makandwa & de Klerk, 2024). The objective of this article was to address these deficiencies by critically analysing the barriers and enablers of women's entrepreneurship in tourism, evaluating the effectiveness of policy, and emphasising the role of technology and sustainability in the development of inclusive entrepreneurial ecosystems. This study offers a novel contribution by integrating feminist theory into a systematic review of women's entrepreneurship in sustainable tourism – an area where such perspectives are still limited. Unlike earlier reviews that focus primarily on economic outcomes, this research adopted a gender-sensitive lens to examine structural barriers, intersectional challenges, and enabling factors. Through its conceptual focus and policy-oriented insights, the study advances a more inclusive and theoretically grounded understanding of tourism entrepreneurship. We aimed to enhance the understanding of gender dynamics in the context of tourist entrepreneurship. This will enable policymakers and governing bodies to develop more effective policies that address the specific challenges faced by entrepreneurs. Ultimately, our research sought to contribute to ongoing policy discussions surrounding tourism entrepreneurship. While previous studies have explored entrepreneurship in the tourist sector (Li, 2008; Solvoll *et al.*, 2015), our focus was to emphasise the importance of addressing gender-related concerns within this context. To achieve this objective, we conducted an integrative review to critically examine the literature on gender, tourism, and entrepreneurship. The remainder of the article is organized into five sections. The next section presents the Literature Review and Hypotheses Development, followed by the Research Methodology. The Results and Discussion section elaborates on the key insights derived from the analysis, and the paper concludes with the Conclusions, highlighting the main implications and directions for future research.

LITERATURE REVIEW

Recent research has drawn attention to the critical role of women entrepreneurs in tourism and their alignment with the fifth UN Sustainable Development Goal, gender equality, highlighting the intricate links between entrepreneurship, shared value creation, and women's empowerment (Bagheri *et al.*, 2023). These studies highlight not only the transformative potential of women entrepreneurship but also the barriers arising from gender-based discrimination, underscoring the need for a theoretical framework that critically engages with power, identity, and agency. Feminist theory offers a lens, enabling researchers to examine the socio-political structures that shape women's entrepreneurial experiences. Within entrepreneurship research, literature highlights that gender is not merely a variable to be measured but a fundamental axis along which we construct entrepreneurial identities and opportunities (Freund & Hernandez-Maskivker, 2021). However, in tourism literature, feminist critiques remain marginal. A growing body of feminist tourism research advocates intersectionality as a core analytical tool, emphasising how gender interacts with class, ethnicity, and geography to shape entrepreneurial pathways (Kharbanda & Sharma, 2024). Ecofeminist approaches further expand this discourse by linking women entrepreneurship with environmental stewardship and

community resilience, particularly in rural and marginalised settings. These perspectives view tourism not only as an economic activity but as a site of potential resistance to entrenched patriarchal norms. Hence, feminist theoretical frameworks deepen the analysis of empowerment beyond economic metrics, advocating for inclusive, sustainable, and context-sensitive approaches to entrepreneurship. Integrating such theoretical underpinnings is essential for reimagining tourism as a domain of equitable participation and structural transformation (Gerged *et al.*, 2022).

This study employs an integrated theoretical framework, drawing on feminist theory, intersectionality, and the theory of planned behaviour (TPB) to analyse the challenges and opportunities for women entrepreneurs in sustainable tourism. Feminist theory examines how patriarchal structures systematically marginalise women in entrepreneurship. It critiques conventional economic models that overlook women's agency, unpaid labour, and systemic exclusion from financial resources, markets, and policy influence. Within tourism, feminist theory highlights how women's entrepreneurial endeavours serve not only as economic activities but also as acts of empowerment and social transformation (Golik & Wasilczuk, 2025). The intersectionality framework acknowledges the diversity of women's experiences, emphasising how factors such as race, class, ethnicity, and geographic location intersect with gender to create unique entrepreneurial pathways. This perspective allows for analysis of how privilege and disadvantage shape women's participation in tourism, revealing why some women face greater barriers than others (Dy & MacNeil, 2025).

We incorporated the theory of planned behaviour (Taghavi & Maharati, 2024), which explores the psychological drivers behind entrepreneurial actions. According to TPB, a woman's decision to engage in tourism entrepreneurship is influenced by three key factors: her attitudes (*e.g.*, confidence, perceived benefits), subjective norms (*e.g.*, societal expectations, familial support), and perceived behavioural control (*e.g.*, access to skills, funding, and networks). By integrating TPB, the study bridges structural constraints with individual agency, demonstrating how internalised beliefs and external pressures collectively shape women's entrepreneurial intentions and behaviours.

Together, these theories offer a comprehensive framework, addressing systemic inequities, identity-based disparities, and cognitive-motivational factors, to better understand women's roles in driving sustainable tourism development.

RESEARCH METHODOLOGY

A systematic and structured review strategy is essential for simplifying complex research areas, particularly when exploring the multifaceted relationship between women's entrepreneurship and sustainable tourism development. We employed an integrative literature review approach, designed to synthesise diverse perspectives from existing research while identifying recurring patterns, key themes, and critical gaps. By combining qualitative and quantitative studies, the study offers a holistic understanding of the barriers and enablers influencing women entrepreneurs in the tourism sector.

The integrative review is characterised as a separate strategy for synthesising research on a certain topic. Combining data from diversely designed projects is challenging and complicated, but a disciplined and comprehensive approach to the process, especially data processing, reduces biases and errors (Souza *et al.*, 2010). We employed a two-tiered analytic approach, integrating manual and software-based analysis, resulting in an integrated literature review (Bansal *et al.*, 2022; Nangia *et al.*, 2023; Rao *et al.*, 2023; Rialti *et al.*, 2019; Sharma et al., 2023, Taheri *et al.*, 2023). The integrated review aims to overcome some constraints associated with narrative techniques by conducting a more comprehensive and structured literature search. The primary aim of integrative reviews is to systematically analyse, evaluate, and amalgamate pertinent scholarly works to provide novel theoretical frameworks and viewpoints (Cronin & George, 2023; Torraco, 2016). It facilitates enhanced adherence to the standards of systematic reviews, which rely on a replicable, systematic, and transparent methodology (Kraus *et al.*, 2020).

Data Collection Protocol

We developed a research-driven policy agenda, followed by a manual examination. Performing and reporting research publications, we adhered to the PRISMA (Preferred Reporting Items for Systematic

Reviews and Meta-Analyses) criteria, as shown in Figure 1 (Sharma *et al.*, 2023 & Verma *et al.*, 2023). We selected the Web of Science (WoS) as the primary database for this integrative review due to its rigorous indexing standards, multidisciplinary coverage, and wide acceptance in systematic review research (Donthu *et al.*, 2021). Compared to other well-established databases, WoS offers greater control over data quality, ensuring that only peer-reviewed, high-impact journal articles are included – an essential criterion given the focus on literature from A-ranked ABDC or 3-rated ABS journals. We utilised the WOS database's advanced search function to get 1268 publications using the keywords 'sustainable,' 'tourism,' and 'women.' Next, we filtered the documents based on management, public administration, business, environmental studies, green sustainable science technology, economics, and business finance subject categories, to obtain only documents related to economics, business, and sustainable finance, following the study topic, leaving 571 documents. Moreover, we filtered the articles to maintain just those written in English, which is widely acknowledged. We retained only review and journal articles. Later, we manually filtered the articles to acquire only documents relevant to the interconnection of sustainable tourism and eco-tourism, bringing the total number of papers to 286. To preserve the quality criteria of the reviewed article, we retained only those articles published in journals graded A or above on the ABDC 2019 list or three or higher on the ABS 2021 list, leaving us with 68 articles (Jena, 2021).
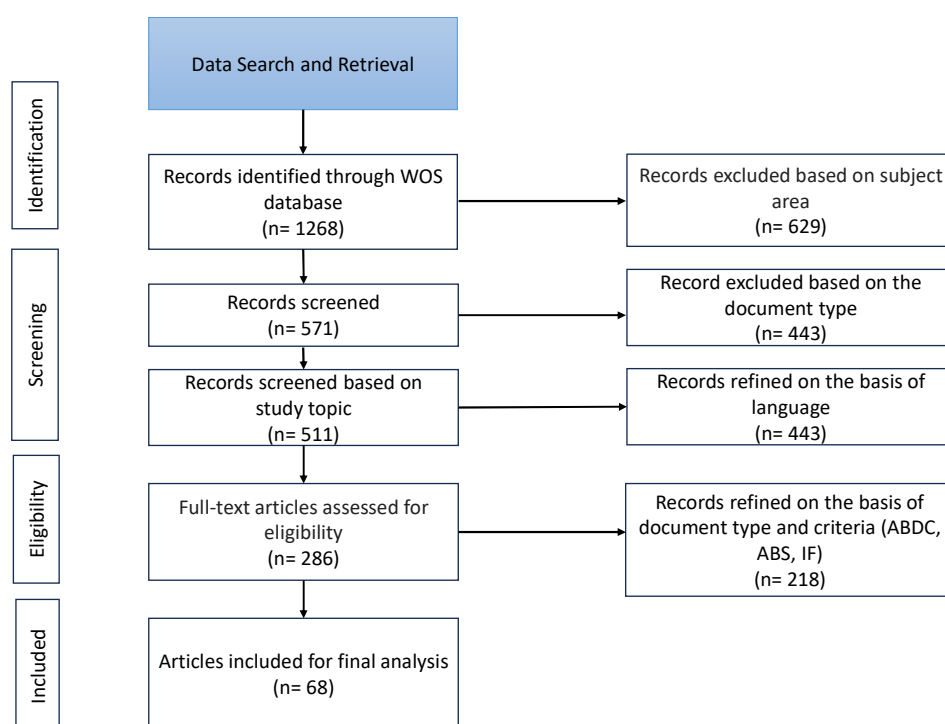

Figure 1. Study flow diagram using PRISMA
Source: own elaboration.

We adopted a robust methodology that integrated both inductive and deductive coding to analyse the data. First, we employed the inductive approach, uncovering themes and constructs through recurring patterns observed in the literature. These overarching dimensions were essential for exploring the relationship between innovation and entrepreneurship (Fereday & Muir-Cochrane, 2006). To further enhance the analysis, we developed a strategic map to visualise the interconnections between themes related to tourism and women entrepreneurship. This map facilitated systematic data organisation and highlighted critical areas for future research (Hoon & Baluch, 2020). The dual approach incorporated both participant-driven and researcher-driven perspectives, ensuring a holistic analysis. The process began with an informed performance analysis (Donthu *et al.*, 2021; Kent *et al.*, 2020), followed by an in-depth qualitative review. The strategic map (Figure 4) served to identify overarching themes and streamline the analytical process, ultimately revealing emergent patterns and themes that

deepened the understanding of the topic. Using the integrated analysis, we gathered data on the publishing and citation (Figure 2). In the second step, we comprehensively evaluated these articles and separated the literature on sustainable tourism and eco-tourism into significant concepts and themes (Figure 3), and we proposed a conceptual framework (Figure 5).

RESULTS AND DISCUSSION

This section presents the results and discussion, beginning with an analysis of annual publication trends, keyword co-occurrence, and a thematic map-based inductive analysis. It explores dimensions, themes, and constructs within the knowledge field to provide deeper insights into women entrepreneurship, tourism, and sustainable tourism.

Annual Publication Trend of Women Entrepreneurship, Tourism, and Sustainable Tourism

The progression of articles concerning women's entrepreneurship, tourism, and sustainable tourism, arranged in a chronological sequence (Figure 2). The publication trend has transformed, with the number of annual articles transitioning from 1-2 between 1993 and 2013 to 8 in the year 2022. Notably, there is a conspicuous upsurge in publications post-2012. The United Nations Conference on Sustainable Development (Rio+20), held on June 20-22, 2012, in Rio de Janeiro, Brazil, coincides with this significant transition. As an expansion of the Millennium Development Goals, the member states agreed during this meeting to begin work on a set of Sustainable Development Goals (SDGs) to extend and concur with the post-2015 development agenda (United Nations, 2012).

We may attribute the zenith of publications 2022 to the United Nations Environmental Programme (UNEP), coupled with the UN's declaration designating the year 2002 as the International Year of Eco-tourism. This proclamation rendered the topic exceptionally promising, holding significant potential for expansion. This initiative notably underscored the significance of integrating sustainable development within the realm of tourism.
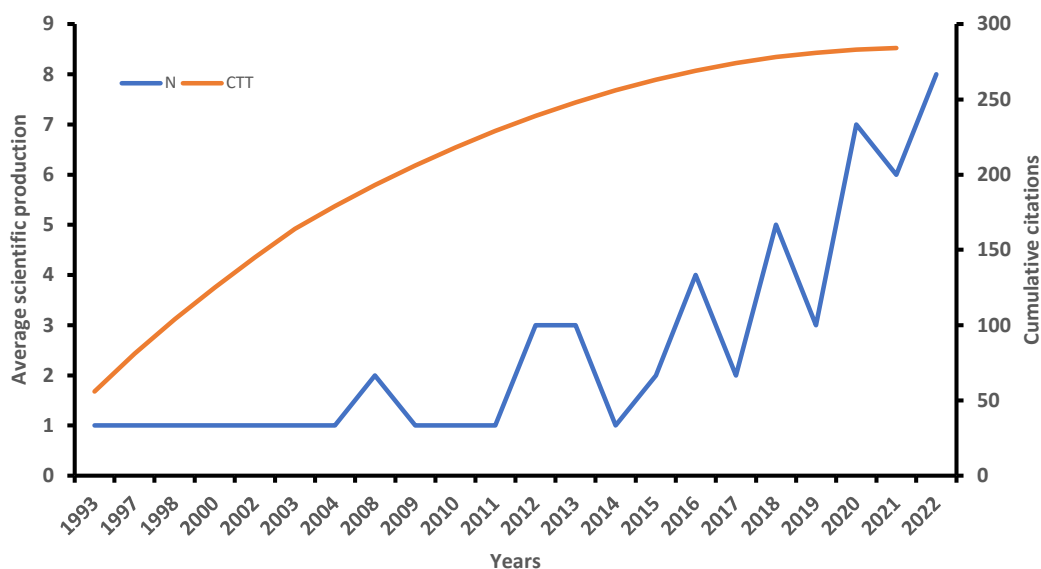

Figure 3. Aggregate dimensions, themes, and constructs in the knowledge field of gender, entrepreneurship
Source: own elaboration.

Inductive and Thematic Analysis

This segment delves into the inductive analysis that is created based on a thematic map-based fashion.

Dimensions, Themes, and Constructs in the Knowledge Field

Inductive analysis identifies five aggregate dimensions (AD), consolidating diverse features into higher-level concepts to uncover underlying patterns. These dimensions not only advance academic

understanding but also guide future research. In hospitality and tourism, thematic mapping (Figure 3) highlights connections among these dimensions. This top-down approach, applicable across disciplines, organises data around predefined dimensions, enabling the identification of relationships and patterns often missed by traditional methods. Overlaying data on a map, it reveals spatial trends, patterns, and variations, enhancing comprehension.
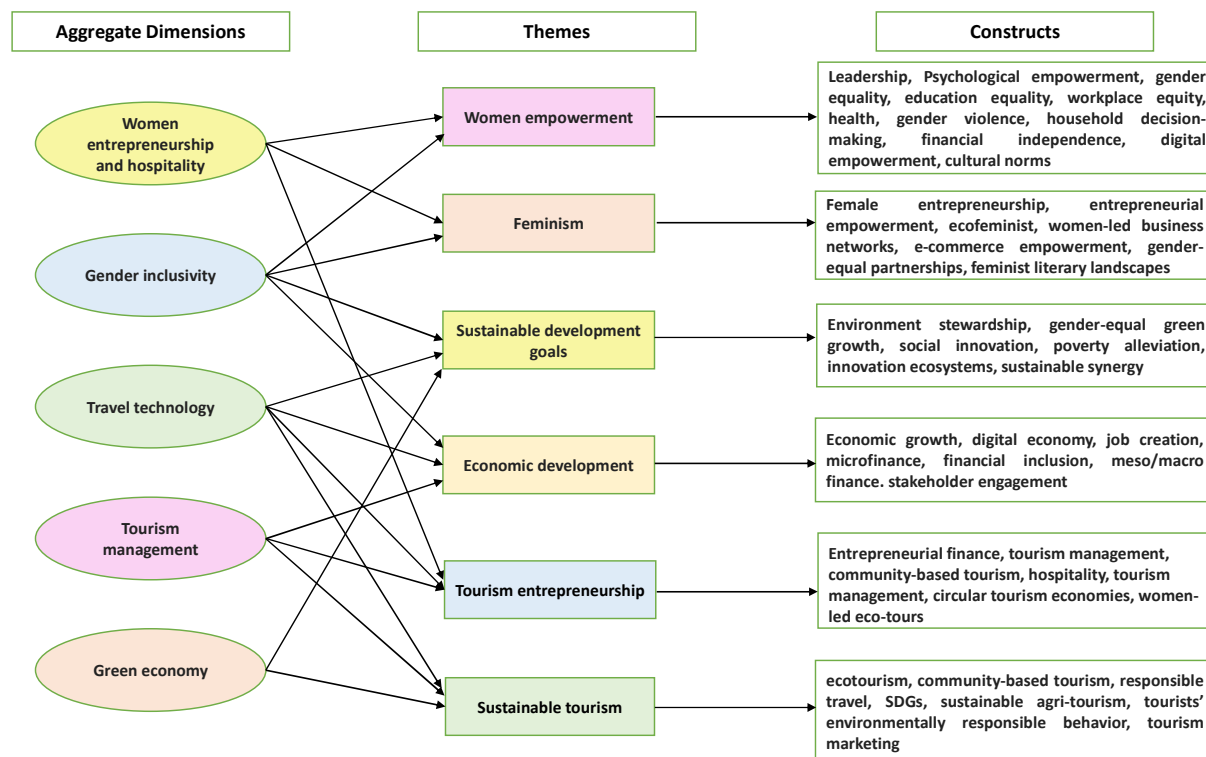
Aggregate Dimensions	Themes	Constructs
Women entrepreneurship and hospitality	Women empowerment	Leadership, Psychological empowerment, gender equality, education equality, workplace equity, health, gender violence, household decision-making, financial independence, digital empowerment, cultural norms
Gender inclusivity	Feminism	Female entrepreneurship, entrepreneurial empowerment, ecofeminist, women-led business networks, e-commerce empowerment, gender-equal partnerships, feminist literary landscapes
Travel technology	Sustainable development goals	Environment stewardship, gender-equal green growth, social innovation, poverty alleviation, innovation ecosystems, sustainable synergy
Tourism management	Economic development	Economic growth, digital economy, job creation, microfinance, financial inclusion, meso/macro finance. stakeholder engagement
Green economy	Tourism entrepreneurship	Entrepreneurial finance, tourism management, community-based tourism, hospitality, tourism management, circular tourism economies, women-led eco-tours
	Sustainable tourism	ecotourism, community-based tourism, responsible travel, SDGs, sustainable agri-tourism, tourists' environmentally responsible behavior, tourism marketing

Figure 3. Aggregate dimensions, themes, and constructs in the knowledge field of gender, entrepreneurship, and sustainable tourism
Source: own elaboration.

Drawing from the literature, we identified five overarching themes that illustrate the role of women entrepreneurship and sustainable tourism, derived from aggregate dimensions. Delving into sub-themes such as 'motor,' 'basic,' 'niche,' and 'emergent' provides deeper insights into future research directions. These sub-themes enrich qualitative research by offering a nuanced understanding of data complexity and diversity, allowing researchers to analyse individual phenomena within a conceptual framework. This comprehensive method expands our understanding of the dynamic relationship between robotics, service automation, and the evolving tourism and hospitality landscape.

The elements within the study form the foundation for conceptualising the framework. They are drawn from commonalities identified in the analysis of existing literature's conceptual structure, further reinforced by inductive analysis (Figure 3). The framework is built upon five components that elucidate the concept of women's entrepreneurship and its interconnectedness. The initial component, labelled the Green Economy, encompasses sustainable tourism, economic development, and sustainable development goals. the subsequent component, focusing on women's entrepreneurship and hospitality, encompasses women's empowerment, feminism, and tourism entrepreneurship. the third component, gender inclusivity, is comprised of women's empowerment, economic development, sustainable development goals, and feminism. The fourth component, tourism management, includes sustainable tourism, economic development, and tourism entrepreneurship. Lastly, travel technology consists of sustainable tourism, economic development, sustainable development goals, and tourism entrepreneurship.

The 'green economy' emphasises sustainable development through responsible resource management and social equity, areas where women's entrepreneurship plays a critical role. In tourism, women often lead initiatives prioritising sustainability, community welfare, and environmental stewardship.

Their participation is particularly impactful in rural and marginalised areas, where it enhances cultural preservation and strengthens agriculture-tourism linkages, fostering economic growth and sustainability (Kutlu & Ngoasong, 2023). The study highlights how initiatives, such as corporate social responsibility (CSR) programs targeting women's empowerment, have successfully promoted sustainability in regions like Nigeria's oil-producing areas. Women represent nearly 40% of the tourism workforce, with hospitality being a major employer, and their leadership in adopting eco-friendly practices helps attract environmentally conscious travellers and boosts market access and consumer loyalty (Uduji *et al.*, 2020). Integrating gender perspectives into green economy strategies further enhances the effectiveness of sustainability efforts, showcasing the potential for women-led businesses to drive sustainable development within the tourism and hospitality sectors.

‘Women's entrepreneurship in hospitality' has emerged as a critical area of study, especially in the context of sustainable tourism development. The study significantly contributes to economic growth while advancing gender equality and empowerment. Their familiarity with hospitality-related tasks often leads to successful homestay ventures, food services, and local crafts (Yoopetch, 2021). This sector provides unique opportunities for women due to its informal roles, but challenges such as limited resources, societal stereotypes, and inadequate support networks persist. The extant literature highlights that the theme is often driven by necessity rather than opportunity, especially in developing regions where economic hardships push women to create businesses (Dutta, 2023). The theory of planned behaviour highlights the importance of fostering positive attitudes toward risk-taking and creating supportive environments to encourage entrepreneurial intentions (Figueroa-Domecq *et al.*, 2022). Social capital, including trust and community support, also plays a vital role in overcoming barriers. Beyond individual empowerment, women-led hospitality businesses align with sustainable tourism principles by emphasising social and environmental priorities. Initiatives in ecotourism and cultural tourism promote economic benefits, cultural preservation, and environmental sustainability, making women's entrepreneurship integral to achieving broader sustainable tourism goals (Kimbu & Ngoasong, 2016a).

The theme of ‘gender inclusivity' is pivotal in advancing women's entrepreneurship and involvement in tourism, particularly in the context of sustainable tourism development. It emphasises equitable opportunities, fair representation, and empowerment for women in an industry where traditional gender roles often limit their participation. Tourism policies that promote gender-sensitive work conditions and leadership opportunities can enhance women's economic empowerment and foster balanced decision-making, contributing to more effective sustainability initiatives (Domecq *et al.*, 2015). Achieving true inclusivity requires considering the intersectionality of gender with other social categories like race and sexuality. Corporate social responsibility (CSR) also plays a vital role by empowering women through community-focused initiatives, especially in cultural tourism, where women's participation boosts community engagement and economic development (Uduji *et al.*, 2020). Gender inclusivity extends beyond empowerment as it shapes organisational culture and operational success in hospitality and tourism. Neglecting gender equality can hinder leadership development and diversity within the industry, reducing the overall effectiveness of tourism enterprises. Integrating gender theory into tourism research offers valuable insights into women's experiences, enabling more sensitive and effective management practices (Elena, 2023). Fostering inclusivity enhances organisational performance while contributing to broader societal goals of equality and diversity (Kutlu & Ngoasong, 2023).

The rapid advancement of information and communication technologies (ICT) has revolutionised ‘tourism management' by enhancing operational efficiency and improving customer experiences. Smart tourism applications facilitate value co-creation between travellers and service providers, boosting satisfaction and engagement while optimizing resource use and minimizing waste. However, inclusivity requires prioritisation to ensure that all demographics, including women and marginalised groups, benefit from these technological advancements. Women entrepreneurs are pivotal in tourism management, particularly in emerging destinations where small tourism firms (STFs) contribute to economic and social empowerment (Kimbu & Ngoasong, 2016a). Women-led STFs generate income, create jobs, and promote community development, which is vital for regions affected by crises such as the COVID-19 pandemic (Sanuja & Joseph, 2022). Recognising women as essential

stakeholders in tourism planning can address gender-specific challenges, ensuring equitable and inclusive development. Effective tourism management aligns with sustainable practices by balancing economic, social, and environmental objectives (Petkova, 2023). Strategic planning that involves local communities and raises women's awareness in ecotourism management is crucial for promoting active participation in sustainability initiatives (Streimikiene *et al.*, 2021). Collaborative networks and supportive policies can further enhance women's human capital and resilience, strengthening their businesses' sustainability. Leadership styles significantly influence tourism enterprises' success. Empowering leadership fosters collaboration and inclusivity, enhancing employee outcomes and improving the effectiveness of management strategies, particularly in contexts where women's participation is critical for achieving sustainable results (Huertas-Valdivia *et al.*, 2019). Integrating women's perspectives into tourism management ensures holistic, inclusive, and sustainable tourism development that benefits economies and communities alike.

'Travel technology' has revolutionised the tourism industry, impacting stakeholders such as travellers, tourism enterprises, and destinations. Innovations in technology have created integrated service ecosystems, enabling value co-creation and enhancing the travel experience at all stages. Leadership plays a vital role in facilitating the adoption of technologies that improve operational efficiency and traveller support (Buhalis, 2020). The use of smartphones and mobile applications has transformed how travellers access information and engage with travel networks, significantly influencing behaviour and decision-making (Wang, 2019). The COVID-19 pandemic accelerated technological adoption, driving digital entrepreneurship and advancing trends such as smart tourism destinations, where technology enhances traveller experiences (Shin *et al.*, 2022). Mobile technology remains integral to the traveller's journey, providing essential support before, during, and after travel (Tussyadiah & Wang, 2016). Destination marketers now rely on travel technologies to deliver real-time content and cater to spontaneous travel behaviours, particularly in reaching specific segments like senior travellers (Otoo *et al.*, 2020). Emerging technologies such as blockchain, wearable computing, and augmented reality are reshaping tourism by improving transparency, integrity, and visitor experiences in destinations and museums (Zhang & Yuriy, 2021; Conyette, 2015). Despite advances, the hospitality sector lags behind airlines in adopting technology-enabled services, though ICT remains key to enhancing e-business efficiency (Wang & Sparks, 2014). The growing importance of smart tourism destinations highlights the interconnectedness of people and technology as part of a socio-technical ecosystem (Boes *et al.*, 2016). Big data, the Internet of Things, and cloud computing have disrupted traditional travel agency models, influencing traveller behaviour and market operations. Mobile technologies bridge the supplier-user gap, transforming travel behaviours and perceptions of destination satisfaction (Linton & Kwortnik, 2019). However, future research should explore traveller experiences with technology beyond attitudes and adoption patterns to capture *the broader impacts of these innovations* (Wang *et al.*, 2017).

Thematic Map

A strategic map is a visual depiction presenting essential ideas within a broader framework. When analysing thematic maps, the main metrics are centrality and density (Cobo *et al.*, 2015b). Density reflects how interconnected ideas are within a particular subject, while centrality gauges the extent to which ideas outside that theme are linked to ideas within it. Centrality indicates the level of association a theme has with other themes, while density signifies the strength of internal connections within the themes (Ameen *et al.*, 2022; Aparicio *et al.*, 2019; Shahzad *et al.*, 2022). The basic theme, the rising theme, the niche theme, and the motor theme make up the four sections of the thematic map (Talan & Sharma, 2019). The thematic mapping reveals six distinct themes distributed across the four quadrants: the pivotal theme, exhibiting high centrality and density, is situated in the upper right quadrant; the peripheral theme, showcasing high density but low centrality, is positioned in the upper left quadrant; the emerging or fading theme, characterised by low density and centrality, is found in the lower left quadrant; and the cross-cutting, universal, or fundamental theme, characterised by low density and high centrality, is located in the lower right.
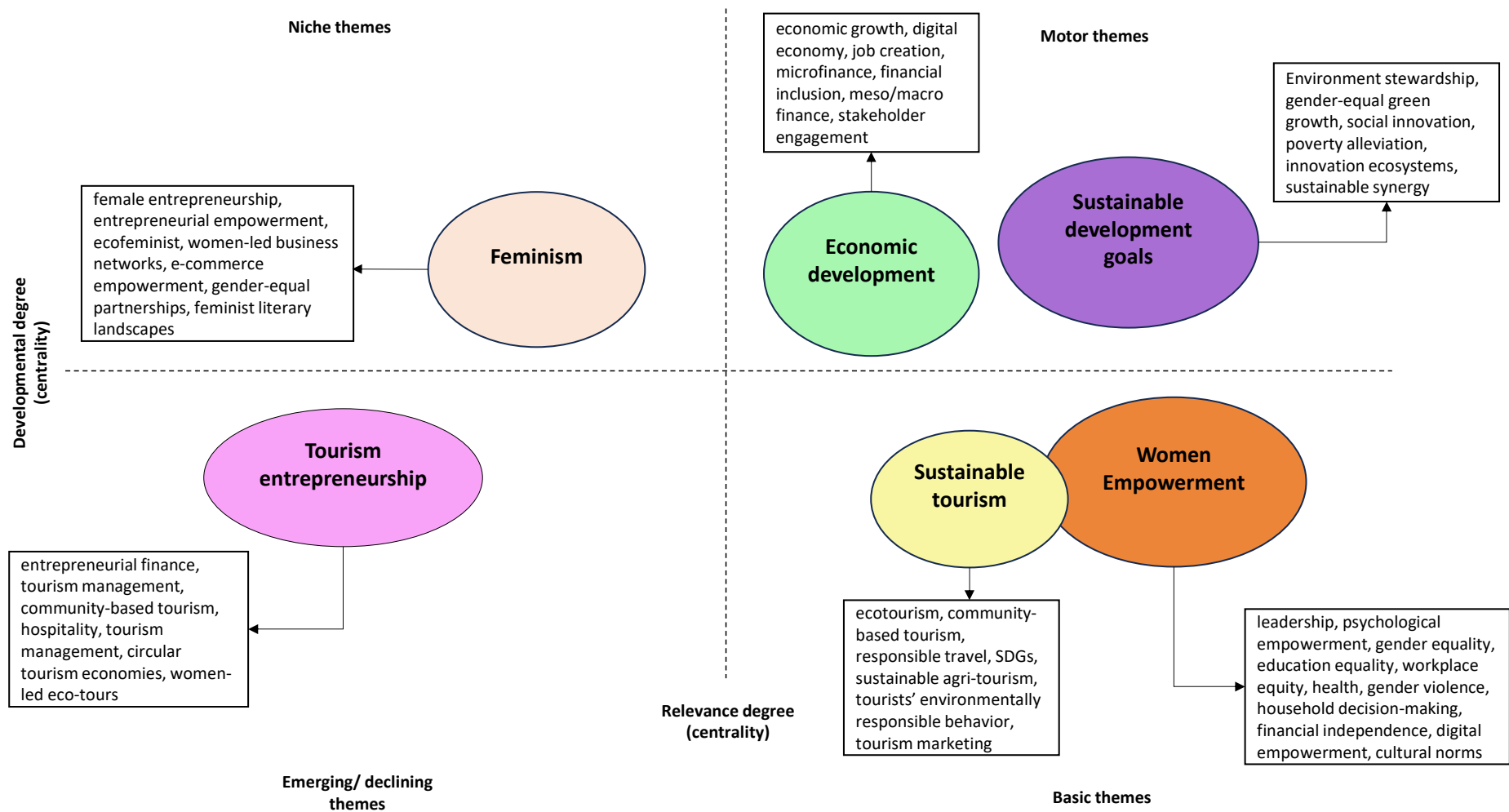
Figure 4. Strategic map in the field of tourism and women entrepreneurship
Source: own elaboration.

Figure 4 exhibits six different themes inside each of the four different quadrants: women empowerment, sustainable tourism, sustainable development goals (SDGs), economic development, feminism, and tourism entrepreneurship. While the connections to the other themes have become more robust as time has passed, the internal linkages within this quadrant exhibit a certain degree of fragility. This suggests the necessity for additional research to comprehensively investigate the underlying sub-themes (Rodríguez-Soler *et al.*, 2020).

'Women empowerment' lies in the basic quadrant that includes sub-themes like leadership, psychological empowerment, gender equality, education equality, workplace equity, health, gender violence, household decision-making, financial independence, digital empowerment, and cultural norms. Promoting women's empowerment holds essential significance within the realm of sustainable tourism, and the engagement of women in entrepreneurial activities significantly contributes to realising this objective. Numerous research investigations have underscored the necessity of comprehending the determinants that impact women's entrepreneurship within the tourism sector and its interrelation with the concept of sustainable tourism. Despite good intentions and mixed findings, research publications on women's entrepreneurship have a pattern of reinforcing the stereotype that women's firms are less important than men's or, at most, complementary. This article uses discourse analysis to explore the methodologies behind these findings. It recommends new lines of inquiry that, rather than perpetuating women's subordination, capture a broader and deeper range of women business owners' experiences and perspectives (Ahl, 2019; Khoo *et al.*, 2024) There is a gender gap in the rate at which new businesses are started, and the literature investigates its causes, both in terms of individual variations and in terms of more systemic causes. Using data from 37 nations, they find that economic and social factors have a role in determining whether or not men or women decide to start their businesses. This study highlights the need of learning about the personal and societal influences on women-owned businesses (Minniti & Nardone, 2007). Women entrepreneurs in the tourism business would do well to study the impact of family dynamics. The literature suggests that tourism can help women gain economic and social autonomy. The importance of women's involvement in tourism-related activities to local economic growth and social transformation is underlined. This demonstrates how tourism may help further the advancement of women, which is in line with the UN's Sustainable Development Goals (Getz *et al.*, 2004; Mohammed, 1923).

The concept of 'sustainable tourism' is an additional element we find within the foundational quadrant, intersecting with the theme of women's empowerment. This intersection underscores the significance of women within the realm of sustainable tourism. It includes sub-themes like ecotourism, community-based tourism, responsible travel, SDGs, sustainable Agri-tourism, tourists' environmentally responsible behaviour, and tourism marketing. The term 'sustainable tourism' refers to any vacation that does not negatively impact the environment and helps promote long-term stability (Filimonau *et al.*, 2024; Liu, 2003). Despite the extensive research on gender dynamics in tourism, these studies have not significantly impacted the correction of gender-based power imbalances within the sector. This article addresses the reasons for this situation and proposes potential remedies. This study contends that the travel industry mirrors and even worsens the difficulties encountered in gender mainstreaming procedures within governmental policy around the world. We argue that the impact of such material has been negligible despite having substantial knowledge of the field. Furthermore, the we propose that this is because the sustainable tourism paradigm has been slow to adopt principles of gender equality and gender analysis. Finally, it suggests ways in which gender might be better integrated into the theory and practice of sustainable tourism, arguing that much more work needs to be done (Ferguson & Alarcón, 2015). The literature highlights sustainable human capital management in women's tourist entrepreneurship, particularly the importance of collaborative networks and tourism policy. The research highlights the positive financial and social outcomes that result when women take the initiative to meet local needs in popular tourist spots through their businesses. The literature review emphasises the value of women business owners in establishing environmentally friendly tourist destinations. Women's participation in the tourism industry promotes economic development, social change, and individual autonomy. The findings highlight the importance of doing additional studies to fully comprehend the interconnected nature of gender,

sustainability, and entrepreneurship in the tourism sector. The extant literature illustrates that policymakers and scholars can gain useful information from the recommended models and frameworks for fostering sustainable tourism through women entrepreneurs (Kimbu *et al.*, 2019).

Sustainable development goals (SDGs) constitute one of the motor themes, along with environment stewardship, gender-equal green growth, social innovation, poverty alleviation, innovation ecosystems, and sustainable synergy as its sub-themes. Sustainable Development Goals (SDGs) have been the topic of much research and writing about the impact of tourism and volunteering. The evaluation highlights the importance of taking a holistic approach to researching the tourist industry's workforce and the role it plays in promoting sustainable tourism. While discussing sustainable tourism and the SDGs, it highlights the lack of focus on workforce-related topics (Lockstone-Binney & Ong, 2022). Another study looks into Tobago specifically to determine how well sustainable tourism fits in with meeting the SDGs. It is clear from this research that tourism can significantly contribute to the SDGs, and that stakeholder engagement is crucial to achieving these goals (Mohan, 2022). Women's entrepreneurship, women's involvement in tourism, and the SDGs are all interconnected in important ways, and the literature provides major insights into these relationships. The potential of tourism to promote peace and regional sustainable development is also highlighted, as is the importance of destination quality in achieving sustainable tourism goals. Women business owners are also honoured for their contributions to sustainable tourism and the SDGs. These business owners are crucial to the tourist industry's continued progress towards sustainability and innovation. The worldwide hotel industry and platforms like Airbnb have been hit hard by the COVID-19 epidemic, especially small and medium-sized businesses and establishments in underdeveloped nations (Nhamo *et al.*, 2020).

'Economic development' forms another crucial theme as part of the motor quadrant. It includes sub-themes like economic growth, digital economy, job creation, microfinance, financial inclusion, meso/macro finance, and stakeholder engagement. There are two facets to the relationship between economic growth and women's empowerment, which encompass expanding women's opportunities to improve their health, their education, their income, their rights, and their participation in the political process. First, economic development has the potential to lessen and significantly minimise gender gaps. Conversely, the persistent bias against women, as emphasised by Sen, can impede overall development. This signifies that empowerment has the potential to expedite the development process (Alcalá-Ordóñez & Segarra, 2023; Duflo, 2012). The literature highlights how the characteristics of a country's supply-side impact the growth of tourism, with a specific focus on the evolving role of economic development as a catalyst for tourism. While previous research has focused mostly on the economic benefits of tourism, the current investigation explores whether or not a specific level of economic development is required to attract visitors. The literature's primary objective is to ascertain how much growth in the economy affects tourists' preferences. It examines a worldwide panel dataset that includes traveller origin and country data. The sample is then broken down further according to geographic and GDP parameters to examine differences across competing nations within the same region. The results highlight the significance of economic development on a worldwide scale and its impact on travellers' choices. Subsample analysis reveals that disparities in economic development are less pronounced in countries with high GDP levels and more pronounced in developing nations (Eugenio-Martin *et al.*, 2008). According to the literature assessment, one ca attain sustainable development goals and economic growth in the tourism industry through the promotion of collaboration, community involvement, and women entrepreneurship.

'Feminism' is another key theme that evolved as an independent theme with a high-density value, which contains sub-themes like women entrepreneurship, entrepreneurial empowerment, ecofeminism, women-led business networks, e-commerce empowerment, gender-equal partnerships, and feminist literary landscapes. Feminism is a social movement that fights for equal rights for women in all spheres of life, including the workplace, politics, education, and personal decision-making. The literature analyses the limited application of feminist theory to overcome gender prejudice in the entrepreneurial discourse. It implies that feminism can serve as an analytical framework to reveal and combat the perpetuation of subordination based on gender.

The research contends that there is little evidence that feminist philosophy has served to combat gender prejudice in entrepreneurship despite repeated appeals to do so. This research provides a framework for 'post-structural feminist analysis' to examine the implicit gender bias in entrepreneurial literature. The study presents feminism as a critical lens that may serve to expose implicit biases and question long-held beliefs about entrepreneurship (Ahl & Marlow, 2012). The emergence of women entrepreneurs has bolstered women's participation in economic growth. A study conducted in Macedonia analysed the state of women in the tourism industry and business ownership in Macedonia. The study's overarching goal was to ascertain the major impediments to women's advancement in tourism-related entrepreneurship. The research used a self-administered questionnaire given to staff and management at travel companies and tourism services in several cities around Macedonia. Although male and female respondents had many points in common, they held vastly different views on the topic of women entrepreneurs in the Macedonian tourism industry. When compared to men's more consistent perspectives, women rated their involvement in tourism entrepreneurship as low and with room for improvement. Moreover, the article details some of the unique difficulties faced by women in the tourism industry (Serafimova & Petrevska, 2018) Existing research emphasises the need of encouraging women to start their tourist businesses to foster long-term growth. The study focuses on sustainable entrepreneurship and the skills of women business owners in the travel sector. Findings emphasise difficulties women business owners confront, such as inadequate funding, inadequate education, and inadequate managerial and marketing expertise (Tovmasyan, 2022). According to Ertac and Tanova (2020), the tourist sector cannot achieve sustainable development without the active participation of women. The research focuses on how ecotourism might help empower women business owners, especially in rural regions, from a gendered perspective. Women's participation in the tourism industry can help boost the economy and advance gender equality. As a whole, the feminist literature on women's entrepreneurship, tourism participation, and sustainable tourism stresses the importance of addressing gender inequalities, institutionalised social institutions, and societal views that affect women entrepreneurs (Ertac & Tanova, 2020; Mahendru *et al.*, 2023).

'Tourism entrepreneurship' is another theme that has evolved as an independent theme along with entrepreneurial finance, tourism management, community-based tourism, hospitality, tourism management, circular tourism economies, and women-led eco-tours as its sub-themes. In-depth studies (Jamal & Getz, 1995; Zeng *et al.*, 2024) have highlighted the value of collaboration in community-based tourism planning and development. These projects show how helpful collaboration and public input can be in creating eco-friendly tourist destinations. They provide guidance for coordinating activities and give insight on the challenges of planning. The role of women in business has also been investigated in the tourism industry. According to studies (Eger *et al.*, 2022), learning the nuances of gender's role in sustainable business is especially important in the tourism sector. To achieve economic growth and gender equality in the workplace, which are both targets of sustainable development goals, more women need to start their own businesses in the tourism sector. The gendered aspects of entrepreneurship and sustainability in tourism are well known, though. The gender dynamics of sustainable entrepreneurship are complex, and further study is necessary to guide policy in the tourism entrepreneurship sector. Kimbu and Ngoasong (2016) cite research highlighting women's participation as social entrepreneurs in the tourism business. According to the findings, women entrepreneurs in the tourism sector are driving initiatives to improve local economies, expand access to quality education and training, create new jobs, and alleviate poverty. In addition to the financial gains, women who work in the tourism industry see boosts in autonomy, intelligence, and self-assurance. To completely understand the opportunities and limits women experience as business owners and employees in the tourism industry, more research is needed. The references here stress the importance of overcoming limitations like those of time, money, and knowledge in areas like management and marketing. They also discuss the positive effects of tourism on women's finances, mental health, and sense of self-worth. The literature on tourism entrepreneurship, particularly that which looks at women's roles and the long-term viability of the industry, sheds light on the value of cooperation, community involvement, and gender equality in the creation of tourist attractions. The importance of women's labour in the tourism industry and the rewards they receive as social entrepreneurs are highlighted. However,

more study is needed to properly grasp the complexities of the connection between gender and environmentally responsible business in the travel sector. With this information in hand, people may create policies and actions to encourage women entrepreneurship in the tourism industry, which in turn will contribute to long-term growth in the sector (Setiawan, 2023).
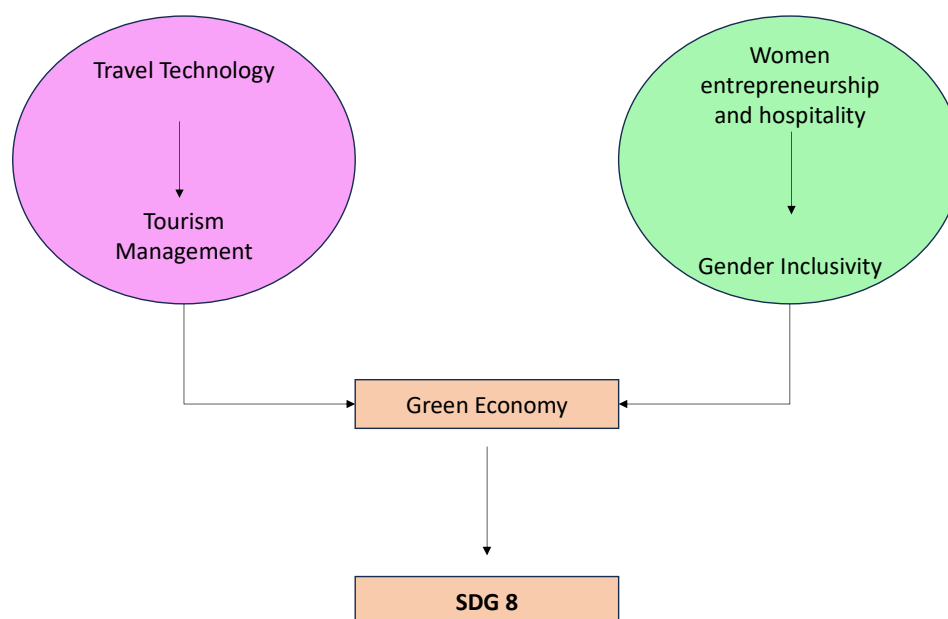

Figure 5. Conceptual framework
Source: own elaboration.

The conceptual framework (Figure 5) illustrates the interconnection between tourism management, gender inclusivity, and the green economy in achieving sustainable development goal 8 (SDG 8), which focuses on promoting sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.

Tourism management centres on the integration of travel technology in managing tourism. The use of technology in travel management can optimise resources, enhance efficiency, and reduce the environmental footprint of tourism activities. Improved tourism management practices align with sustainable principles, contributing to a green economy by promoting environmentally friendly and efficient practices in the tourism sector. The framework highlights the importance of gender inclusivity in the tourism and hospitality sectors, with a specific focus on women's entrepreneurship and hospitality roles (Li *et al.*, 2022). Gender inclusivity within the tourism sector fosters diversity and empowerment, enabling women to take on active roles as entrepreneurs and leaders. This inclusivity promotes economic growth and supports the social aspects of the green economy by ensuring that economic opportunities are equitably accessible (Pimpa, 2021a).

The green economy is positioned at the centre of the framework, representing the nexus where tourism management and gender inclusivity converge. By incorporating sustainable practices in tourism and promoting gender-inclusive policies, the green economy supports SDG 8's objectives by driving economic growth that is inclusive and sustainable. This approach encourages the development of eco-friendly practices and policies that reduce environmental impacts while promoting equitable economic opportunities. Notably, SDG 8 is at the bottom of the framework constituting the ultimate goal, showing how tourism management, gender inclusivity, and the green economy collectively contribute to sustainable economic growth, decent work, and inclusive employment opportunities (Raman *et al.*, 2022).

This framework illustrates a pathway to achieving SDG 8 by fostering a green economy through sustainable tourism management practices and gender-inclusive entrepreneurship in the hospitality sector. The interdependence of these elements emphasises a holistic approach to economic growth that values both environmental sustainability and social inclusivity.

Along with the conceptual framework, our study proposes some more future research agendas, as the review underscores the pivotal role of women's business ownership in advancing gender equality and contributing to the SDGs set by the United Nations. Prioritising access to funding, training, and mentorship programs for women within the tourism sector emerges as a critical agenda for policymakers. Furthermore, there is a pressing need for tourism policies that foster sustainable entrepreneurship by promoting eco-friendly tourism activities, supporting community-based enterprises, and implementing certification programs for sustainable tourism (NilgünAvcı, 2022). The review highlights the critical role of women's business ownership in advancing gender equality, creating economic value, and contributing to the achievement of the United Nations' SDGs. However, to maximise these impacts, future research must address several key areas that can provide actionable insights for policymakers, business leaders, and community organisers.

The access to financial resources remains one of the most significant barriers for women entrepreneurs, particularly in tourism. Research could explore models for improving funding accessibility, such as microfinance programs, low-interest loans, or government-backed grants tailored specifically for women in tourism. In-depth studies on the effectiveness of these funding initiatives and their impact on women's business longevity and growth in various regions could provide policymakers with data-driven guidance. Moreover, future studies may investigate the role of public-private partnerships in establishing training, mentorship, and networking platforms to strengthen women's participation in tourism entrepreneurship.

Training and mentorship are essential to empower women with the knowledge and skills to succeed in the competitive tourism industry. Future research may examine the effectiveness of various training methodologies (*e.g.*, experiential learning, digital learning platforms, peer-led mentorship) in enhancing women entrepreneurs' capabilities. Understanding the impact of mentorship networks within the tourism sector, especially in underrepresented communities, could shed light on effective practices for fostering mentorship relationships (Naderi *et al.*, 2019). Future research may also delve into the efficacy of eco-certification programs, the role of green marketing, and the economic impact of eco-friendly practices on local communities. One can expand this agenda to include examining the policy frameworks that encourage sustainable entrepreneurship and how these frameworks could be optimised to promote higher levels of compliance and innovation among women-led tourism businesses. Comparative studies on countries with established green tourism policies may offer insights into best practices for implementing similar policies in developing regions (de Lange & Dodds, 2017).

The lack of necessary knowledge and skills is a substantial barrier that limits the growth of women entrepreneurs in tourism. Research on skill development programs tailored to women in tourism may assess the effectiveness of programs that focus on management, marketing, and digital competencies. Exploring the potential of digital technology and social media in bridging knowledge gaps and creating virtual communities for women entrepreneurs could provide valuable insights. Comparative studies across different geographic and cultural contexts may also reveal unique challenges and tailored approaches to skill-building in tourism entrepreneurship (de Lange & Dodds, 2017).

The volatile nature of tourism due to external factors such as economic fluctuations, pandemics, and climate change impacts demands resilience. Future research may explore adaptive policy measures that bolster the resilience of women entrepreneurs in tourism. Examining risk management training, disaster response frameworks, and sustainable business practices can help women-led businesses withstand and recover from crises. Research on policies that foster resilience and adaptability in tourism could lead to actionable recommendations for supporting women entrepreneurs in navigating challenges and sustaining growth (Tovmasyan, 2022).

By addressing these research directions, future studies can contribute to a more inclusive, sustainable, and resilient tourism industry where women entrepreneurs play a leading role in driving socio-economic progress.

Policy Implications

The intersection of gender and sustainable tourism entrepreneurship presents unique challenges and opportunities that warrant targeted policy interventions. The following policy implications address the

critical areas identified in this study, underscoring the need for gender-responsive, multilevel policies that support sustainable practices within tourism entrepreneurship.

To promote gender equity within sustainable tourism, it is essential for policymakers to design and implement gender-responsive policies. Such policies would not only encourage women to engage in sustainable tourism but also provide a supportive environment for them to thrive. One can also focus on policies that tackle gender-specific barriers, such as limited access to funding, training, and mentorship. By fostering an inclusive ecosystem, governments and tourism agencies can better support women in adopting sustainable practices and growing their ventures (Kutlu & Ngoasong, 2023). Furthermore, the role of gender in shaping entrepreneurial attitudes toward sustainability requires exploration, as it can inform strategies for fostering eco-friendly business practices. Golik and Wasilczuk (2025) confirm that gendered entrepreneurial identity strongly influences sustainability-oriented decision-making in tourism enterprises.

Women entrepreneurs often face unique obstacles in implementing sustainability initiatives due to limited access to resources, networks, and training. Policy interventions can focus on creating accessible pathways for women to adopt eco-friendly practices. Subsidies, tax breaks, or grants could incentivise sustainable practices among women-led tourism businesses. Moreover, policies that encourage the formation of networks, alliances, and cooperatives specifically for women in tourism could help them share resources, knowledge, and strategies (Alarcón & Cole, 2019). To ensure the effectiveness of these policies, governments could establish monitoring systems to measure the impact of gender-responsive sustainability policies on women entrepreneurs in tourism. Shrestha *et al.* (2024) found that gender-focused sustainability training combined with peer-based mentoring significantly enhanced the adoption of circular economy models among women-led tourism SMEs.

The gendered impact of economic sanctions and foreign policy on women in the tourism sector highlights a critical policy gap. Policies that account for the effects of statecraft on tourism-related businesses can help mitigate unintended negative consequences for women. Governments and international organisations could consider creating sanction relief programs to support women entrepreneurs in regions affected by economic or political instability. Research on the effects of foreign policy on women's empowerment in tourism may emphasise the need for adaptive, gender-sensitive policies that provide a safety net for women entrepreneurs in tourism during periods of economic sanctions or political challenges (Seyfi *et al.*, 2022). Stylianou *et al.*, Liasidou, and Garanti, (2025) explain that crisis-responsive tourism policies with gender considerations have proven effective in post-conflict tourism recovery strategies.

The extant literature on tourism entrepreneurship reveals that many existing policies do not include all entrepreneurial demographics, often overlooking women and other marginalised groups. To address this gap, policymakers must adopt an inclusive approach to tourism entrepreneurship. This may involve setting diversity targets for tourism grants, implementing mentorship programs specifically for underrepresented groups, or incorporating gender diversity criteria into tourism development policies. A comprehensive framework that promotes inclusivity would enhance economic opportunities and foster a more diverse and resilient tourism sector. In particular, inclusive policies could focus on promoting women-led small and medium enterprises (SMEs) in rural areas, where women entrepreneurs often have the potential to bring significant socio-economic change (Ratten, 2020). Dy and MacNeil (2025) emphasise that intersectional approaches targeting rural, ethnic, and older women can significantly improve inclusivity outcomes in sustainable tourism programs.

The adoption of a multilevel model to understand sustainable entrepreneurship in tourism requires policy alignment across individual, organisational, and national levels. This approach suggests that sustainable entrepreneurship policies should be designed to address distinct challenges at each level. For instance, at the individual level, policies could focus on entrepreneurial education and capacity-building initiatives tailored to women. At the organisational level, incentives for adopting sustainable practices, such as certifications or recognitions for eco-friendly businesses, could drive organisational commitment to sustainability. At the national and regional levels, broader policy frameworks promoting green tourism infrastructure and sustainable practices could be implemented. Such a multilevel policy approach would create a cohesive support system, fostering sustainable entrepreneurship across different scales of operation (Crnogaj *et al.*, 2014; Figueroa-Domecq *et al.*, 2022; Stylianou *et al.*, 2025).

To ensure that gender-responsive policies effectively support women entrepreneurs in sustainable tourism, governments must establish monitoring and evaluation (M&E) systems. These systems would track policy outcomes, measuring the extent to which women-led tourism enterprises benefit from sustainability initiatives. Data collection on the effectiveness of policies, such as access to funding, mentorship, and eco-certification programs, would offer insights into areas for improvement. Moreover, M&E systems could also incorporate feedback from women entrepreneurs to make policies more responsive to their needs. Through transparent and accountable policy evaluation processes, governments can continuously refine their approach to supporting women in sustainable tourism entrepreneurship (Figueroa-Domecq *et al.*, 2022).

Sustainable tourism is a global issue that requires international cooperation to address. Policies that encourage cross-border collaboration and knowledge-sharing can help develop gender-responsive and sustainable tourism practices worldwide. Governments could create bilateral or multilateral programs to facilitate the exchange of best practices, technological innovation, and funding opportunities, particularly for women-led tourism businesses. By working together, countries can develop joint initiatives that support women entrepreneurs in sustainable tourism, fostering resilience and growth in the sector.

These policy recommendations aim to create a more inclusive, sustainable, and resilient tourism industry where women entrepreneurs can play a central role in driving socio-economic progress. By prioritising gender equity and sustainable practices, policymakers can help build a tourism industry that not only contributes to economic growth but also supports environmental preservation and social well-being.

CONCLUSIONS

The role of women entrepreneurship in advancing gender inclusivity and sustainable tourism development plays a great role in advancing the country's economic condition. We examined the structural barriers and enabling factors that influence women's participation in tourism entrepreneurship and synthesises key themes and conceptual frameworks. Through a dual analytical lens, combining feminist critique and sustainability discourse, we revealed persistent gender disparities in access to resources, institutional support, and policy recognition, while also identifying opportunities where women's entrepreneurial efforts foster environmental stewardship, community resilience, and socio-economic progress (Martínez Caparrós, 2020).

The study offers actionable insights for tourism practitioners, policymakers, and business leaders. Tourism enterprises and destination managers can promote inclusivity by implementing gender-sensitive policies, mentorship programs, and women-led innovation initiatives. Hospitality organisations should prioritise work-life balance, leadership development, and equitable career pathways for women. For policymakers, the study emphasises the need for gender-responsive tourism frameworks. Targeted interventions, such as financial access programs, microcredit schemes for women-led startups, and green entrepreneurship incentives, empower women in the sector. Governments should align tourism policies with SDG 5 (gender equality) and SDG 8 (decent work), ensuring women's contributions are recognised and amplified. Authorities should also establish rigorous monitoring systems to assess the effectiveness of gender-inclusive policies. Women's entrepreneurship in tourism challenges traditional gender roles, fosters inclusive growth, and elevates local communities in global tourism narratives. By valuing women's economic participation, societies can drive cultural shifts toward greater equity, sustainability, and shared prosperity.

The study is not without limitations. It may overlook region-specific insights, unpublished data, and non-English research that could provide deeper contextual understanding. The proposed conceptual framework remains theoretical and requires empirical validation through case studies, cross-country comparisons, and participatory research. Future studies may adopt an intersectional approach, considering factors like ethnicity, class, and geography, to develop more inclusive tourism models.

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Use of Artificial Intelligence

The manuscript is free of AI/GAI usage.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Is digitalization necessary for e-commerce adoption at small and medium-sized enterprises? The pandemic effects

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A B S T R A C T
Objective: The study aimed to conduct a comparative analysis of e-commerce adoption in small and medium-sized enterprises (SMEs) of Pakistan and Bangladesh in the period following the COVID-19 pandemic. This study aims to observe in detail the significance of e-commerce adoption for small and medium sized enterprises, their abilities to evolve consumer preferences and to dissect the challenges that hinder in the way of e-commerce adoption in Bangladesh and Pakistan. The key focus of this study was to find out how digitisation acts as a moderator to overcome challenges.
Research Design & Methods: We based the study on a quantitative design using a structured questionnaire to collect data from 500 SMEs with 250 respondents from each country, Bangladesh and Pakistan. We collected the study sample through a stratified random sampling from key industrial cities in both countries. We analysed the data of the study with SmartPLS version 4.0 to explore the relationship between external factors, need-bead factors, organisational factors, technological factors and e-commerce adoption with digitisation as a moderator.
Findings: This study has also examined that market related demands and the access to the technology has significant positive impact on digitisation in both countries. However, company's resources and cultural factors that are related to the organisational factors have negative impact on digitisation in Bangladesh and Pakistan. The multi-group analysis composed to find the distinguishing factors among two countries, found the impact of all the factors on digitisation.
Implications & Recommendations: We observed a crucial role of digitisation in different fields to adopt e-Commerce in SMEs of Pakistan and Bangladesh. This study has been conducted in the time of COVID-19 pandemic, suggests that it should be the top priority of the policymakers to focus more on digitisation to enrich the country's economic and digital infrastructure. The partnership programs can help both countries improve digitisation on modern standards. Findings suggests combined strategies to boost economic stability of both countries. However, this study has some limitations and future suggestions to entertain the role of artificial intelligence (AI) to examine the adoption of e-Commerce in both countries.
Contribution & Value Added: This study has provided a qualified analysis of the drivers of e-commerce adoption in SMEs of Pakistan and Bangladesh in the specific context of the post-COVID-19 pandemic, with digitisation as a moderator. It offers novel insight into the different types of challenges faced by SMEs in both countries and in the transformation of digitisation in the South Asian region.

Article type:	research article
Keywords:	pandemic; e-Commerce; digitisation; Pakistan; Bangladesh
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INTRODUCTION

The COVID-19 pandemic has had a profound impact on the world, especially regarding the way businesses function. A key change has been the rising popularity of e-commerce, driven by people's

desire to minimise physical interactions. This shift to online shopping has rapidly gained momentum and is expected to persist even after the pandemic recedes. Consequently, there has been a surge in demand for e-commerce platforms, with traditional establishments also adapting by incorporating online sales channels into their operations (Farmaki *et al.*, 2020).

Consumer behaviour has also changed in the wake of this global crisis (Kułyk & Michałowska, 2016). We can now buy products typically purchased in local stores through online retailers, expanding into new categories such as groceries or homewares while minimising transmission risks, especially with the increasing adoption of mobile payments (Hayashi & Bradford, 2014). As consumer trends fundamentally change during this challenging period, companies that rely on face-to-face interactions have no choice but to accelerate their digital transformation initiatives. This drives sellers to become more adaptable to existing technologies such as customer experience and delivery (Gourinchas, 2020). Consequently, such sharp changes brought substantial growth potential with contractors looking increasingly back at building out requirements based on data proactively gathered transforming themselves before upsetting fragile industries influenced predominantly impacts. Such timely adaptation highlights the earthen-like importance of cultivating both indeed successful readings within still operating uncertainty giving voice to humanity's welfare across ecosystems (Syriopoulos, 2020). The pandemic has highlighted the importance of having an online presence and adapting quickly to changing consumer behaviour. There is a close relationship between e-commerce adoption and digitisation. The term 'digitisation' refers to the transformation of information from analogue to digital. In that case, the information is transferred through different sources. E-commerce is electronic commerce that involves digital technology for buying and selling products and services (Chaudhuri & Kumar, 2015). As the digitisation increases in the society, e-commerce will prosper more and more. The prosperity factor of e-commerce is directly linked with awareness and propagation of digitisation in businesses. Digitisation has increased the chance for companies and firms to prosper their businesses by selling and engaging with consumers over the Internet through different mediums (Bashir *et al.*, 2023). Websites have been a platform to introduce e-commerce to the world. Now, smartphone applications, and social media platforms are involved in e-businesses. Consumers' direct access to the online stores is 24/7 with unlimited brands and products (Bhatti *et al.*, 2020). Digitisation has transformed the payment system in businesses (Marushchak *et al.*, 2021). The online transaction process is the best example of digitisation. Digital payments eased the consumers to pay for products anytime, anywhere without any hassle. The invention of 'digital payments' accounts has eliminated the cash-carrying risk. The system of online payment is not only easy but also offers a safer and more convenient mode of shopping (Fatonah *et al.*, 2018).

The remote way to observe the factors driving e-commerce adoption in SMEs is the need-based approach (Huseynov & Yıldırım, 2017). What are the common challenges that a small or medium-sized industry has to face to adopt e-commerce? These challenges have different aspects. The challenges are not common in the developed and developing world, rather the developing world faces different types of challenges. It includes the process of facilitation to the consumers regarding the products, minimising the risk of fraudulent payments and settling the easy instalment plans because the people in the developing world are not all rich enough to pay the price. In the COVID-19 pandemic, need-based challenges converted into survival challenges for the SMEs. Millions of SMEs were affected during the COVID-19 pandemic and many more came to an end (Ahmed *et al.*, 2020). Moreover, SMEs observed lockdowns, limitations and restrictions all over the globe. In that time, product-making processes, and supply chains were disrupted (Bhatti *et al.*, 2020). E-commerce adoption was the only hope for the businesses to stay alive in despair.

This research examined the 'role of digitisation' as a moderator to examine the adoption of e-commerce in the COVID-19 pandemic. The process of digitisation for the SMEs was slow before the COVID-19 pandemic. However, the pandemic sped up the digitisation for small and medium-sized enterprises in the developing world. Several studies in the developing world have observed the e-commerce adoption in the post-COVID period (Ahmed & Kumari, 2022; Higueras-Castillo *et al.*, 2023; Kumari & Ahmed, 2022). Scholars observed that the adoption process was slow but progressive, and there was no urgency to accomplish the transformation of business to e-business. However, researchers noted a remarkable shift after the COVID-19 period and during it (Akpan & Ibidunni, 2021).

Digitisation has offered a variety of benefits to SMEs by enhancing their profit margin, minimising their problems and providing a better and enhanced payment system, which is the cashless process of purchase and buying (Parviainen *et al.*, 2017). This process is secure, unique, and consumer-friendly. Cost reduction is the prominent benefit that every small and medium-sized enterprise enjoys. Owning a store in a luxury apartment building, and making slow progress, was much more painful than offering products online by creating a website, smartphone application and similar services (Ritter & Pedersen, 2020). This is the reason; policymakers and stakeholders prioritized the e-commerce adoption through digitisation process. Digitisation has progressed and sped up the delivery of products on time, inspecting the location of the product and observing the supply chain process smoothly (Hossain *et al.*, 2022). In a classic business environment, it takes time to transfer the product, make a shipment, and notify the consumer when the product will be delivered, and how the payment will be made. In the digitisation era, the consumers place the product order online with several modes of payment available (Akpan & Ibidunni, 2021).

E-commerce adoption and digitisation are interlinked with each other. The interlinking process of digitisation is simple, because it is a part of electronic technology. It works as a framework. The role of digitisation is the role of a kernel in a computer system, which links the hardware and software in a system (França *et al.*, 2018). Without a kernel, the communication between hardware and software is not possible. The case with digitisation is similar. It serves the purpose of kernel between consumer and e-commerce (Jamil, 2021; Alam, 2023). The availability of smartphone applications, websites, social media platforms, and user-friendly networks has made e-commerce an opportunity for consumers and buyers (Fedorko *et al.*, 2018). Every business has strategic goals to achieve in a certain period. Digital transformation is the process of using tools and processes to achieve the target in the business. It helps fulfil the target (Santos-Jaén *et al.*, 2023). It has a diverse role to mutually meet the requirements of the consumers and organisations at the same time. Innovation in the field of digitisation has minimised the distances between the consumer and the producer and SMEs. Online stores have a special place in the minds of consumers. Providing a better experience to the consumer is the goal of every e-commerce company. It is the first and foremost duty of a company to handle its customers with care. Customers of e-commerce are fragile. Therefore, it is necessary to keep a customer happy, safe and attached to the store (Baubonienė & Gulevičiūtė, 2015). Through digitisation, companies can reach out the customers with the help of artificial intelligence (AI) tools that are built into the system. These tools observe the needs of the consumer, note down every click, time of staying, and observing a product, showing interest, etc. Through this, the AI tool offers the customer what a customer needs. We call this process personalisation (Bawack *et al.*, 2022; Goy *et al.*, 2007; Khrais, 2020). The personalised traffic is easy to deal with, and customers are eager to buy a product of AI's choice.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

E-commerce Adoption

E-commerce has become important for businesses as more consumers turn to online shopping, especially in the time of COVID-19 pandemic. The purpose of this literature review is to investigate the factors affecting e-commerce and its impact on business performance. Many studies have identified factors that influence e-commerce performance, such as operational planning, external stressors, and consensus. For example, research shows that strategic planning (including IT infrastructure, organisational culture, and workforce planning) is a critical factor in e-business adoption (Poong *et al.*, 2006). Other variables paying external pressures are the rules and regulations of the government and competition. Research proves that perceived benefits have a positive impact on e-commerce adoption (Chandra & Kumar, 2018).

Researchers have also studied the impact of e-commerce on business activities. Research consistently showed the role of e-Commerce with plus impact on business performance, including amplified sales, profit margin and consumer satisfaction (Yadav & Mahara, 2018). Moreover, the positive impact of e-commerce is particularly evident for small and medium-sized enterprises (SMEs), which is benefi-

cial to increasing the number of customers and reducing transaction costs (Bite *et al.*, 2020). Advantages and challenges in e-commerce goes side by side. There are major issues, one such issue is scarcity of skills and resources in SMEs. Security and privacy concerns and high initial investment are another challenges that hinder the adoption of e-commerce (Lertwongsatien *et al.*, 2004). If a business stays competent, e-commerce adoption is the first adoption kit for it. Along with it, planning, pressure and benefits goes side by side as key determinants of e-commerce.

The e-commerce Adoption Framework

Scholars widely use diffusion of innovations (DOI) and technology acceptance model (TAM) methods in e-commerce research. Rogers and Cartano's DOI development (1962) 'suggests that the use of new technologies is influenced by factors such as: relative advantage, compatibility, complexity, trialability, and observability.' Meanwhile, TAM framework, developed by Davis (1968) which was stated that the intention to use technology is affected by perceived usefulness and perceived ease of use. Both frameworks are popular in the context of e-commerce adoption (Jacob *et al.*, 2020). Moreover, Ahmed *et al.* (2020) found that the DOI framework is useful in explaining e-commerce adoption. The relative advantages of e-commerce, such as efficiency and cost savings, are important factors in e-commerce adoption. Furthermore, Wani and Ali (2015) found that compatibility with existing business practices and values is important for the use of e-commerce. Complexity and trialability have also been found to influence e-commerce adoption (Marangunić & Granić, 2015).

Scholars widely use the TAM framework in e-commerce research. According to Tanos *et al.* (2024), perceived usefulness and perceived ease of use are the most important factors in e-commerce studies. A study by Ajibade (2018) found that perceived usefulness and ease of use were beneficial to Korean SMES suggesting adopting e-commerce. Moreover, the TAM framework can serve to predict the usage of various types of e-commerce, trading, and marketing (Abualrob & Kang, 2016). Diffusion of innovation and TAM define the key elements that influence e-commerce, such as perceived value, perceived ease of use, and relative advantage (Paris *et al.*, 2016).

Factors Relating to e-Commerce Adoption

E-commerce has changed the way modern businesses operate. It has created new opportunities for businesses and consumers around the world. In this process, it is mandatory to define e-commerce. E-commerce refers to the process of integrating online innovative technologies into businesses, allowing them to sell goods and services from online platforms and websites. The reasons to adopt e-commerce in SMEs are diverse and complex (Chowdhury *et al.*, 2021). However, the advantages of e-commerce for organisations are global scale, cost reduction, supply chain simplification, 24/7 business open, fast production, and product introduction. The benefits of e-commerce adoption for consumers and customers are anonymity, ubiquity, choice to choose between the large selection of products, personalisation, prompt delivery, cheap delivery charges, no-travel costs. The benefits of e-commerce for society include availability of a wide range of services, improved standards of living, improved national security, online sales, and reduced digital divide (Panasenko *et al.*, 2021). In the case of digitisation, it has been removing a singular link between the consumers and shopping. Through e-commerce, digitisation has enabled a direct interaction among the consumers and salesmen, and in some cases, it has enabled the consumers to establish a link with manufacturers (Zhang, 2021). Digitisation has improved the consumer satisfaction index (Sesar *et al.*, 2021). In cross-border e-commerce trade, digitisation has played an important role to establish a strong link, making it convenient and efficient. The use of digital technology has accurately located the target markets, helped the manufacturers to develop new customers, improved customer satisfaction and sales (Luthfiandana *et al.*, 2024). Digitisation strongly supports foreign trade, and supply chain management. It helps to reduce costs, upgrade logistics and improve customer experience. However, there are some challenges attached to e-commerce and digitisation (Mihailă *et al.*, 2021). In the case of protecting consumer rights, providing security to the customers, dealing with complex financial issues and regulatory policies etc. (Mihailă *et al.*, 2021). To this end, we hypothesised:

H1:   Digitisation has a strong positive impact on e-commerce adoption in Pakistan and Bangladesh.

External Environment Factors: Perceived Benefits

Another important factor affecting e-commerce is the 'perceived benefits of e-commerce' (Ismail & Masud, 2020). It has been argued that companies are eager to adopt e-commerce if they believe that e-commerce will bring them benefits such as increased sales, improved customer relationships, and reduced costs. Many factors cam affect the perceived benefits of e-commerce, such as the market in which the company operates, the level of competition and the company's overall strategy. Internet infrastructure is also an important factor affecting the implementation of e-commerce. According to Ismail and Masud (2020), companies located in regions with better communication will be more likely to adopt e-commerce. This is because e-commerce requires reliable, high-speed Internet connections, and companies located in areas with poor Internet connectivity may have difficulty using e-commerce (Emon *et al.*, 2023; Shahriar, 2024).

H2: In Pakistan, in comparison to Bangladesh, the adoption of e-commerce increased more due to external environmental factors after the COVID-19 pandemic.

H2a: External environmental factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.

Need-based Factors

E-commerce has become an important part of the modern business world, providing many benefits to consumers and businesses. However, many factors influence market acceptance of e-commerce. These include demand-driven requirements. One of the main factors affecting e-commerce is the need for online sales. Research shows that companies that are more involved in online sales are more likely to adopt e-commerce (Vaidya & Khachane, 2017). The need for e-commerce can arise from many factors such as the competitive environment, customer needs, and cost savings (Jacob *et al.*, 2020). Another demand-based factor affecting e-commerce is the size of the company. Small and medium-sized businesses (SMES) seem to have a greater need for e-commerce due to limited resources and the need to compete with large companies (Onjewu *et al.*, 2022). In contrast, larger companies may find that they have a lower need to adopt e-commerce because they have established sales pipelines. Furthermore, IT infrastructure and the level of expertise within a company are other demand-driven factors that influence e-commerce implementation. Companies with a higher level of IT infrastructure and expertise will be perceived to have a greater need for e-commerce (Cuellar-Fernández *et al.*, 2021). This is because they have the resources and talent to effectively build and manage e-commerce platforms (Alam *et al.*, 2022; Rana *et al.*, 2022). The perceived risk associated with e-commerce also affects the demand for e-commerce implementation. Companies that perceive higher risk in adopting e-commerce are less likely to adopt e-commerce (Paris *et al.*, 2016). These risks may include security issues, privacy concerns, and uncertainty regarding return on investment. However, many demand-driven factors influence e-commerce, including the need to sell online, company size, IT infrastructure and expertise, and the risk involved (Garai *et al.*, 2023). Understanding these factors can help businesses make e-commerce decisions and develop effective e-commerce strategies.

H3: After the COVID-19 pandemic, the need-based factors led to a greater adoption of e-commerce in Bangladesh compared to Pakistan.

H3a: Need-based factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.

Organisational Factors

Another important factor affecting e-commerce is the organisationsize. According to Chandra and Kumar (2018), small businesses are more likely to adopt e-commerce because they have less capital and can benefit more from cost savings and business efficiency. Large organisations may be less likely to adopt e-commerce because their operations may be more complex and more resistant to change. Organisational culture is an important institution in influencing e-commerce. Organisational culture refers to the shared

values, beliefs, and behaviour that shape the behaviour of the organisation. A study by Chandra and Kumar (2018) and Emon *et al.* (2023) revealed that organisational culture affects e-commerce culture. Organisations with a culture that prioritizes innovation and risk-taking are more likely to adopt e-commerce. Therefore, organisations need to create a culture that values innovation and risk-taking to make e-commerce more profitable. Culture is another important institution that affects e-commerce. Managers play an important role in improving behaviour and decision-making, and their support is essential in e-commerce implementation. A study by Peterson (2004) found that corporate support affects e-commerce performance. Therefore, organisations need to have a culture that supports increasing the adoption rate of e-commerce. Capital is also an important institution that affects the e-commerce business. Adopting e-commerce requires significant investments in technology, infrastructure, and human resources. A study by Alqodsi (2021) found that resources influence e-commerce adoption, with organisations with more resources being more likely to adopt e-commerce. Therefore, organisations need to have adequate resources to invest in e-commerce adoption to increase adoption rates.

H4:   The adoption of e-commerce increased more in Bangladesh compared to Pakistan after the COVID-19 pandemic due to organisational factors.

H4a: Organisational factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.

Technological Factors

One of the most important factors guiding e-commerce is the company's willingness to use new technologies. According to Hossain *et al.* (2022), companies with more technology are more likely to adopt e-commerce. This is because e-commerce requires significant technology investment, and companies that are already using advanced technology have the necessary skills and expertise to incorporate e-commerce into their business. User experience is an important technology that affects e-commerce applications. User experience includes ease of navigation, user interface design, website loading speed, and overall website functionality. Pedro *et al.* (2015) showed that user experience is the most important factor in e-commerce. Therefore, e-commerce websites should be designed to enable communication and interaction with users, and their implementation should be encouraged. Security is another important technology in e-commerce. Online shoppers need to feel safe when shopping online, and e-commerce platforms need to provide secure payment systems and protection against cyber threats. Kaiser *et al.* (2021) found that perceived security and trust in e-commerce platforms are important factors in the e-commerce decision-making process. Therefore, e-commerce platforms need to prioritise security measures to increase customer trust and adoption. The widespread use of smartphones has made it important for e-commerce platforms to have mobile-responsive websites and mobile applications. The accessibility of mobile devices also affects e-commerce. Consumers prefer to shop from mobile devices due to convenience and ease of use (Oliinyk *et al.*, 2023). Therefore, e-commerce platforms need to ensure mobile compatibility to increase adoption. Technology infrastructure is an important technology in e-commerce. E-commerce platforms need advanced technology to provide high-speed internet, payment security, and flawless website performance (Emon *et al.*, 2023; Przetacznik, 2022). Axman and Kročová (2019) found that technology is an important determinant of e-commerce. Therefore, e-commerce platforms need to prioritise investing in technology to increase adoption.

H5:   After the COVID-19 pandemic, the adoption of e-commerce increased more in Pakistan compared to Bangladesh due to technological factors.

H5a: Technological factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.

Research Gap

Based on the extensive literature review, there are many different potential research areas in e-commerce that need further research. Literature analysis discusses various aspects such as technology, collaboration, external environment, and internet usage. Further research can focus on understanding the interrelationship and importance of these factors. Examining how these factors interact and how together they influ-

ence e-commerce's decision-making can provide further insight. The studies generally broaden the perspective on e-commerce adoption factors. This study shows how these conditions play out differently in different sectors, regions, and organisations. This provides an intuitive understanding of the changing context for e-commerce adoption. The literature review focuses on corporate values, but cultural and social factors can also play a role in shaping attitudes and decisions regarding e-commerce adoption, as observed in the study of Hendricks and Mwapwele (2024). Investigating how culture and tradition influence decision-making, especially across different cultures, is an interesting area of research. While the literature mentions benefits of e-commerce to businesses, there are also different studies examining its long-term benefits. Investigating whether there are positive effects over time or whether there are problems after the adoption of e-commerce may provide further information. This study focuses on the diffusion of innovations (DOI) and technology acceptance model (TAM) models. This study will help future researchers to discover and develop newer strategies such as digital transformation, online platform marketing, and data decision-making. Whereas, issues and problems persist, such as a lack of digital skills among consumers, security breaches and theft issues and high investment. However, the solution lies in analysing practices among e-commerce platforms, successful strategies adopted by small and medium-sized enterprises to overcome challenges. According to previous literature, it has been supposed that SMEs will benefit by adopting e-commerce in their respective firms, which will broaden their scope and reach.

Theoretical Framework

Technology organisation-environment (TOE) developed by Tornatzky and Fleischer (1990) forms the basis of the study's theoretical design. This framework presents three factors that influence SMEs, *i.e.*, technological advancements, organisation upgradation, and external environmental factors. The organisational context refers to the resources of the firms, employees' structure, a process of communication between the firms. This study examined organisational factors to identify the relationship between the innovation adoption process. The environmental context includes industry's structure, firm life cycle, availability of technology, and its providers. We observed the structure of the industry in the form of intense competition and innovation adoption. Researchers observed that a rapidly growing industry tends to adopt innovation better than others. However, in reverse, if a company is in decline, it cannot be said it is due to non-innovative practices (Baker, 2011). One can furnish the TOE framework according to the COVID-19 pandemic-related e-commerce adoption. We modified the TOE framework to include demand-driven dimensions to explain SMEs' e-commerce ubiquitously after the COVID-19 pandemic. We based the demand on demand available online, the need to reduce costs and the need to enter new markets. The TOE framework suggests that three factors influence the technological innovation in organisations, *i.e.*, technology, organisation, and external environment. Building on this framework, this study brings together insights from previous studies to shed light on the e-commerce performance of SMEs post-COVID-19. Technology availability and performance influence SMEs' adoption of e-commerce (Ajibade, 2018; Marangunić & Granić, 2015). An emphasis on preparation and compatibility is important in determining the successful integration of e-commerce platforms. In e-commerce, the size of the organisation and formal and informal communication play an important role. According to the study of Chandra *et al.* (2018), design and internal communication processes are relevant factors in e-commerce decision-making. Government policies, business models, and technological processes support the activities of small and medium-sized businesses. Chandra and Kumar (2018) underscore the importance of government policies and industry ecosystem dynamics on SMEs' technology adoption strategies. This study continues TOE's mission to include needs as a key factor in explaining SMEs' e-commerce in the wake of the COVID-19 pandemic. These factors include the need for an online presence, cost reduction costs, and entering new markets. Evidence from studies by Vaidya and Khachane (2017) shows that there have been post-pandemic changes in consumer and business behaviour, creating significant demand for SMEs.

These factors will become more important for SMEs due to changes in consumer behaviour and business practices after the pandemic. Digitalization will be included as a moderator in the revised TOE framework. Digitalization refers to the extent to which companies adopt digital technologies to transform their business processes and operations. The degree of digitisation should ensure a good relationship between needs and the use of e-commerce. The size of the organisation, informal

and formal systems, and communication systems also influence the use of e-commerce (Gallant, 2024). Environmental factors such as government regulations, business models, and technology trends can also affect SMEs' use of e-commerce.

We introduced the concept of digitalization as a practical step in the reform of the TOE framework. Digitalization, defined as the degree of integration of digital technologies in the transformation of the economy, should ensure the relationship between needs and the acceptance of e-commerce. According to the findings of Parviainen *et al.* (2017), the positive impact of digitalization demonstrates its ability to expand or reduce the impact of demand for e-commerce products. The revised TOE includes demand-driven requirements and digitalization as moderators to explain SMEs' e-commerce after COVID-19. Combining insights from previous research with a cross-sectional study framework, we sought to better understand the underlying mechanisms driving e-commerce implementation in the evolving business environment.

RESEARCH METHODOLOGY

Research Design

We employed across-sectional survey with a structured questionnaire to collect data from the target population. Small and medium-sized enterprises encountered the profound impact of the COVID-19 pandemic over the course of a year, during which these SMEs transformed their business operations over the Internet (Abuhussein *et al.*, 2023). This change made products more convenient for customers, ensured on-time delivery, and supported cashless payment options. The COVID-19 pandemic has had a huge influence on the health of people, including employees and managers working in small and medium-sized businesses around the world. Strict COVID-19 regulations imposed by the government have caused consumers to turn to online platforms to purchase products. Simultaneously, existing online platforms were also benefiting from this change in consumer behaviour. Digitisation has become a key strategy for these SMEs, allowing them to store information online for easy access from anywhere in the world while reducing operating costs. This includes information collected from websites, social media platforms, and similar online sites. Small and medium-sized businesses in both Pakistan and Bangladesh saw digitalization as a way to reduce supply costs, ensure continuous customer engagement, and solve problems arising from the government's COVID-19 lockdown.

We established the comparative structure of the two diverse population from Pakistan and Bangladesh by collecting data. The segmentation was clear to justify two national cohorts for direct comparison. The TOE framework guided the selection of specific factors to examine in the study. In SmartPLS, the core-technique adopted to compare two countries data was through multi-group analysis (MGA), which allows to inspect the difference with path coefficient variability. We used path coefficient values as statistical indicators to represent direction and strength among different factors. Moreover, P-values determined the statistical significance of relationship among countries and MGA calculated the 'differences' between hypothesized relationships.

The independent factors included in the study were: (1) need-based factors, (2) external environment factors, (3) organisational factors, (4) technological factors, and the dependent factor of the study was (5) e-commerce adoption. There exist several researches on Hungarian companies' export activities from macroeconomic.

Sampling

Small and medium sized enterprises in Pakistan and Bangladesh were the study's target population. We selected the sample using stratified random sampling which increased the chances of data collection. For the study, we selected a sample size of 500 SMES. We divided the sample into two sections, 250 respondents from each country (Bangladesh, Pakistan) participating in the study. The target industrial cities in Pakistan were Faisalabad, Lahore, and Karachi, in Bangladesh; Dhaka, Chittagong, and the Dhaka-Chattogram industrial corridor, Bangabandhu Sheikh Mujib. We limited the sample of the study limited to 500 respondents through statistical considerations of power analysis for the SmarPLS tests. Similar studies of Abtahi *et al.* (2023) and Azam *et al.* (2023) have adopted the similar pattern.
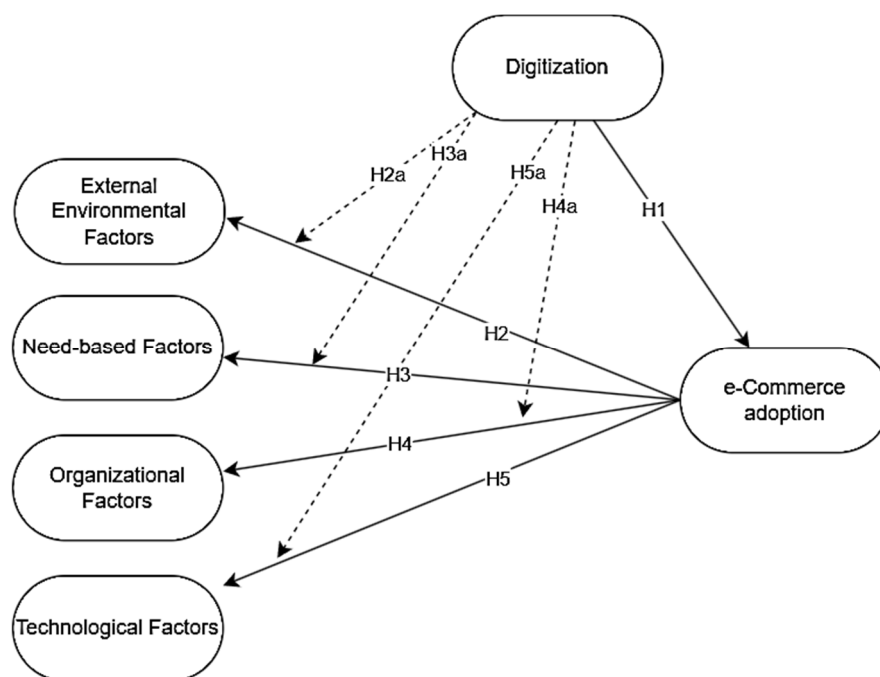
Figure 1. Conceptual Framework of the Study
Source: own elaboration in draw.io.

Data Collection

We used a structured questionnaire to collect data from the SMES in Pakistan and Bangladesh. To carry on the research process, it was necessary to transform the questionnaire into an online platform to circulate the link between the SMES of Bangladesh and Pakistan. We designed the questionnaire based on the research objectives and hypotheses of the study. The questionnaire is pre-tested to ensure that it is clear, concise, and easy to understand. We conducted a pilot study to pre-test questionnaire's reliability and validity. The main purpose to conduct pre-testing was to ensure that the structured questionnaire was concise to collect data, understandable to the targeted SMEs in Pakistan and Bangladesh. The pilot testing targeted 30 samples, 12 from Bangladesh, and 18 from Pakistan. Once we achieved satisfactory refinement, we circulated full-scaled questionnaire to collect data from each country. We collected the data with a 5-point Likert scale, (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. We collected the primary data from the SME employees, including the (1) manager, (2) supervisor, (3) junior staff, (4) procurement manager, and (5) others (Training & Diplomas). The data collection process started in August 2022 to June 2023. We used English in the questionnaire development, which is understandable for both countries. However, the questionnaire has been translated into Urdu and Bengali for a proper understanding of the questions for the respondents of Pakistan and Bangladesh.

RESULTS AND DISCUSSION

The Table below provides demographic details of the respondents. It shows their gender, age, educational level, position in the SMES, and type of e-commerce industry.

Respondents were men and women as observed in the Table 1. Male respondents constituted 420 (84.0%), whereas female respondents – 80 (16.0%). We categorised respondents by age as follows: between 21 and 30 years, 92 (18.4%); between 31 and 40 years, 280 (56.0%); between 41 to 50 years, 210 (42.0%); and aged 51 and above, 8 (1.6%) of the total respondents. Respondents having a graduate-level education amounted to 45 (9.0%), post-graduate education, 305 (70.0%), whereas others, including diploma holders, training staff, amounted to 150 (30.0%). Junior staff positions made up 220 (44.0%), supervisor positions accounted for 120 (34.0%), managerial position holders

were 35 (17.0%), the procurement manager position holders were 10 (2.0%), and other position holders were 15 (3.0%). We observed that this study encompassed 100 manufacturing firms (20%), 35 construction firms (7%), 65 financial industries (13%), services firms 130 (26%), communication firms 65 (13%), technology firms 100 (20%), and others 5 (1%).

Table 1. Demographics

Category	Subgroup	Pakistan (N=250)	Bangladesh (N=250)	Total (N=500)
Gender	Male	220 (88%)	200 (80%)	420
	Female	30 (12%)	50 (20%)	80
Age	21-30 years	40 (16%)	52 (20.8%)	92
	31-40 years	135 (54%)	145 (58%)	280
	41-50 years	50 (20%)	70 (28%)	120
	51+ years	2 (0.8%)	6 (2.4%)	8
Education	Graduate	22 (8.8%)	23 (9.2%)	45
	Post-graduate	175 (70%)	130 (52%)	305
	Others (Training/Dip.)	53 (21.2%)	97 (38.8%)	150
Position	Junior staff	110 (44%)	110 (44%)	220
	Supervisor	85 (34%)	35 (14%)	120
	Manager	25 (10%)	10 (4%)	35
	Procurement manager	5 (2%)	5 (2%)	10
	Other	25 (10%)	90 (36%)	115
Industries	Manufacturing	50 (20%)	50 (20%)	100
	Construction	17 (6.8%)	18 (7.2%)	35
	Finance	32 (12.8%)	33 (13.2%)	65
	Service	65 (26%)	65 (26%)	130
	Communication	32 (12.8%)	33 (13.2%)	65
	Technology	50 (20%)	50 (20%)	100
	Other	4 (1.6%)	1 (0.4%)	5

Source: own study.

Measurement Model Assessment

Reliability and Validity

We examined reliability and validity based on Cronbach's alpha value, composite reliability, and average variance extracted (AVE). As observed in the Table 2, composite reliability and validity (rho c), and composite reliability (rho a) for digitisation, external environment factors, need-based factors, organisational factors, technological factors, and e-commerce adoption were higher than 0.7. According to Hair Jr *et al.* (2017), the reliability and validity of the study is satisfactory if the values remain higher than 0.7. The average variance extracted for digitisation, external environment factors, need-based factors, organisational factors, technological factors and e-Commerce adoption were 0.860, 0.795, 0.748, 0.783, 0.907, and 0.914 respectively. All the values of the latent variables regarding AVE were higher than 0.5 showing enough validity (Hair Jr *et al.*, 2017).

Table 2. Reliability and validity

Latent variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Digitisation	0.980	1.022	0.982	0.860
External environment factors	0.820	1.319	0.872	0.795
Need-based factors	0.706	1.233	0.752	0.748
Organisational factors	0.867	1.121	0.626	0.783
Technological factors	0.974	0.978	0.980	0.907
e-Commerce adoption	0.969	0.974	0.977	0.914

Source: own study in SmartPLS.

Discriminant Validity

We used Fornell-Larcker criterion to observe latent variable's discriminant validity. It is the parameter to observe; how different each latent variable is from the other construct as stated in the Table 3. We observed that each value was above 0.50 which is the threshold value. Technology factors was 0.956 and e-Commerce adoption – 0.954, which shows excellent convergent validity. External environmental factors (0.560) and organisational factors (0.629) meet the criteria.

Table 3. Fornell-Larcker criterion

Pakistan						
Construct	D	EEF	NBF	OF	TF	ECA
Digitisation	0.928					
External env. factors	-0.036	0.560				
Need-based factors	0.054	0.079	0.635			
Organisational factors	-0.092	0.066	0.182	0.629		
Technological factors	0.009	-0.042	-0.097	-0.127	0.956	
E-commerce adoption	0.056	0.223	-0.083	-0.083	0.096	0.954
Bangladesh						
Digitisation	0.928					
External environment factors	0.101	0.629				
Need-based factors	0.005	-0.165	0.669			
Organisational factors	-0.084	0.005	0.128	0.627		
Technological factors	0.230	0.087	-0.009	0.026	0.953	
E-commerce adoption	-0.069	0.054	-0.103	0.138	0.255	0.956

Source: own study in SmartPLS.

We observed the Heterotrait-monotrait (HTMT) ratio of the latest variables as above the threshold value 0.8, which shows a good discriminant validity according to the (Ab Hamid *et al.*, 2017).

Table 4. Heterotrait-monotrait ratio (HTMT)

Construct Pairs	Bangladesh	Pakistan	Validation
External env. factors ↔ Digitisation	0.247	0.124	**Valid** (Both < 0.85)
Need-based factors ↔ Digitisation	0.069	0.060	**Valid**
Need-based factors ↔ External env. factors	0.450	0.156	**Valid**
Organisational factors ↔ Digitisation	0.158	0.161	**Valid**
Organisational factors ↔ External env. factors	0.528	0.473	**Valid**
Organisational factors ↔ Need-based factors	0.277	0.491	**Valid**
Technological factors ↔ Digitisation	0.245	0.044	**Valid**
Technological factors ↔ External env. factors	0.190	0.070	**Valid**
Technological factors ↔ Need-based factors	0.109	0.095	**Valid**
Technological factors ↔ Organisational factors	0.155	0.139	**Valid**
E-commerce adoption ↔ Digitisation	0.062	0.041	**Valid**
E-commerce adoption ↔ External env. factors	0.094	0.261	**Valid**
E-commerce adoption ↔ Need-based factors	0.080	0.072	**Valid**
E-commerce adoption ↔ Organisational factors	0.106	0.088	**Valid**
E-commerce adoption ↔ Technological factors	0.260	0.090	**Valid**

Source: own study in SmartPLS.

Factor Loading

Figures below show latent variables and their respective factor loading regarding Bangladesh and Pakistan. The factor loading of each construct is above the threshold value 0.7. Each indicator has a positive factor loading.
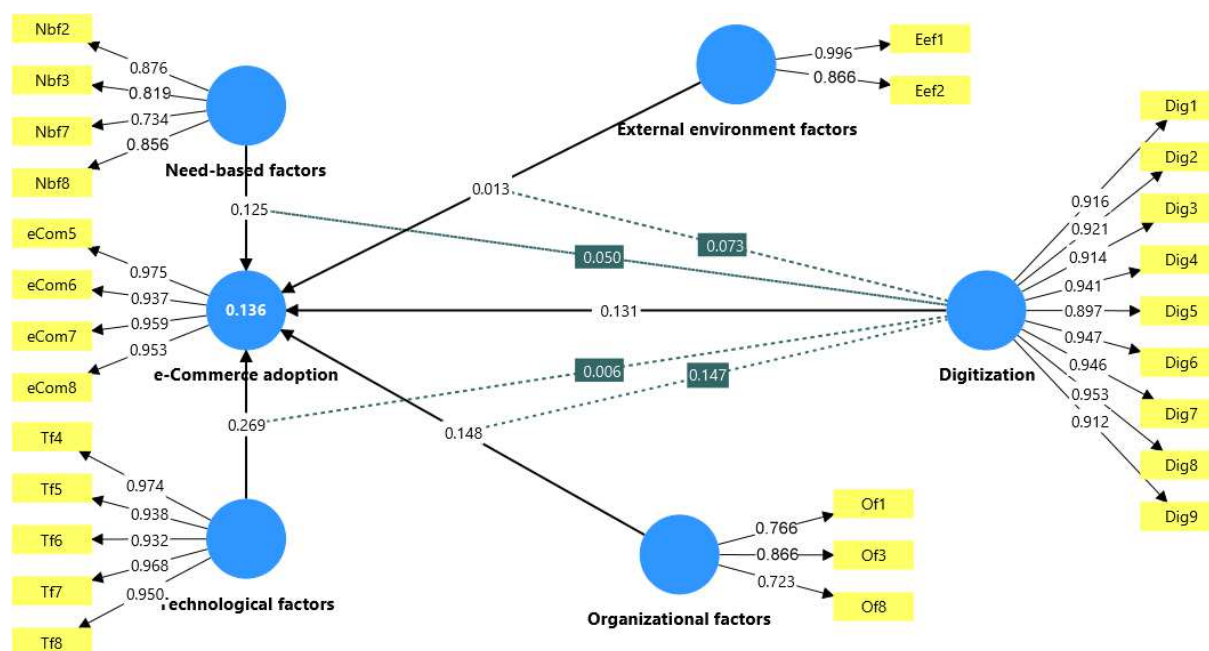
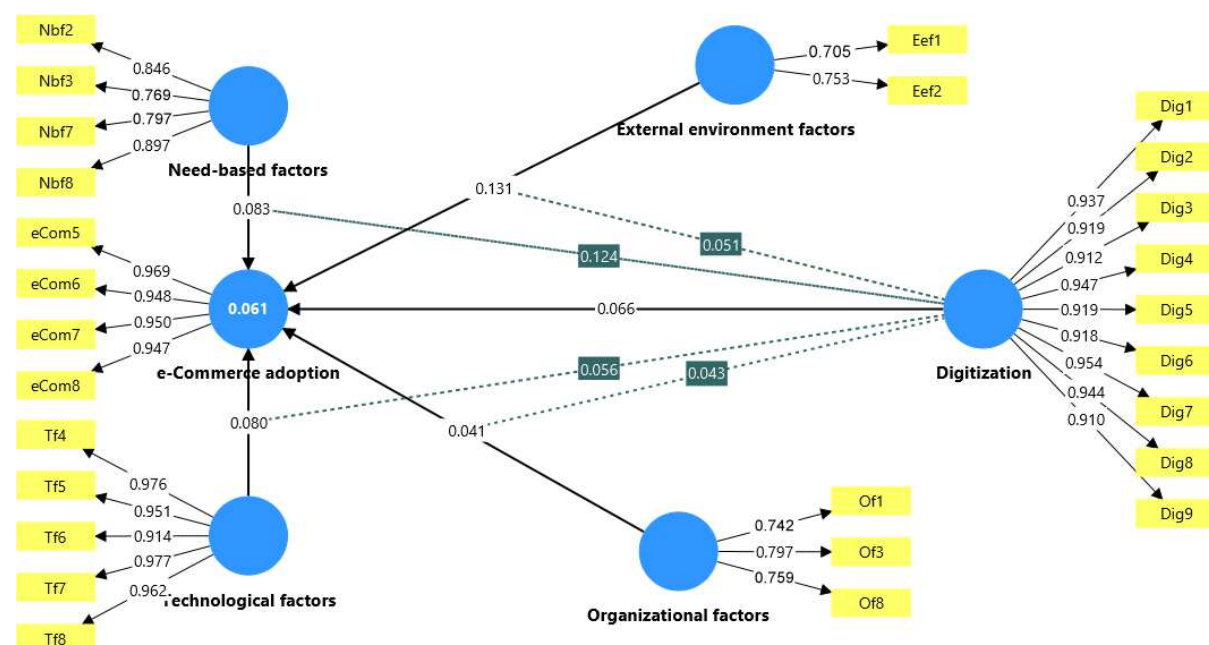**Figure 2. PLS path model (Bangladesh)**
Source: own elaboration in SmartPLS.

Figure 3. PLS path model (Pakistan)
Source: own elaboration in SmartPLS.

R Square

As stated in the Table 5, shows values of R^2, adjusted R^2 in Bangladesh and Pakistan for e-commerce adoption. We observed that Bangladesh, value of R^2 was 0.136 (adjusted 0.082), whereas the value of R^2 in Pakistan was 0.061 (adjusted 0.054).

Table 5. R Square

Variable	Bangladesh		Pakistan	
	R^2	R^2 adjusted	R^2	R^2 adjusted
e-Commerce adoption	0.136	0.082	0.061	0.054

Source: own study in SmartPLS.

Moderation Analysis

Modelling in SmartPLS refers to the part of SEM that shows the relationship between latent variables. In SmartPLS, a graph can represent the model. The model shows paths or arrows connecting the latent variables and coefficients that represent the strength of the relationship between them (Kamis *et al.*, 2020). The model in SmartPLS is estimated using a technique called partial least squares (PLS) regression. PLS regression is a multivariate analysis method used to model the relationship between variables. The purpose of SmartPLS modelling is to estimate the relationship between latent variables in the model and evaluate the significance and strength of the relationship (Kamis *et al.*, 2020). The output of the model in SmartPLS includes estimates of path coefficients. These measurements serve to evaluate the overall quality of the model and it's fit to the observed data.

Table 6. Multi-group analysis

Path	Bangladesh	Pakistan	difference	p
Digitisation -> E-commerce adoption	0.131	0.066	0.065	0.001
Digitisation x External environment factors -> E-commerce adoption	0.073	0.010	0.063	0.000
Digitisation x Need-based factors -> E-commerce adoption	0.050	-0.035	0.085	0.000
Digitisation x Organisational factors -> E-commerce adoption	0.147	0.022	0.125	0.000
Digitisation x Technological factors -> E-commerce adoption	0.006	0.028	-0.022	0.000
External environment factors -> E-commerce adoption	0.013	0.131	-0.118	0.000
Need-based factors -> E-commerce adoption	0.125	0.083	0.042	0.000
Organisational factors -> E-commerce adoption	0.148	0.041	0.107	0.000
Technological factors -> E-commerce adoption	0.269	0.080	0.189	0.003

Source: own study in SmartPLS.

As stated in Table 7, in Bangladesh, multi-group analysis a significant positive relationship between e-commerce adoption and digitisation -> e-com adoption β=0.131, p<0.000, digitisation x external environment factors -> e-commerce adoption β=0.073, p<0.001, digitisation x need-based factors -> e-commerce adoption β=0.050, p=0.001, digitisation x organisational factors -> e-commerce adoption β=0.147, p<0.001, digitisation x technological factors -> e-commerce adoption β=0.006, p<0.001, external environment factors -> e-com adoption β=0.013, p<0.001, need-based factors -> e-com adoption β=0.125, p<0.001, organisational factors -> e-com adoption β=0.148, p<0.001, technological factors -> e-commerce adoption β=0.269, p<0.001. Whereas in Pakistan, multi-group analysis found that there is a significant positive relationship between e-com adoption and digitisation -> e-com adoption β=0.066, p<0.000, digitisation x external environment factors -> e-com adoption β=0.010, p<0.001, digitisation x need-based factors -> e-com adoption β=-0.035, p=0.001, digitisation x organisational factors -> e-commerce adoption β=0.022, p<0.001, digitisation x technological factors -> e-com adoption β=0.028, p<0.001, external environment factors -> e-com adoption β=0.131, p<0.001, need-based factors -> e-com adoption β=0.083, p<0.001, organisational factors -> e-com adoption β=0.041, p<0.001, technological factors -> e-com adoption β=0.080, p<0.001.

Hypothesis Testing

As stated in the Table 8, hypothesis H1 'digitisation has a strong positive impact on e-commerce adoption in Pakistan and Bangladesh' showed the difference between Bangladesh and Pakistan 0.065 (P> 0.05). The difference indicates that path coefficient of Bangladesh was higher than Pakistan. The result was significant. We accepted the hypothesis as digitisation has a strong impact on both countries,

Bangladesh (Bangladesh β=0.131, p<0.000) and Pakistan (β=0.066, p<0.000 in one analysis). Hypothesis H2: 'In Pakistan, the adoption of e-commerce increased more due to external environmental factors after the COVID-19 pandemic compared to Bangladesh.' In the case, of external environmental factors, the difference was -0.118, which shows that e-commerce adoption in Bangladesh after the COVID-19 pandemic was significantly higher as compared to Pakistan. We rejected this hypothesis because external environmental factors had a greater impact in the adoption of e-commerce in Bangladesh. In the case of organisational factors and technological factors, there was a significant increase of e-commerce adoption in Bangladesh with the difference of 0.107, and 0.189 as compared to Pakistan. Hypothesis H3: 'After the COVID-19 pandemic, the factors based on needs led to a greater increase in the adoption of e-commerce in Bangladesh compared to Pakistan.' We observed that need-based factors have performed better in Bangladesh as compared to Pakistan, with a difference of 0.042. We accepted the hypothesis. Hypothesis H4 'The adoption of e-commerce increased more in Bangladesh compared to Pakistan after the COVID-19 pandemic due to organisational factors.' The difference was 0.107 because the organisation factors performed better in Bangladesh as compared to Pakistan. Hypothesis H5: 'After the COVID-19 pandemic, the adoption of e-commerce increased more in Pakistan compared to Bangladesh due to technological factors.' The results showed the difference of 0.189, which shows that technological factors performed better in Bangladesh for the adoption of e-Commerce as compared to Pakistan. Hence, we rejected hypothesis H5.

Table 7. Multi-group analysis

Relationship	Difference (BANGLADESH – PAKISTAN)
Digitisation -> E-commerce adoption	0.065
Digitisation x external environment factors -> E-commerce adoption	0.063
Digitisation x need-based factors -> E-commerce adoption	0.085
Digitisation x organisational factors -> E-commerce adoption	0.125
Digitisation x technological factors -> E-commerce adoption	-0.022
External environment factors -> E-commerce adoption	-0.118
Need-based factors -> E-commerce adoption	0.042
Organisational factors -> E-commerce adoption	0.107
Technological factors -> E-commerce adoption	0.189

Note: if (p <0.05).
Source: own study in SmartPLS.

Table 8. Hypothesis testing

#	Hypothesis	Difference	P	Remarks
H1	Digitisation has a strong positive impact on e-commerce adoption in Pakistan and Bangladesh	0.065	0.001	**Accepted**
H2	In Pakistan, the adoption of e-commerce increased more due to external environmental factors after the COVID-19 pandemic, compared to Bangladesh	-0.118	0.000	**Rejected**
H2a	External environmental factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.	0.063	0.000	**Rejected**
H3	After the COVID-19 pandemic, the need-based factors led to a greater increase in the adoption of e-commerce in Bangladesh compared to Pakistan	0.042	0.000	**Accepted**
H3a	Need-based factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.	0.085	0.000	**Accepted**
H4	The adoption of e-commerce increased more in Bangladesh compared to Pakistan after the COVID-19 pandemic due to organisational factors	0.107	0.000	**Accepted**
H4a	Organisational factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.	0.125	0.000	**Accepted**
H5	After the COVID-19 pandemic, the adoption of e-commerce increased more in Pakistan compared to Bangladesh due to technological factors	0.189	0.003	**Rejected**
H5a	Technological factors increased the adoption of e-commerce in Bangladesh as compared to Pakistan.	-0.022	0.000	**Accepted**

Source: own study.

Discussion

We observed a significant impact on small and medium sized enterprises all over the globe. It was not limited to any country or specific place. Developed and developing countries have faced the similar situation. In the developing countries of South Asia, Pakistan and Bangladesh faced severe consequences of the COVID-19 pandemic. Many businesses have faced unprecedented challenges, survival issues. After the COVID-19 pandemic, it was necessary for every business to progress. This progression resulted in the form of e-commerce adoption for businesses. The revival of businesses in the time of pandemic needed e-commerce adoption to innovate their business models. E-commerce not only made the businesses remote, but also facilitated the consumers with lower costs and rapid movement. Research indicates that small and medium sized enterprises in Pakistan and Bangladesh were more likely to adopt e-commerce as they embrace digital tools and technologies. This study's observations align with the study of Chaudhuri and Kumar (2015) and Hossain *et al.* (2021) as observed in our research's literature review section. However, we observed that adoption of e-commerce with the help of digitisation in Bangladesh was more advanced as compared to Pakistan. The findings revealed that small and medium-sized enterprises (SMEs) in Pakistan and Bangladesh leverage digital technologies to strengthen their e-commerce operations, enabling business growth through improved operational efficiency and enhanced adaptability to market demands. The findings also revealed that need-based factors and digitisation is more likely to have strong positive impact, but the case of need- based factors is different in the case of Bangladesh, more favourable as compared to Pakistan. It is more likely because the economic condition of Bangladesh is better than Pakistan. This study's observations totally align with a similar study of Alam *et al.* (2023) and Rana *et al.* (2022) as observed in our literature review. The case with external environmental factors significantly affecting e-commerce adoption in Bangladesh is similar. However, the direct effect of environmental factors is stronger in Pakistan as compared to Bangladesh. Emon *et al.* (2023) and Shahriar (2024) observed a similar case in their studies. Onjewu *et al.* (2022) reaffirm the importance of need-based factors as observed in the literature review. This study has observed the moderation impact of environmental factors on the adoption of e-commerce. The study showed that Bangladesh likely contributed more the impact of environmental factors as compared to Pakistan. Organisational factors have strong impact on businesses. In the case of Bangladesh, organisational factors were more likely to have better impact as compared to Pakistan. Emon *et al.* (2023) have drawn similar conclusions. The organisational factors have a strong impact on e-commerce adoption in Bangladesh, whereas the organisational factors are weak in Pakistan. In the case of technological factors that contribute in the development of businesses for small and medium sized enterprises, impact more likely remained positive in both countries. This study's observation align with the studies of Emon *et al.* (2023) and Przetacznik, (2022) as discussed in our study's literature review. The comparative analysis shows that Pakistan has several issues regarding the economic crisis and shutdown of industries due to the economic collapse. Due to the economic crisis, Pakistan received less support from the external environment. The results show that SMES in Pakistan and Bangladesh can benefit from a strategic approach through the use of e-commerce that focuses on the use of technology to enhance their capabilities. Policymakers and business organisations can facilitate this adoption by investing in digital infrastructure, promoting digital literacy and skills training, and creating a regulatory environment that supports innovation and growth in e-commerce. Small and medium-sized businesses need to establish an online presence to attract customers who are reluctant to visit stores due to the pandemic. They also need to simplify operations by using technology to help them manage inventory, order processing, and delivery more efficiently. The integration of digital technologies has emerged as a critical facilitator for e-commerce implementation among small and medium enterprises in Pakistan and Bangladesh as stated in the studies of (Jamil, 2021; Alam, 2023). Technologies such as cloud computing and AI can help SMEs achieve automation, reduce costs, and increase efficiency. This technology can also help them develop new business models that suit the changing needs of customers in the post-pandemic era. Policymakers and industry bodies can play an important role in promoting

e-commerce among SMEs in Pakistan and Bangladesh. They can provide them with training and resources to help them develop their digital capabilities and implement e-commerce solutions based on their specific needs. They can also work to create a regulatory environment that supports innovation and growth in e-commerce. In Pakistan and Bangladesh, the adoption of need-based e-commerce by SMEs is important after the COVID-19 pandemic. By using technology and developing new business models, SMEs in these countries can overcome the problems caused by the pandemic and revolutionize the economic conditions of both countries. After the COVID-19 pandemic, Pakistan did not survive the e-commerce revolution in the country. In Bangladesh, the situation regarding economic stability is better than in Pakistan, which is the reason for its e-commerce adoption.

The comparative analysis between Pakistan and Bangladesh's SMEs in the adoption of e-commerce have shown distinct challenges. These challenges demand from both countries specific policies to mitigate the challenges and enrich the adoption of e-commerce on broad standards. Meanwhile, both countries have accepted digitisation is a major role player for the adoption of e-commerce, especially in the time of COVID-19 pandemic. The findings underscore the importance of tailored strategies. Bangladesh has shown an emerging trend for digital transformation and its economic stability is better than Pakistan. However, we recommend an advanced level of e-commerce adoption. To achieve this target, authorities should devise policies accordingly for a sustainable development. Policy makers should focus more on digital infrastructure to provide support for the adoption of e-commerce in industries.

CONCLUSIONS

The COVID-19 pandemic has profoundly reshaped the landscape for SMEs across nations, casting a particular spotlight on Pakistan and Bangladesh, because these developing countries are facing the aftermath of the COVID-19 pandemic. The e-commerce adoption moderated by digitisation has a pivotal role in the survival setup of small and medium industries in both countries. The results of the study explain the role of digitisation, and its deep-rooted principles for need-based e-commerce adoption that empower the small and medium-sized enterprises to engage with potential consumers, and customers, empowering their production line based on competitiveness. As these businesses deal with the impact of the pandemic, the integration of e-commerce solutions is vital for the survival and growth of small and medium-sized businesses. E-commerce adoption is a great opportunity for small and medium industries to enter the digital world, engage with customers in online atmosphere, improve business processes and become more efficient and competitive. Comparative analysis of the two countries reveals that Bangladesh has emerged as the hub of digital transformation and development initiatives have intricately driven e-commerce adoption. The interaction of many multifaceted factors affects the course of e-commerce. In particular, Bangladesh has taken full advantage of these factors to create fertile ground for e-commerce adoption after the COVID-19 pandemic. Bangladesh has implemented protectionism and security, and Pakistan faces growing economic challenges such as rising inflation and rising poverty. The post-pandemic situation has put Pakistan in a difficult situation, hindering the survival of small and medium-sized businesses and creating an economic quagmire. Bangladesh's keen understanding of leveraging the intricacies of digitalization has ensured its leading position in e-commerce. Instead, Pakistan's problem constitutes an important reminder of the unity of financial stability and e-commerce.

Limitations

Some of the limitations of this study may include the use of a convenience sampling technique which may not be representative of the target population. The self-reported nature of the data may also introduce bias in the results. Moreover, the study may not be generalisable to other industries outside of the e-commerce industry, and the study is limited to the post-pandemic era.

Future Recommendations

We can make several recommendations to promote the need-based e-commerce adoption for SMEs after the COVID-19 pandemic with special reference to digitisation as a moderator in Pakistan and Bangladesh.

There is a need to encourage partnership programs between small and medium-sized enterprises and internet service providers to help SMEs attain their potential target of e-commerce facilitation for consumers at all levels. There is a need to joint venture the investment process between public and private bodies to expand the e-commerce in Pakistan. Moreover, there is a need to initiate e-Commerce mutual platforms that can cover both country's needs. Through this platform, consumers can buy products from other countries that are linked with one system. The level of inflation is high in Pakistan and Bangladesh. Due to high inflation, internet access, availability of smartphones is not easy for every potential customer. Through partnership, SMEs can introduce smartphones on easy instalments for every consumer, that will enrich their business. On government level, authorities must initiate business awareness programs and e-commerce adoption programs to ensure the level of business literacy in the country.

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Use of Artificial Intelligence

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Green buys more than gold: Pollution, pay, and attractiveness of small and medium-sized enterprise employer brand

Xia Chen, Michał K. Lemański, Michał Staszków, Casey Watters

A B S T R A C T
Objective: The objective is to examine how signals about the environmental pollution of a Small and Medium-sized Enterprise affect its perceived attractiveness as an employer, and whether higher pay can offset the negative effect of such signals.
Research Design & Methods: To test our hypotheses, which required investigation of causal relationships, we used an experimental research design. The participants were Gen Z business students (N = 125). We operationalised employer attractiveness as the intention to recommend the firm as an employer. To analyse data, we used one-way ANOVA with Tukey HSD post-hoc tests after verifying normality and homogeneity of variance.
Findings: As expected, pollution information significantly lowered the intention to recommend (ANOVA: $F(3, 121) = 11.433$, $p < 0.001$). All three 'polluting' conditions scored significantly below the non-polluting control. Even a +50% wage premium did not restore attractiveness to control levels, and pay differences among polluting conditions were not statistically significant.
Implications & Recommendations: Environmental harm is a strong negative labour-market signal that compensation alone cannot neutralise. Managers should prioritise real, measurable pollution reductions in employer branding, align HR policies with sustainability and operations to avoid 'mixed signals', and account for a hidden 'recruitment tax' when environmental performance is poor.
Contribution & Value Added: The study extends signalling theory and employer branding research by documenting the 'dark side' of environmental signals: negative environmental impact depresses employer attractiveness, and higher pay, even substantial premiums, cannot compensate for this impact. The article offers causal, experimental evidence that clarifies the magnitude of these effects among young job seekers'.

INTRODUCTION

Firms perceived as environmentally sustainable are more attractive to potential employees. That effect boasts ample evidence in the literature, as scholars have explored the phenomenon for a long time. For instance, the work of Turban and Greening (1997) and Duarte *et al*. (2014) alongside a recent extensive study by Deloitte (2025) confirms this positive effect. The listed studies highlight that organisations with strong environmental sustainability practices often gain a favourable view from job seekers, who are increasingly prioritising ecological considerations in their employment. This trend seems particularly pronounced among younger generations, who are more likely to seek employment at organisations that align with their values regarding environmental stewardship (Hinson *et al*., 2018).

However, while numerous studies confirmed that environmental sustainability ameliorates the attractiveness of employer brand (Aiman-Smith *et al.*, 2001; Huber & Hirsch, 2017), prior research focused on the positive side of environmental sustainability, resulting in a dearth of works exploring the role of the firm's negative impact on the natural environment in its employer branding. Unfortunately, many firms, including those essential for everyday functioning of the modern society, such as power plants or farms, are environmental polluters. Such firms need to build their employer brands to attract qualified workforce, but prior research has provided them with little advice. However, we know that payment is the most important factor affecting employer attractiveness (Dassler *et al.*, 2022), and that firms operating in areas suffering from environmental pollution do offer significantly higher salaries (Zhang *et al.*, 2021; Yang *et al.*, 2022). Still, to the best of our knowledge, prior research did not determine whether high salary is able to offset the negative impact of corporate pollution on the polluting firm's attractiveness as a prospective employer. Addressing this gap, this article explores the relationship between negative environmental performance and the attractiveness of the employer brand for small and medium-sized enterprises (SMEs) through the lens of signalling theory (Spence, 1973). We focus on SMEs, since they globally represent around 90% of all businesses and more than 50% of employment worldwide (World Bank, 2025). In the European Union, SMEs employ 65% of the workforce (European Commission, 2025).

In the next section, we will review relevant literature and formulate hypotheses. Then, we will elaborate on the experimental quantitative methodology we used. Finally, we will present and discuss the results, indicating our implications for future research and for business practice.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Signalling Theory

As the theoretical lenses guiding this study, we employ signalling theory, which suggests that information asymmetry and uncertainty require organisations to utilise a wide range of personal data related to observable attributes to make informed decisions within the marketplace (Spence, 1973). Similarly, on the labour market, job seekers exert considerable effort to acquire knowledge about potential employers through relevant cues, inferring whether the organisation is a desirable place to work (Turban, 2001). To attract desired prospective employees, firms can use their employer brand to send intended signals, thus emphasising their strengths and advantages as an employer (Celani & Singh, 2011). Following Spence (1973) and his transplantation of the terms used by Jervis (1970), and adapting that definition to the firm, signals are observable characteristics attached to the firm that undergo manipulation by that firm.

Environmental Sustainability and Employer Attractiveness

Abundant studies highlight the significant role of corporate social responsibility (CSR) in predicting employer attractiveness. For instance, Turban and Greening (1997), Greening and Turban (2000), Albinger and Freeman (2000), Evans and Davis (2011), Biswas and Suar (2016), and Klimkiewicz and Oltra (2017) all report that a firm's corporate social performance (CSP) influences applicants' perceptions of employer brand and attractiveness. Backhaus *et al.* (2002) found that CSP has a similar predictive power, while noting that environmental factors, social relations, and diversity have the most significant impact on employer attractiveness. Onkila (2015) posits that the beneficial effects of CSR may relate to employees viewing their organisations differently when environmental sustainability is high, as it evokes positive emotions and organisational satisfaction.

Extensive past research explored how companies' sustainability affects their attractiveness as employers and found positive associations (Pfister, 2020). Research by Coelho *et al.* (2022) demonstrates that including pro-environmental messages in job advertisements enhances applicants' intentions to apply. Similarly, Guillot-Soulez *et al.* (2022) found that green certification positively influences perceptions of organisational attractiveness. In their study of business students, Presley *et al.* (2018) investigated the influence of a company's sustainability practices on perceived employer attractiveness. Find-

ings revealed that both the overarching concept of sustainability and its individual components significantly affected a company's attractiveness to potential employees. Chaudhary (2019) found that to generate perceived organisational attractiveness, the organisation should communicate ecological values and green practices to pro-environmental job seekers. Gintale *et al*. (2024) found that environmental CSR significantly improves employer attractiveness, while ethical CSR shows a less substantial impact. Considering the negative signals about employer brand, Ambec and Lanoie (2008) claim that 'no one wants to work for a dodgy company'. Bauer *et al*. (2012) also assert that 'negative images will threaten the individual image, may bring unfavorable comments from friends and family, and may depress the person'. Thus, reasoning by analogy, we expected that companies that exhibit a negative impact on the natural environment would appear as less attractive as employers.

Organisations that engage in environmentally harmful practices may send mixed signals regarding their commitment to sustainability. Pernkopf *et al*. (2020) discuss how incongruent signals, such as promoting green initiatives while engaging in polluting activities, can negatively impact employer attractiveness. This inconsistency can lead to scepticism among potential applicants, particularly among younger generations who prioritise environmental sustainability in their employment choices. Therefore, organisations need to align their branding efforts with their actual practices to avoid damaging their employer image.

Negative publicity surrounding environmental practices can significantly affect an organisation's attractiveness to potential employees. Ouyang *et al*. (2020) found that exposure to negative information about an organisation, such as its involvement in environmental scandals, may diminish the applicants' intentions to pursue employment opportunities within that organisation. This highlights the need for organisations to manage their public relations effectively, particularly in the face of environmental controversies, to maintain their attractiveness as employers.

Therefore, we formulated the first hypothesis:

H1: Signals about environmental pollution lower the propensity to recommend a job with the polluting company.

The Moderating Role of Payment

Higher salaries often seem a significant factor in attracting talent, particularly on competitive job markets. As organisations increasingly face scrutiny regarding their environmental practices, the question arises whether higher salaries can effectively compensate for the negative impacts associated with environmental pollution.

Montgomery and Ramus (2011) claim that, as an objective and tangible indicator, salary often serves as a baseline for applicants in their compensatory decision-making. Aiman-Smith *et al*. (2001) found that a company's environmental rating had the greatest impact on perceived attractiveness. However, the compensation still came as the factor most significant to affect the decision whether to apply. Simpson and Aprim (2018) came to a similar conclusion: although social and environmental factors attracted graduates to a company, economic factors ultimately determined to which company they applied. Bustamante *et al*. (2021) obtained similar findings, indicating financial benefits are the most important factor for students' perception of employer attractiveness. Further, research by Tanwar and Kumar (2019) indicates that employer branding and compensation are crucial in shaping perceptions of organisational attractiveness. However, while attractive compensation packages can draw candidates, they may not fully mitigate concerns regarding environmental practices. Employees increasingly seek alignment between their values and those of their employers, particularly concerning sustainability (Younis & Hammad, 2020). This suggests that while higher pay can attract talent, it may not compensate for adverse environmental impacts if candidates perceive those practices as misaligned with their values. Therefore, the second hypothesis reads:

H2: A higher pay moderates the negative effect of environmental pollution signals, increasing the propensity to recommend a job with the polluting company.

RESEARCH METHODOLOGY

Research Design and Research Process

To test our hypotheses, which required investigation of causal relationships, we used an experimental research design. In management research, experimental research design is particularly valuable for understanding causal relationships and the effects of specific interventions on organisational outcomes, particularly when testing hypotheses regarding behavioural changes or the efficacy of managerial practices. The experimental research design allowed us to control extraneous variables effectively, isolating the independent variable to observe its impact on the dependent variable. Such an approach proved beneficial in our study as we set out to analyse the impact of specific company characteristics on the behaviour of prospective job applicants. Ercan *et al*. (2025) emphasise that this method's strength lies in its ability to yield insights into causality, which observational studies often miss.

We randomly assigned the subjects to one of four groups: one control (baseline) group and three experimental (treatment) groups to test the effect of the stimuli. To minimise the potential effect of unobserved conditions that could bias the results, we selected participants to ensure homogeneity of the sample, i.e., participants who shared the same characteristic of interest, and assigned them randomly to one of the groups, each presented with a different stimulus.

Stimuli

Since the primary purpose was to test the effect of signals concerning environmental pollution on the propensity to recommend the presented SME as an employer, we manipulated the variable 'environmental pollution'. The control group received a vignette description of an SME presented as a firm that employed 100 people, was currently recruiting, and did not pollute the environment. Moreover, the three treatment groups read a description of an environmental polluter. Further, since we intended to determine the effect of higher payment, the three treatment groups received the same company description but with various information about the salary: the industry average level, 20% above the industry average, and 50% above the industry average. Following this, we asked a series of questions about pro-environmental values, control questions, and socio-demographic questions, included at the end of each version.

Measures

Employer Attractiveness

Attractiveness of the employer is a complex construct. When building our hypotheses on previous studies, we indicated two dimensions: application intentions, namely a respondent's likelihood to apply for a job with a company, and their likelihood to recommend the company as an employer, for example to family or friends looking for a job.

We measured the intention to recommend with a five-point Likert-type scale of Styvén *et al*. (2022). The measurement results appear in Table 1 below. We point out that both scales showed high Cronbach's alpha scores, 94% and 84% respectively, and as such, they constituted appropriate instruments to measure our variables of interest.

Table 1. Reliability analysis for measures of employer attractiveness

Construct	Items	Cronbach's alpha if item omitted	Cronbach's alpha
Intention to recommend	I would recommend this company to a friend looking for a job.	0.752	0.84
	I would post job ads from this company on my social media to encourage others to apply here.	0.846	
	I would recommend the company's products/services to friends and acquaintances.	0.705	

Source: own study.

Control Questions

We included a socio-demographic question about age to determine if the respondent qualified as Generation Z, which was the target demographic in this study. To check whether the respondents belonged to the target group, we asked the control questions 'What is your highest educational degree?' and 'When will you graduate?' to check whether the respondent was a student. Additional questions about job search activities served to check if the respondent qualified as a job seeker and therefore considered applying for jobs.

Participants and Procedure

To study potential job applicants, we selected students at a large business school as respondents. First, in a pre-test study, 10 students received a link to the questionnaire, which requested them to test its functionality and comment on the clarity of the questions and tasks. After reviewing their comments and suggestions, we distributed the final version via the online mailing list of university students who agreed to receive contact for participation in online studies. Additional invitations were sent through social media. The invitation to participate included a briefing about the purpose of the study and a research ethics statement, which guaranteed anonymity of responses. The invitation message included a link to the questionnaire, stored on the university portal, which does not collect IP addresses or any personal data of respondents. The questionnaire included a randomiser. Therefore, clicking the invitation link randomly assigned the participant to one of the four scenarios describing one firm and then asked them to answer questions measuring the variables described above.

Out of 133 respondents who started the study, 125 completed the questionnaire. For experimental designs, a sample size of at least 30 participants per condition is an established requirement (Daniel, 2011; Memon *et al.*, 2020) Given that our study included four conditions, namely the baseline scenario and three treatment conditions, the required sample size was 120. We met that condition as 125 participants provided usable responses.

RESULTS AND DISCUSSION

Descriptive Statistics

Our sample consisted of 125 participants, of whom 74 (59%) were female and 51 (41%) were male. All respondents were born between 1995 and 2004, which places them within Generation Z. Ages ranged from 19 to 28 years, with a mean age of 24.64 years (SD = 1.88). At the time of the survey, all were students at WU Vienna University of Economics and Business. All participants expected to graduate between 2023 and 2026, with over a half (56%) planning to graduate in 2025. A substantial proportion (82.40%) reported plans to begin their first full-time position either in 2025 or 2026. Consequently, 67% of respondents were job hunting, and 73.60% had applied for at least one job within the past 12 months. We summarise the descriptive statistics in Table 2.

Table 2. Descriptive statistics of the sample

Research sample	Number and percentage	Mean (SD)
Gender Female Male	 74 (59.20%) 51 (40.80%)	
Age		24.64 (SD = 1.88)
Total	N = 125	

Source: own study.

For the experimental study, we randomly assigned the participants to one of four groups. Group 1 served as the control group, while Groups 2, 3, and 4 constituted experimental groups, in which we manipulated the independent variable. The characteristics of these groups and scenarios appear in Table 3.

Table 3. Characteristics of the experimental groups

| Group 1 (n = 32)	Group 2 (n = 32)	Group 3 (n = 27)	Group 4 (n = 34)
No manipulation.	Company has a negative environmental record.	Company has a negative environmental record but pays salaries 20% higher than the average.	Company has a negative environmental record but pays salaries 50% higher than the average.

Source: own study.

The data reveal that Group 1, in which we manipulated no information about the company's environmental impact, obtained the highest mean scores for recommendation intention. While a higher salary increased employer attractiveness, it did not reach the control group's level, even with a 50% salary premium. We summarise the descriptive statistics for group comparison in Table 4.

Table 4. Descriptive statistics for group comparison

Group	N	Intention to recommend		
		M	*SD*	**95% CI**
1	32	3.302	1.085	[2.911, 3.693]
2	32	2.146	0.610	[1.926, 2.366]
3	27	2.247	0.771	[1.942, 2.552]
4	34	2.647	0.914	[2.328, 2.966]

Source: own study.

These results also appear in Figure 1, to illustrate the level of organisational attractiveness measured as the intention to recommend the company as an employer. Group 1 represents the neutral scenario, while Groups 2-4 demonstrate the organisational attractiveness of environmental polluters with three levels of pay: no extra pay, 20% above market, and 50% above market. As mentioned above, higher pay increases organisational attractiveness, but even a 50% increase in salary does not elevate organisational attractiveness to the non-polluter's level.
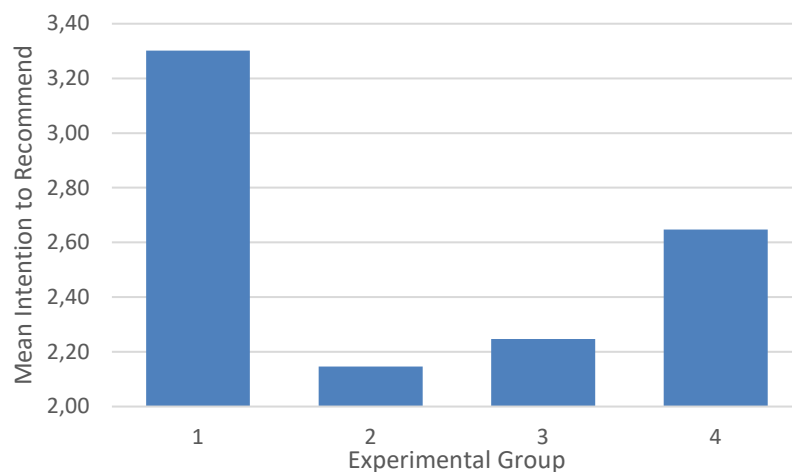
Figure 1. Average scores for the inter-group comparison
Source: own elaboration.

Hypotheses Testing

We tested the hypotheses using a one-way analysis of variance (ANOVA) to examine whether significant differences existed in the dependent variable of 'intention to recommend' across the groups. Prior to conducting the ANOVA, we assessed the assumptions of normality and homogeneity of variance to ensure the appropriateness of the parametric test. To assess the assumption of normality, we conducted Shapiro-Wilk tests on the residuals for each group and a visual inspection of normal Q–Q plots. The Shapiro-Wilk test for normality was not significant for any group (Group 1: $W = 0.940$, $p = 0.076$;

Group 2: W = 0.939, p = 0.072; Group 3: W = 0.958, p = 0.326; Group 4: W = 0.965, p = 0.332), indicating normal distribution of the data for 'intention to recommend' within each group. The following graphs display the normality for each group.
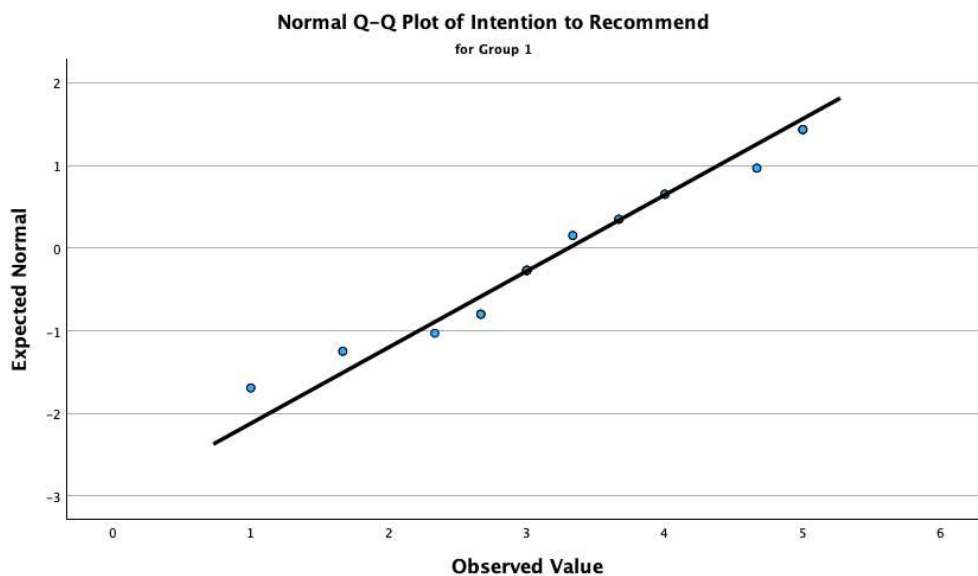

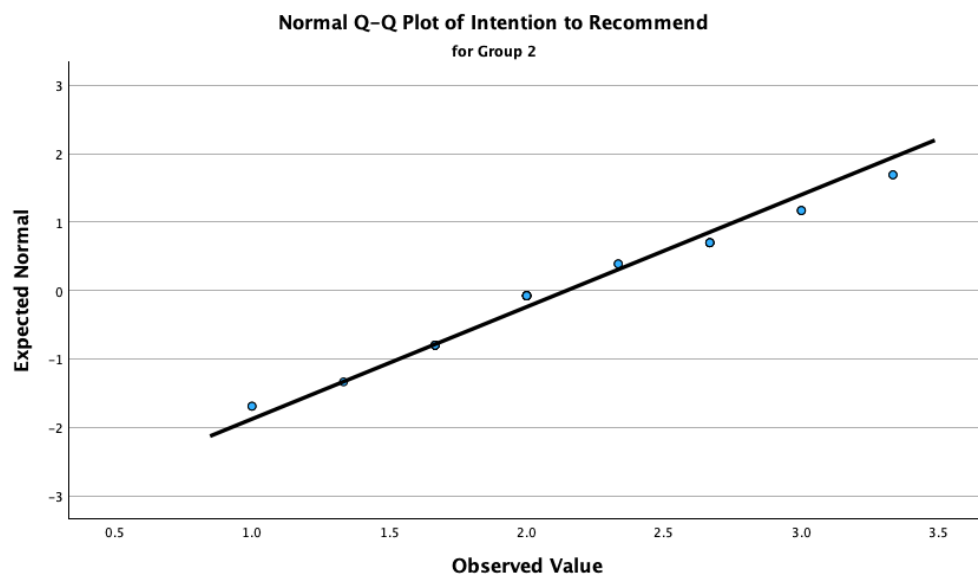**Figure 2. Normality test for Group 1**
Source: own elaboration.

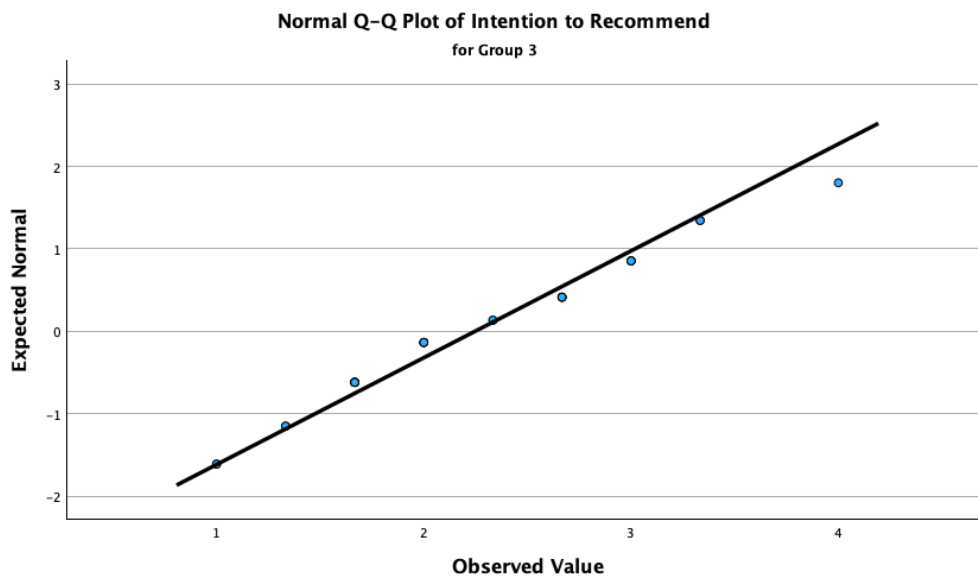**Figure 3. Normality test for Group 2**
Source: own elaboration.
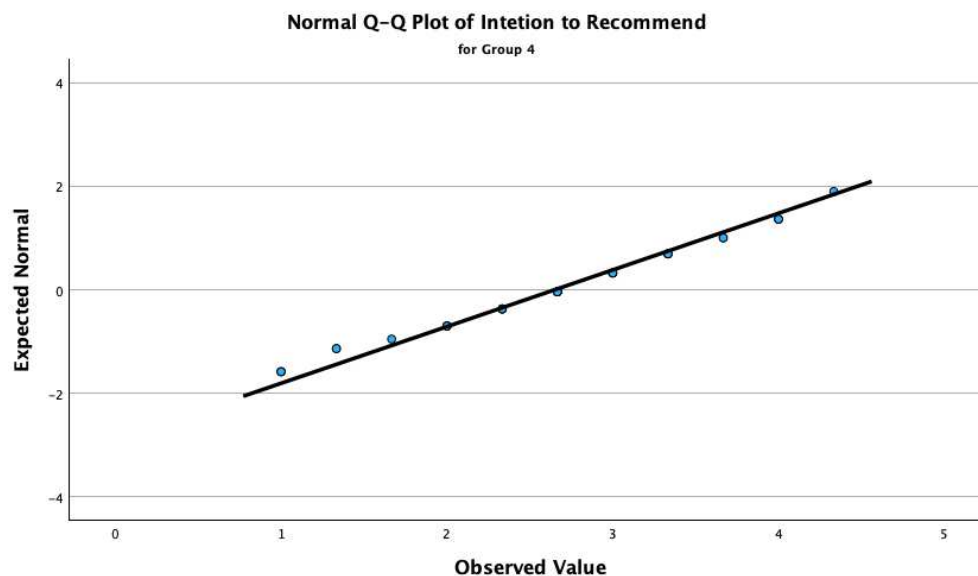
Figure 4. Normality test for Group 3
Source: own elaboration.

Figure 5. Normality test for Group 4
Source: own elaboration.

A Levene's test for homogeneity of variance yielded a p-value of 0.052, exceeding the 5% significance level, which indicated no significant violations of the homogeneity assumption, F (3, 121) = 7.660, p = 0.052. Therefore, we report the results of the standard one-way ANOVA. The Levene's test results appear in Table 5.

Table 5. Levene's test for the homogeneity of variance for 'intention to recommend'

Group	Levene – statistic	F	df1	df2	Sig.
Intention to recommend	2.649	11.433	3	121	0.052

Source: own study.

The dependent variable 'intention to recommend' also exhibited a normal distribution, supported by the sufficient sample size within each group.

Meeting both assumptions – normality and homogeneity of variance – meant that we fulfilled the requirements for conducting ANOVAs. Therefore, we performed one-way ANOVA to examine whether significant differences existed across the four experimental groups in the dependent variable of 'intention to recommend'. Together, the groups reflect employer attractiveness.

As indicated by the descriptive statistics, differences in mean values of the dependent variables appeared across the experimental groups. The one-way ANOVA revealed a significant effect for the 'intention to recommend', with an F-value of 11.433, $p < 0.001$ (Table 6). Therefore, a statistically significant difference existed between the groups. The effect size, expressed as Cohen's $d = 0.533$, reflected a medium effect, suggesting that the observed differences are not only statistically significant, but also meaningful, and potentially relevant in practical terms.

Table 6. Exploring group differences in dependent variables with ANOVA

Variables		Sum of squares	df	Mean square	F	Sig.
Intention to recommend	Between the groups	25.815	3	8.605	11.433	< 0.001
	Within groups	91.073	121	0.753		
	Total	116.889	124			

Source: own study.

The ANOVA indicates that at least one significant difference existed between the groups, yet it did not specify which groups differed from each other. Therefore, we conducted a Tukey honestly significant difference (HSD) post-hoc test to identify which group differences were statistically significant. The results appear in Table 7.

Table 7. Post-hoc Tukey test

Variable	(I) QuestNR	(J) QuestNR	Mean difference (I-J)	Std. error	Sig.
Intention to recommend	1	2	1.156*	0.217	<0.001
		3	1.055*	0.227	<0.001
		4	0.655*	0.214	0.014
	2	1	-1.156*	0.217	<0.001
		3	-0.101	0.227	0.97
		4	-0.501	0.214	0.094
	3	1	-1.055*	0.227	<0.001
		2	0.101	0.227	0.97
		4	-0.400	0.224	0.284
	4	1	-0.655*	0.214	0.014
		2	0.501	0.214	0.094
		3	0.400	0.224	0.284

Source: own study.

We compared the values of Group 1 with those of the experimental groups to examine whether a significant difference existed in the 'intention to recommend' when a company polluted the environment (Table 7). The results indicate a significant difference in the recommendation intention between Group 1 and Group 2 (M = 1.156, $p < 0.001$), Group 1 and Group 3 (M = 1.055, $p < 0.001$), as well as Group 1 and Group 4 (M = 0.655, $p = 0.014$), with all the experimental groups showing a significantly lower recommendation intention compared to the control group. These findings suggest that environmental pollution significantly and negatively affected the intention to make recommendations. When the company polluted the environment, the intention to recommend was significantly lower across all the experimental conditions. Even offering a substantially higher salary – 50% above market – did not mitigate this effect. Therefore, the results support hypothesis H1.

To investigate whether a higher salary caused a greater intention to recommend the company, we compared Groups 3 and 4, namely those with elevated salary levels, with Group 2, which entailed no salary increase. Post-hoc pairwise comparisons using the Tukey HSD test indicated that there was no significant difference in the recommendation intention, with all the p values higher than > 0.05. Thus,

an increasing trend in salary levels did not necessarily generate the intention to recommend the company to other job seekers overall. Therefore, we rejected hypothesis H2. Let us now proceed with the interpretation of the results obtained.

Discussion

Summary of Findings

Whereas previous studies showed that companies demonstrating environmental sustainability are more attractive to younger job candidates, our research complements those findings by logically extending to the opposite corporate behaviour, namely a direct negative impact on the natural environment. It provides empirical proof of the damage caused by environmental pollution. These results are consistent with the findings of Aiman-Smith *et al*. (2001), Carballo-Penela (2019), Huber and Hirsch (2017), as well as Setó-Pamies and Papaoikonomou (2016), who argue that younger job applicants prefer sustainable companies as employers. However, we add an important extension to the research on the dark side of the impact that business exerts on the environment. In other words, previous research established that efforts to make a positive impact or reduce a negative impact on the environment also exert a positive impact on organisational attractiveness, and we show evidence that damaging the environment also damages organisational attractiveness.

The information about environmental pollution has a more substantial effect on men than on women. This finding adds an interesting insight to the literature on the sustainable behaviour of individuals. Most studies report that women score higher on personal ecological values than men. Our findings suggest that while women appreciate and adopt positive environmental measures, men react stronger to signals about pollution and distance themselves from those who make a negative impact on the natural environment, showing more sensitivity to signals about the negative environmental impact of business.

Furthermore, we investigated whether a higher salary could compensate for the perceived employer attractiveness if the firm pollutes the environment. Since we used an experimental research design, we were also able to show the extent of this effect. Most importantly, we demonstrate that environmental polluters can increase their attractiveness by paying higher salaries, but higher pay, even by 50% above the market level, does not balance the effect of environmental pollution. These findings stand in opposition to the results of a few other studies. For instance, Duarte *et al*. (2014) and Bustamante *et al*. (2021) found that pay is more important to job applicants than the firm's sustainability practices.

We now proceed to discuss the practical implications of these findings, and next we will address the limitations and the directions for future research.

CONCLUSIONS

This study contributes to signalling theory by integrating insights from the literature on employer branding and environmental sustainability, demonstrating that job applicants rely on environmental sustainability signals in employer branding when choosing employers. In doing so, we contribute a distinct employer brand signal of environmental sustainability to the signalling theory.

For practitioners, this article provides empirical evidence that environmental sustainability affects talent's perception of employers. Thus, it is an important attribute of the employer brand. Meanwhile, payment cannot compensate for corporate negative environmental activities, such as pollution, which further emphasises the importance of environmental sustainability. The study contributes to a better understanding of the interface between sustainability and employer attractiveness and shows how firms can increase their competitiveness on the labour market by aligning themselves with the values of the young generation of employees.

Managerial Implications

The evidence indicates that environmental harm functions as a strong negative labour-market signal that materially depresses employer attractiveness among business school students. At the same time, even sizable wage premiums fail to restore perceptions to the level of non-polluting firms. For managers, this

implies that companies must position environmental sustainability as a core element of the employer value brand embedded in operations rather than treat it as a peripheral communication theme.

In practical terms, credibility should precede communication. Investments that measurably reduce pollution such as emissions, waste, and local externalities ought to anchor employer branding and campus recruiting. Conceptualising the incremental spend required to attract candidates despite environmental controversies as a 'recruitment tax' helps internalise the hidden cost of pollution and strengthens the financial case for operational improvements. While many business school curricula and professional trainings educate managers to appreciate that strong social and environmental performance enhances organisational attractiveness, our findings suggest that managers should also realise the asymmetric risk of negative signals that compensation alone does not offset.

Consistency across signals is likewise pivotal. Discrepancies between day-to-day practices and public claims – mixed signals – invite scepticism and reduce attractiveness, particularly among younger cohorts sensitive to environmental integrity. Managers should therefore align HR, sustainability, and operations behind an evidence-based narrative. Specifically, they need to disclose quantified goals and progress, clarify the scope and limits of certifications, and foreground concrete operational changes rather than generic slogans.

Reframing total rewards around the impact and the income offers an additional lever. Because higher pay did not erase pollution penalties in our experiment, early-career roles should connect to projects with measurable environmental outcomes; managerial bonuses can include modifiers tied to environmental milestones; and employees should have transparent pathways to contribute to green initiatives, such as internal carbon-reduction sprints or supplier sustainability audits.

Limitations and Future Research

Like all empirical research, this study also has limitations, which one can address in future investigations. Therefore, in this final section, we identify what we perceive as key limitations of our work, suggest ideas for addressing them, and outline the most important avenues for future research.

The use of a manufacturing SME in our description of the protagonist employer is a natural choice to illustrate environmental pollution. However, some respondents may have been interested in careers in different industries and firms of different size, for example in large banks, small non-governmental organisations (NGOs), or various governmental institutions. Therefore, replication studies using vignettes of employers from other industries could provide better insight into how different negative effects of businesses on the natural environment affect perceptions of their attractiveness as employers. For example, the impact of logistics and transport firms on the environment primarily lies in air pollution from emissions. Companies in the construction industry harm the environment with noise and soil degradation, while the real estate industry is responsible for significant deforestation. Such studies would enable comparisons of the impact of different pollution types. For instance, people may be more sensitive to air pollution than to the pollution of water or soil, and these perceptions of various pollution types may affect the perceived attractiveness of firms from various industries.

Concerning the sample, we surveyed 125 young students in Austria – a very specific demographic group in a region with relatively few problems regarding environmental pollution. Therefore, it would be important to conduct studies based on larger and diverse samples, to compare the attitudes of people who witness severe environmental pollution daily, for instance those living in regions that struggle with such pollution. Similar studies could reveal whether personal experience with environmental pollution increases or decreases the perceived attractiveness of companies as employers. Furthermore, our respondents come from one generation. We made this choice to shed light on the attitudes within the demographic group of our interest: young people entering the job market. Nevertheless, considering the generational changes in both public attitudes and regulation concerning environmental pollution, attitudes towards environmental polluters may vary between generations. Among others, people who lived in a heavily polluted environment and now enjoy cleaner surroundings may be more sensitive to environmental pollution.

In this study, we found men to be more sensitive to environmental pollution signals than women. Future research should determine whether this finding is specific to our chosen region and the young

generation or is a universal pattern. Furthermore, all our respondents declared being either female or male, even though we listed three choices for the profiling question about gender. Given that many governments allow the registration of persons under more than two gender options, and companies increasingly use non-binary profiling in their job advertisements, we call for research to address gender differences concerning perceptions of employer attractiveness. Individuals who identify as non-binary only recently received the permission to indicate their identity in job applications. At the same time, most of the literature on perceptions of sustainability distinguishes only between two genders. Consequently, such research is particularly necessary.

Finally, we call for longitudinal studies, which could trace the temporal development of attitudes towards employers who have a damaging effect on the environment. Such studies can provide novel and valuable insights, as the results allow for the identification of factors that change job seekers' attitudes towards environmental polluters. For example, external events, like scandals discussed in popular media, could magnify the negative effect of environmental pollution on perceived employer attractiveness. Job market conditions can also influence attitudes. In times of high unemployment, even environmental polluters might appear as attractive employers, or high salaries could make them attractive again.

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Use of Artificial Intelligence

The authors used the AI tools Consensus (consensus.app) and Litmaps (www.litmaps.com) to find relevant literature. The Grammarly (www.grammarly.com) version with AI functionality served for proofreading, including grammar and spelling checks, and for suggesting paraphrasing. The authors reviewed the changes suggested by these tools and the final responsibility for the manuscript rests with the authors.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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