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DIGITAL TRANSFORMATION AND INTERNATIONALISATION AS DRIVERS OF INNOVATION:

THE MODERATING ROLE OF INTER-ORGANISATIONAL COLLABORATION

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DIGITAL TRANSFORMATION AND INTERNATIONALISATION AS DRIVERS OF INNOVATION: THE MODERATING ROLE OF INTER-ORGANISATIONAL COLLABORATION

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Abstract

This study explores digital transformation (DX) and firms' internationalisation as potential drivers of innovation, and examines the moderating role of inter-organisational collaboration on such relationships. By integrating theoretical frameworks such as the Knowledge-Based View, Resource-Based View, Open Innovation Theory and the Dynamic Capabilities Framework, the study highlights how DX, internationalisation and DX converge to enhance innovation performance.

This dissertation aims to contribute to the literature by assessing how digital transformation (proxied by the adoption of digital technologies) and internationalisation (proxied by exporting status) affect innovation directly, and if the presence of inter-organisational collaboration strengthens or not such relationships.

To this end, a robust econometric study was conducted to investigate these relationships using data collected from the *Flash Eurobarometer 486: SMEs, Start-ups, Scale-ups and Entrepreneurship* dataset from the year 2020, with multi-sector and country firms ranging from SMEs to large-scale. The estimations were performed using a Probit model and the results provide substantial contribution to the extant literature as there is strong evidence that DX, exporting and inter-organisational collaboration have all positive and significant direct relationship with innovation. Therefore, firms engaging in DX, exporting firms and firms with higher levels of inter-organisational collaboration have a higher probability of innovating. However, contrary to our initial predictions, inter-organisational collaboration seems to weaken the relationship between DX and innovation, a result we attribute to coordination complexity and resources' allocation trade-off in the SME contexts, which ultimately dampens the positive effects of DX on innovation. Additionally, there is no significant evidence that inter-organisational collaboration alters the relationship between exporting status and innovation, which suggests that innovation may be impacted by internationalisation primarily due to internal learning and market exposure, rather than from collaborative mechanisms or networks.

Keywords: Digital Technologies; Digital Transformation; Collaboration; Innovation; Exports; KBV; RBV; Open Innovation; Small and Medium Enterprises (SMEs).

JEL Classification: O32, O33, F23, L25

Resumo

Este estudo explora o potencial da transformação digital e da internacionalização das empresas para promover a inovação, bem como analisa o papel moderador da colaboração interorganizacional. Através da análise de teorias como a Knowledge-Based View (KBV), Resource-Based View (RBV), a Teoria da Inovação Aberta e o Quadro das Capacidades Dinâmicas, esta dissertação destaca como a transformação digital, a internacionalização e a colaboração interorganizacional convergem para reforçar a inovação.

A presente dissertação visa contribuir para a literatura avaliando de que forma a transformação digital (representada pela adoção de tecnologias digitais) e a internacionalização (representada exportação) afetam diretamente a inovação e se a presença de colaboração interorganizacional reforça, ou não, essas relações.

Para tal, foi realizado um estudo econométrico robusto com o objetivo de investigar tais relações, utilizando dados da base *Flash Eurobarometer 486: SMEs, Start-ups, Scale-ups and Entrepreneurship* relativos a 2020. A amostra abrange empresas de múltiplos países e setores, desde PMEs a empresas de grande dimensão. As estimativas foram realizadas utilizando um modelo Probit, e os resultados demonstrarem que as tecnologias digitais, a exportação e a colaboração interorganizacional apresentam todas uma relação direta e positiva com a inovação. Assim, empresas que investem em tecnologias digitais, exportadoras e aquelas com níveis mais elevados de colaboração interorganizacional têm uma maior probabilidade de inovar. No entanto, contrariamente às previsões iniciais, a colaboração interorganizacional parece enfraquecer a relação entre a tecnologias digitais e a inovação, um resultado que atribuímos à complexidade da coordenação e aos *trade-offs* na alocação de recursos no contexto das PMEs, o que atenua os efeitos positivos das tecnologias digitais na inovação. Adicionalmente, não se verifica evidência significativa de que a colaboração interorganizacional altere a relação entre o estatuto de exportador e a inovação, o que sugere que o impacto da internacionalização na inovação poderá surgir, sobretudo, da aprendizagem interna e da exposição ao mercado, e não de mecanismos colaborativos ou redes externas.

Palavras-chave: Tecnologias Digitais; Transformação Digital; Colaboração; Inovação; Exportação; KBV; RBV; Inovação Aberta; Pequenas e Médias Empresas (PMEs).

Classificação JEL: O32, O33, F23, L25

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List of Acronyms

AI: Artificial Intelligence

BMI: Business Model Innovation

BPO: Business Process Outsourcing

DTs: Digital Technologies

DX: Digital Transformation

GVCs: Global Value Chains

I4.0: Industry 4.0

IOC: Inter-organisational Collaboration

IoT: Internet of Things

IT: Information Technology

KBV: Knowledge-Based View

SMEs: Small and Medium-sized Enterprises

OI: Open Innovation

RBV: Resource-Based View

R&D: Research and Development

SSCs: Shared Service Centres

UK: United Kingdom

VIF: Variance Inflation Factor

VRIN: Valuable, Rare, Imperfectly Imitable, and Non-substitutable

Introduction

In today's increasingly digital and interconnected global world, innovation has become a critical driver of competitive advantage, particularly for small and medium-sized enterprises (SMEs). Firms are constantly pressured to adapt their business models and operations to remain relevant, efficient, and innovative. In this context, two major forces are increasingly recognised as key potential drivers of innovation: Digital Transformation (DX) and Internationalisation.

Firstly, Digital Transformation (DX) refers to the integration of digital technologies (DTs) into all areas of business, fundamentally altering how organisations operate and deliver value to customers (Vial, 2019). DX involves rethinking business processes, capabilities, and culture to leverage emerging technologies for strategic renewal (Zaman et al., 2025). Indeed, the integration of DTs, including artificial intelligence (AI), big data analytics, and the Internet of Things (IoT), into operations has been identified as a key driver of innovation (Dilyard et al., 2021; Patrucco et al., 2022).

Internationalisation, on the other hand, is the increasing involvement of firms in international activities (Welch & Luostarinen, 1988), often requiring the reconfiguration of organisational resources and routines to address diverse institutional environments and customer needs (Johanson & Vahlne, 1977). This study is focused on exports as they are the most common entry mode in the case of SMEs (type of firm that is central to the dissertation). Exporting status has been widely associated with higher levels of innovation, as international exposure exerts competitive pressures on firms and creates knowledge spillovers that stimulate novel activities (Fassio, 2018; Golovko & Valentini, 2014).

Conversely, inter-organisational collaboration (IOC) is being increasingly recognised as a critical mechanism for addressing complex challenges and fostering innovation. It refers to the process by which firms and organisations engage in joint activities to achieve shared goals (Camarinha-Matos & Afsarmanesh, 2008; Heath & Isbell, 2021). In this dissertation, we aim to study the moderating role of IOC, in order to understand its potential to strengthen the effects of DX and internationalisation on innovation.

Despite extensive research on each of these areas individually, a gap remains in what concerns understanding whether DX and internationalisation affect the propensity for innovation in SMEs. We also address the moderating role of inter-organisational collaboration in such relationships, while extant literature has mainly focused on its mediating role. Therefore, this dissertation aims to examine how DX and internationalisation affect innovation at firm level, and how inter-organisational collaboration moderates such relationships. Specifically, the study addresses the following research question: *Do Digital Technologies and Internationalisation affect Innovation directly, and what is the moderating role of Inter-organisational Collaboration?*

Firstly, it provides a comprehensive literature review integrating the definition of key concepts and international business theories, such as KBV and RBV, Open Innovation, and the Dynamic Capabilities Framework. Secondly, we analyse empirical literature to build our hypotheses and analyse the complex relationship between DX, internationalisation, inter-organisational collaboration and innovation. Finally, an empirical investigation is conducted using firm-level data from the EU27 and 12 additional countries to test these theoretical propositions, applying a Probit model to estimate the likelihood of innovation as influenced by DX, internationalisation and inter-organisational collaboration, as well as the moderating role of inter-organisational collaboration.

The empirical analysis is based on the *Flash Eurobarometer 486: SMEs, Start-ups, Scale-ups and Entrepreneurship* dataset and refers to the year 2020. The results show that firms engaging in DX, exporting firms and inter-organisational collaboration have a direct and positive impact on the probability of innovation. However, contrary to our expectations, inter-organisational collaboration seems to weaken the relationship between DX and innovation, which we consider is due to resources' allocation trade-off in the SME contexts. Furthermore, we find that there is no significant evidence that inter-organisational collaboration alters the relationship between exporting status and innovation, suggesting that internationalisation impacts innovation mainly due to internal learning and market exposure.

The dissertation is structured as follows. Chapter 1 provides a thorough review of the key concepts, theories, and literature covering DX, Internationalisation, Innovation and Inter-organisational Collaboration. Chapter 2 describes the quantitative nature of the study and presents the methodology and results. Lastly, conclusions and implications are derived.

Chapter 1. Literature Review and Hypotheses Development

Chapter 1 provides a thorough review of both seminal and contemporary literature, explaining the relevant key concepts and theoretical foundations. It is divided into three main sections. The first section focusses on the key concepts related to Digital Transformation, Innovation, Internationalisation and Inter-organisational Collaboration, respectively. The second section reviews the relevant theoretical literature related to these areas. The final section is focused on the development of the hypotheses tested empirically in this dissertation, examining the intricate relationship between these dimensions and their influence on innovation.

1.1. Key Concepts

1.1.1. Digital Transformation and Related Concepts

In order to understand the concept of Digital Transformation (DX), a crucial starting point is clarifying the distinction between digitization, digitalization, and digital transformation (DX), as often these three terms are confused. Digitization refers to the technical process of converting analogue information into digital formats, while digitalization builds on this by embedding DTs into processes, products, and services, often creating new business models and revenue streams (Zaman et al., 2025). DX, in turn, encompasses a more profound organisational and strategic change process whereby digital technologies disrupt existing practices, trigger structural and cultural shifts, and reshape value creation pathways across firms, industries, and even societies (Vial, 2019). It is thus not only about technology adoption but about leveraging combinations of information, computing, communication, and connectivity technologies to achieve organisational renewal and sustainable competitive advantage (Vial, 2019).

Digital technologies (DTs) have become pivotal in reshaping firms, industries, and global competition. On one hand, DTs are transformative tools and systems that facilitate data-driven operations, connectivity, and automation. They encompass a wide range of applications, including, but not limited to, big data analytics, cloud computing, AI, the IoT, blockchain, 3D printing, digital platforms, robotics and augmented reality (Audretsch & Belitski, 2024; Chen & Kim, 2023; Dilyard et al., 2021). DTs have the potential to boost productivity and enable the creation of new industries, allowing firms to improve their

productivity and global competitiveness through advanced solutions (Chen & Kim, 2023; Khan et al., 2023).

On the other hand, DX is reshaping traditional business models and can be defined as the integration of DTs in all activities. The transition from tangible to intangible assets has enabled firms to adopt platform business models, having platforms such as Uber and Airbnb disrupt whole sectors by leveraging network effects and user data (Stallkamp & Schotter, 2021). The automation and customisation of processes is another area in which DTs can facilitate improvements, as the utilisation of AI and robotics enables the implementation of scalable and customisable manufacturing processes (Autio et al., 2021; Bouncken & Barwinski, 2021). DX is also a facilitator of knowledge exchange, as it enables the instantaneous communication across borders, which is crucial for the formulation of global strategies and collaboration processes (Bouncken & Barwinski, 2021; Cherbib et al., 2021).

DX is driven by a variety of factors. From an organisational perspective, leadership, culture, absorptive capacity, and IT readiness have been identified as critical enablers. Indeed, effective leaders play a critical role in articulating a vision, mobilising resources, and embedding agility into the transformation process (Bilal et al., 2024). Similarly, a supportive organisational culture that embraces change and knowledge sharing reduces resistance and accelerates implementation (Bilal et al., 2024). Firms with stronger absorptive capacities are more able to integrate external knowledge into their routines, transforming it into innovation and competitive advantage (Tallarico et al., 2024). Externally, competitive pressure, regulatory frameworks, and shifting consumer expectations also stimulate firms to undergo digital transformation (Autio et al., 2021; Bilal et al., 2024).

The process of DX unfolds along trajectories and phases. Firms often begin with digitisation of existing processes, proceed to digitalisation by redesigning operations around digital tools, and ultimately achieve DX when business models and organisational logics are fundamentally reconfigured (Zaman et al., 2025). However, this trajectory is neither linear nor without obstacles: firms face challenges such as legacy systems, skill shortages, cybersecurity vulnerabilities, and uncertainty over returns on digital investments (Bilal et al., 2024; Vial, 2019).

Indeed, DX is not immune to tensions and trade-offs. Firms frequently struggle to balance exploitation of existing capabilities with exploration of new digital opportunities,

thereby creating strategic dilemmas surrounding speed, control, and resource allocation (Furr et al., 2022). A significant amount of DX initiatives also fail due to an underestimation of the complexity of the required change, inadequate cultural alignment, or a lack of clear performance metrics (Paul et al., 2024; Vial, 2019). Moreover, ethical concerns, data privacy, and the digital divide highlight the broader societal challenges of transformation (Paul et al., 2024). Yet, when effectively implemented, DX enhances agility, strengthens competitiveness, and enables firms to thrive in dynamic environments by reconfiguring their value creation logic (Bilal et al., 2024; Vial, 2019).

Another important related concept is "Industry 4.0" (I4.0), also known as the "Fourth Industrial Revolution". Industry 4.0 refers to the integration of DTs into manufacturing and industrial processes, although it can be extended to any other sector (Patrucco et al., 2022). It represents a paradigm shift in industrial operations, emphasising interconnected, automated, and data-driven processes. Its potential to increase efficiency, enable customisation and promote sustainability makes it a cornerstone of modern innovation strategies (Bouncken & Barwinski, 2021; Dilyard et al., 2021; Furr et al., 2022).

Some examples are the way in which IoT facilitates the interconnection of machines and systems, enabling the seamless aggregation of data and the enhancement of operational efficiency (Autio et al., 2021; Bouncken & Barwinski, 2021); also, how AI enhances predictive maintenance, anticipating equipment failures to optimise schedules and reduce downtime (Furr et al., 2022); how 3D printing revolutionises production with rapid prototyping and on-demand manufacturing, minimising waste (Bouncken & Barwinski, 2021); the way in which blockchain technology ensures transparency and security in supply chains with tamper-proof transaction records (Dilyard et al., 2021); and how cloud computing provides scalable, cost-effective solutions for storing and processing vast data as its integration allows firms to leverage advanced analytics, real-time insights, and collaborative platforms, ensuring that data-driven decisions can be made quickly and accurately (Brem et al., 2023; Furr et al., 2022; Weber, 2020).

1.1.2. Internationalisation

In the current globalisation era, internationalisation has evolved into a key strategic move for firms aspiring to achieve growth and competitiveness. Welch & Luostarinen (1988) define the concept of internationalization as an increasing involvement in international

activities, when a firms operations go beyond the borders of its home market (Welch & Luostarinen, 1988).

The traditional internationalisation process was first seen as the gradual increase in commitment to foreign markets, evolving through stages as firms acquire knowledge and reduce perceived risks (Johanson & Wiedersheim-Paul, 1975). It involves more than just a decision to expand geographically, as it is a complex, multifaceted progression involving strategic, structural and behavioural changes (Johanson & Wiedersheim-Paul, 1975; Root, 1944). This notion was later refined by Johanson and Vahlne (1977), who proposed the Uppsala Model, explaining internationalisation as a gradual learning-based process shaped by knowledge acquisition and commitment decisions over time. This approach assumes that firms begin their internationalisation process in nearby and familiar markets, gradually expanding as experiential knowledge and resources accumulate (Johanson & Vahlne, 1977). Additionally, knowledge and learning are considered key components of internationalisation, as firms gradually become more internationalised as they gain experiential knowledge about foreign markets, leading to incremental resource commitments (Johanson & Vahlne, 1977).

From a networking perspective, internationalisation is often driven by relational ties. Firms do not operate in isolation and frequently base their decisions to expand abroad on established business and social networks (Zain & Ng, 2006). These networks reduce uncertainty, provide access to resources and help firms to overcome the 'liability of foreignness' (Zain & Ng, 2006).

For SMEs in particular, the process of internationalisation is often influenced by their capacity to manage knowledge, establish networks, and mitigate liabilities of foreignness (Zain & Ng, 2006). Autio, Sapienza, and Almeida (2000) introduced the concept of "born globals" or "international new ventures", emphasizing that firms can skip gradual stages and internationalise rapidly, often driven by entrepreneurial orientation, technological capabilities, and network relationships (Autio et al., 2000). This challenges traditional stage models by demonstrating that firms can engage in international markets early on, provided they possess the right capabilities and partnerships (Deng et al., 2022).

Furthermore, firms must consider the most appropriate mode of entry into foreign markets, balancing risk, control, and resource commitment. Entry modes are generally divided into two main categories: equity-based and non-equity-based strategies (Hollender et

al., 2017; Pan & Tse, 2000; Root, 1944). Equity entry modes involve foreign direct investment (FDI), either through wholly owned subsidiaries or joint ventures. These modes provide greater control for the investing entity, but also require higher resource commitment and exposure to risk. They are often pursued when strategic assets or long-term market presence are prioritized (Hollender et al., 2017). In contrast, non-equity modes such as exporting, licensing, franchising, and contractual partnerships are characterized by lower commitment and reduced control. Exporting, particularly relevant to this study, is often the first step in international expansion, especially for SMEs with limited international experience (Deng et al., 2022). It allows firms to test foreign markets with lower investment while leveraging external intermediaries or existing distribution channels (Root, 1944).

Firms' decisions are influenced by internal factors, such as knowledge intensity, technological capabilities, and strategic goals, as well as external factors, such as host market conditions, institutional frameworks, and network availability (Yip, 1989; Hollender et al., 2017). Specifically, SMEs may prefer flexible modes like exporting or alliances to accommodate their limited scale and need for adaptability (Zain & Ng, 2006).

This study is focused on exports. Exports are the most common entry mode in the case of SMEs, reflecting an accessible strategic approach for SMEs aiming to enter international markets while managing risks and resource constraints. On the other hand, as explained in the econometric part, the large scale, multi-country dataset used also provided data on exports and not on other entry modes.

1.1.3. Innovation

Innovation is defined as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005, p. 46). For a development to be considered innovative, it must be implemented, meaning that it has been introduced to the market or incorporated into a company's operations (OECD, 2005). The concept is intentionally broad, encompassing technological and non-technological changes ranging from product and process innovation to shifts in marketing or organisational practices. Innovation can result from a major breakthrough or a series of smaller incremental improvements that collectively bring about significant change (OECD, 2005). Firms that introduce at least one innovation (of any of the four types mentioned

before) during a specific reference period are classified as innovative (OECD, 2005) This is the definition that we used in Chapter 2 to classify innovative firms.

The third edition of the Oslo Manual makes the distinction between four types of innovation: product, process, marketing and organisational (OECD, 2005). The two central types of innovation that have been studied more intensively by extant literature are product and process innovation, with marketing and organisational innovation being a more recent concept. In the last version of the Oslo Manual (2018), the latter two were considered as a part of process innovation (OECD, 2018). For our empirical purposes, the classification in four types of innovation is more discerning and relevant.

Product Innovation

Product innovation can be defined as the introduction of a good or service that is either entirely new or has been significantly improved in terms of its characteristics or intended uses (OECD, 2005). Improvements can involve changes to technical specifications, components, materials, embedded software, user-friendliness or other functional attributes. Importantly, product innovations may stem from the use of entirely new technologies, or from the combination of existing technologies and knowledge to serve new purposes. However, routine upgrades and seasonal design changes that have no impact on functionality are excluded from this definition (OECD, 2005).

Product innovation is a central focus of both internal R&D and collaborative innovation strategies and has been shown to be a key performance outcome across multiple industrial and national contexts (H. Zhang et al., 2023, 2024; Zhou & Wu, 2009). Technological capability, defined as a firm's ability to develop, adapt, and apply DTs to create new products, is one of the primary internal enablers of product innovation (Kim, 2021; Sun et al., 2019; Zhou & Wu, 2009). Firms with higher levels of technological capability are indeed better equipped to manage product development processes, introduce new features, and reduce time-to-market. Furthermore, strategic flexibility (organisational ability to reconfigure resources and adapt to environmental changes) amplifies the impact of technological capabilities on product innovation outcomes (H. Zhang et al., 2024; Zhou & Wu, 2009).

Open innovation (OI), which is defined as the intentional flow of knowledge in and out of the organisation, has transformed the way firms approach product development. It

allows them to incorporate external knowledge sources into their internal innovation processes (Chesbrough H.W., 2003; Zhang et al., 2023). Inbound OI provides access to ideas from customers, suppliers, and research institutions, while outbound OI enables firms to monetise unused technologies (Sun et al., 2019; H. Zhang et al., 2023). The effectiveness of OI for product innovation depends on a firm's capacity to manage knowledge flows, which is supported by DTs and knowledge management capabilities (Urbinati et al., 2020; Zhao, 2023). Partner diversity and platform openness can enhance innovation, but require careful governance (Belitski et al., 2024; Zhao, 2023). OI theoretical considerations are discussed in more detail in section 1.1.3 of this study.

Firms face challenges in protecting the outputs of product innovation, especially when relying on external partnerships. Therefore, innovation protection strategies should be tailored to the nature of the product innovation: secrecy and lead-time advantages are beneficial for radical innovations, whereas patents and trademarks offer better protection for incremental innovations (Kim, 2021). Thus, the choice of protection mechanism reflects a strategic balance between openness and control (Kim, 2021).

Historically, product innovation has been understood as a process that is both structured and adaptive. Brown and Eisenhardt (1995) emphasise the importance of semi-structured development frameworks that balance flexibility and discipline, enabling firms to innovate under conditions of uncertainty (Brown & Eisenhardt, 1995). This perspective remains relevant in today's digital and collaborative landscape, where agile development and user-driven feedback loops are crucial for successful product innovation (Sun et al., 2019; Urbinati et al., 2020; H. Zhang et al., 2023).

Process Innovation

Process innovation refers to the implementation of a new or significantly enhanced production or delivery method (OECD, 2005). Such improvements may be the result of advancements in the techniques, equipment or software used by the firm. The primary goals of such innovations are usually to reduce production or delivery costs, enhance quality, or enable the development and provision of new or improved products and services (OECD, 2005). Process innovations can relate to production methods, such as new automation systems or computer-aided design tools, or delivery methods. In service-oriented sectors,

this may involve substantial improvements to software, tracking devices or internal procedures such as booking systems or project management tools (OECD, 2005).

Process innovation models have evolved from simple, linear frameworks towards integrated, non-linear approaches that better reflect the feedback loops and dynamic interactions across R&D, design, production, and commercialisation stages (Tohidi & Jabbari, 2011). It spreads across multiple stages, and its benefits vary according to the timing and location of its introduction: early-stage process innovation (before product launch) has a stronger effect on cost reduction and time-to-market, while late-stage process innovation (post-launch) can improve flexibility and adaptability, particularly in environments with ongoing customer feedback (Hervas-Oliver et al., 2017). This temporal dimension of process innovation underscores its importance throughout the innovation lifecycle.

Firms with high absorptive capacity are better positioned to implement process innovations effectively as they can identify, assimilate, and apply relevant external knowledge to reconfigure internal processes (Urbinati et al., 2020). In fact, DTs play a critical role in enabling such capabilities as they can improve visibility across operations, facilitate real-time decision-making, and enable adaptive process configurations (Urbinati et al., 2020; Zhao, 2023).

Lastly, OI also intersects with process innovation, although to a lesser extent than with product innovation. Firms can adopt inbound OI strategies to enhance their process capabilities by integrating suppliers, technology providers, or external specialists into their operational design (Belitski et al., 2024; H. Zhang et al., 2023). However, the benefits of such collaboration are dependent on the firm's ability to manage coordination costs and intellectual property risks (Kim, 2021; Sun et al., 2019). OI is discussed in more detail in section 1.2.3 of this study.

Marketing Innovation

Marketing innovation is defined as the implementation of a novel marketing method that brings about substantial changes in aspects such as product design, packaging, placement, promotion, or pricing, with the primary goal of better addressing customer needs or entering new markets (OECD, 2005). Unlike routine marketing adjustments, a marketing

innovation must represent a departure from the firm's previous practices and be part of a newly developed marketing strategy (OECD, 2005).

Such innovations can manifest in several domains: product design (significant alterations to the physical appearance or form of a product without modifying its technical or functional characteristics); product placement (adoption of new sales channels or distribution strategies, introducing franchising systems, exclusive retailing, or licensing models); product promotion (use of new media or promotional strategies); pricing (pricing strategies previously unused by the firm) (OECD, 2005).

Organisational Innovation

Organisational innovation is defined as the implementation of novel organisational methods in a firm's business practices, workplace organisation, or external relations that have not previously been utilised by the firm and result from strategic decisions by management (OECD, 2005). The objective of these innovations is to enhance a firm's performance by reducing costs, enhancing workplace satisfaction and productivity, or increasing access to non-tradable knowledge assets.

Organisational innovation can be classified into three main areas: business practices (includes new approaches to organising routines, codifying knowledge, and improving internal knowledge sharing); workplace organisation (restructuring responsibilities and decision-making processes, and integrating business activities in new ways); external relations (new methods for managing collaborations with external stakeholders such as research institutions, customers, or suppliers) (OECD, 2005).

Despite the absence of direct reference to business model innovation (BMI) in the Oslo Manual (OECD, 2005), there is a conceptual alignment between BMI and organisational innovation. BMI frequently necessitates the reconfiguration of internal firm structures, processes, and external relations in ways that closely mirror organisational innovation areas. Consequently, BMI is interpreted as an observable *proxy* for organisational innovation, particularly in Chapter 2 on the econometric analysis.

Indeed, BMI refers to the intentional, novel reconfiguration of a firm's value logic, i.e. how it creates, delivers, and captures value (Liang et al., 2024). BMI can also be defined

as a capability built over time through three interdependent routines: (1) establishing digital infrastructures, (2) embedding digital experimentation into strategic initiatives, and (3) fostering organisational learning loops. These capabilities allow firms to continuously adapt their business models, aligning them with rapidly evolving technological contexts and globalization pressures (Liang et al., 2024; Wang et al., 2025).

Lastly, BMI is closely linked to a firm's knowledge and resource configuration, reflecting principles of the resource-based view (RBV) and knowledge-based view (KBV), which will be discussed more thoroughly in section 1.2. on applicable theoretical frameworks. The integration of digital capabilities with externally sourced knowledge from customers, partners, or ecosystems is particularly important for designing robust, scalable, and differentiated business models (Liang et al., 2024; Wang et al., 2025).

1.1.4. Inter-oganisational Collaboration and International Collaboration

Inter-organisational collaboration (IOC) is increasingly recognised as a critical mechanism for addressing complex challenges and fostering innovation. It refers to the process by which autonomous organisations engage in joint actions to pursue shared goals that cannot be effectively achieved alone (Camarinha-Matos & Afsarmanesh, 2008; Heath & Isbell, 2021). Such collaborations involve the pooling of complementary resources, knowledge, and capabilities, often across sectoral, disciplinary, or national boundaries, to create mutual value (Adomako & Nguyen, 2024; Camarinha-Matos & Afsarmanesh, 2008).

While often conflated with terms such as *networking*, *coordination*, and *cooperation*, collaboration represents a distinct and more integrated form of inter-organisational interaction. Camarinha-Matos and Afsarmanesh (2008) distinguish collaboration as the highest level of engagement, requiring shared goals, mutual trust, co-dependence, and joint responsibility for outcomes. The concept of collaboration differs from that of cooperation, which implies aligned yet separate actions, and from that of coordination, which entails task alignment for efficiency. Rather, collaboration demands a joint definition of tasks, roles, and success metrics (Camarinha-Matos & Afsarmanesh, 2008).

Keyton et al. (2008: p. 381) define IOC as a "the set of communicative processes in which individuals representing multiple organizations or stakeholders engage when working interdependently to address problems outside the spheres of individuals or organizations

working in isolation." (Keyton et al., 2008, p. 381). This conception positions communication at the centre of collaboration, conceptualising it as an ongoing and principled process influenced by the dynamics of legitimacy, accountability, and power-sharing (Heath & Isbell, 2021; Keyton et al., 2008).

Soliman et al. (2005) propose that IOC, regardless of whether it occurs face-to-face or through technological mediation, depends on eight essential ingredients: people, shared space, time, a common objective, focus on the objective, a common language, knowledge in the area of the objective, and interaction (Soliman et al., 2005). People are the fundamental element, as collaboration requires at least two participants whose diverse perspectives and experiences contribute to joint problem-solving. A shared space, whether physical, virtual, or symbolic, provides the context in which communication and joint work take place (Soliman et al., 2005). This space should enable both synchronous and asynchronous interaction and allow for the emergence of shared understanding and identity (Camarinha-Matos & Afsarmanesh, 2008). Time is also critical, since the amount available influences both productivity and the level of stress experienced by participants. In addition, collaboration requires a common objective that unites individuals beyond personal relationships, and sustained focus on this objective to ensure efficiency and avoid distraction. A common language is necessary for mutual understanding, while participants must also bring relevant knowledge, which can be expanded through learning within the group. Finally, interaction integrates all other elements, as reciprocal actions and exchanges between participants provide the dynamic character of collaboration (Soliman et al., 2005).

Heath & Isbell (2021) emphasise the importance of principled collaboration, where legitimacy, accountability, and shared power guide the interaction. Legitimacy is defined by the principles of transparent and inclusive decision-making, while accountability is understood as the responsibility to respond to the diverse and marginalised stakeholders involved. Shared power, meanwhile, is defined as the process of fostering equitable participation among partners (Heath & Isbell, 2021).

Inter-organisational collaboration has, nowadays, very often an international dimension. International collaboration is used to describe cooperative efforts between organisations or entities situated in different countries. These efforts are undertaken with the aim of pooling resources, exchanging knowledge, and achieving shared objectives (Audretsch

& Belitski, 2024). Such partnerships frequently involve firms, governments, universities, or other stakeholders with the aim of addressing complex challenges, fostering innovation, and gaining competitive advantages. The transfer of both tacit and explicit knowledge is facilitated by collaboration networks, which foster innovation through the sharing of expertise and diverse perspectives (Audretsch & Belitski, 2024; Belitski et al., 2024).

International collaboration provides access to a diverse knowledge base and a range of resources, which facilitates the generation of innovative solutions through the combination of local expertise with global perspectives and resources. Studies highlight that collaboration across national boundaries can facilitate the transfer of knowledge and accelerate the development of cutting-edge technologies (Audretsch & Belitski, 2024; Fu et al., 2022).

DTs and international collaboration are inherently interlinked. DX has relied heavily on collaborative frameworks to leverage expertise and resources across borders. In parallel, DTs facilitate real-time knowledge sharing and communication, thereby reducing barriers to global cooperation and transaction costs, as well as enhancing the efficiency of collaboration (Autio et al., 2021; Sturgeon, 2021).

Nonetheless, the effectiveness of international collaboration is often contingent on the dynamic capabilities of firms, including their ability to sense opportunities, seize them, and reconfigure resources. These capabilities empower organisations to adapt to complex and changing international environments. Empirical evidence indicates that enterprises with well-developed dynamic capabilities are better positioned to oversee collaboration networks and employ digital instruments to augment innovation and performance (Brem et al., 2023; Schöggl et al., 2024).

It is similarly pertinent to highlight the mechanisms through which firms engage in international collaboration, focusing on the application of modern technologies. These modes can be classified as internal or external (Weber, 2020). Internal collaboration refers to connections and cooperative efforts within the same firm or institutions, while external collaboration implies connection with at least one other organisation. On one hand, two identified internal collaboration modes are virtual teams and shared service centres (SSCs). Virtual teams are collaborative units composed of geographically dispersed individuals who work together towards a common goal, relying primarily on digital communication tools

(Gibson & Cohen, 2003; Weber, 2020); while SSCs are centralized units within organizations that manage support functions such as finance, IT, and human resources, enabling companies to improve efficiency and reduce costs (Weber, 2020). On the other hand, external collaboration modes (or inter-organisational collaboration) include open innovation processes and business process outsourcing (BPO). These external modes of collaboration are the ones being studied on this dissertation.

After this clarification of the key concepts and key ideas related with digital transformation, innovation, internationalisation and interorganisational collaboration, pertinent to this dissertation, the next section will address the main theories (international business and innovation-related) that are also important to the current research topic.

1.2. Theories and Conceptual Background

Section 1.2. builds a theoretical framework by relating the research topic with International Business theories and conceptual background.

The intersection of innovation, DX, internationalisation and IOC offers a rich domain for theoretical exploration, particularly when anchored in the theoretical frameworks explained in this section, notably the Resource-Based View (RBV), the Knowledge-Based View (KBV), the Dynamic Capabilities framework, and Open Innovation (OI). RBV and KBV jointly underscore that firms gain competitive advantage by developing valuable, rare, imperfectly imitable, and non-substitutable resources such as digital infrastructures and international networks (Barney, 1991). It is crucial for firms to effectively generate and integrate knowledge in order to achieve this goal. However, in global and rapidly changing environments, the possession of resources alone is not sufficient. The Dynamic Capabilities framework extends this logic by emphasizing the firm's ability to adapt, reconfigure, and transform its resource base to seize innovation opportunities (Teece et al., 1997). This is particularly relevant in the face of digital transformation and international expansion. Lastly, the OI perspective reinforces that innovation is increasingly boundary-spanning in nature, requiring firms to leverage external sources of knowledge and inter-organisational collaboration (Chesbrough, 2003).

1.2.1. Resource-Based View and Knowledge-Based View

The Resource-Based View (RBV) and the Knowledge-Based View (KBV) provide fundamental frameworks for understanding the role of DX, internationalisation and IOC in fostering innovation.

RBV posits that firms are heterogeneous in terms of their resources, and that if these resources are valuable, rare, imperfectly imitable, and non-substitutable (VRIN) they can serve as sources of sustained competitive advantage (Barney, 1991). A valuable resource enables a firm to exploit opportunities or neutralize threats in the environment; a rare resource is not widely possessed by competitors; an imperfectly imitable resource cannot be easily replicated due to unique historical conditions, causal ambiguity, or social complexity; and a non-substitutable resource has no strategically equivalent alternatives (Barney, 1991). This approach shifts focus from external market conditions to internal firm capabilities as primary determinants of strategic success.

Furthermore, resources can be categorised as tangible or intangible and include assets such as intellectual property, processes, technologies, and managerial skills (Barney et al., 2001). Such resources are frequently deeply embedded within firm routines and organisational processes, making them difficult to acquire or replicate through market transactions (Mowery et al., 1998). Mowery et al. (1998) further argue that such resources, particularly those related to technological capabilities, are developed cumulatively and cannot be instantaneously mobilised, making them crucial in dynamic, innovation-driven markets (Mowery et al., 1998).

Building on RBV, the Knowledge-Based View (KBV) treats knowledge as the most strategically significant resource of the firm. It emphasizes the central role of knowledge creation, integration, and application in developing competitive advantage (Grant, 1996). According to KBV, the firm exists as a governance structure superior to the market in integrating individual specialist knowledge (Kogut & Zander, 2009). Under this view, firms are not merely repositories of information but complex systems of coordinated knowledge flows, processes, and routines (Grant, 1996). The KBV also addresses the challenges posed by knowledge heterogeneity, suggesting that innovation results from the recombination of

diverse and previously unconnected knowledge domains (Ambos et al., 2006; Grant, 1996; Laursen & Salter, 2003).

Moreover, KBV distinguishes between different types of knowledge: explicit vs. tacit, individual vs. collective. Explicit knowledge refers to information that is codified and easily communicated through formal language, such as technical manuals or blueprints, while tacit knowledge is deeply embedded in individual experiences and difficult to articulate or formalize (Barney, 1991; Grant, 1996). On the other hand, individual knowledge resides within specific members of the organization, often shaped by personal learning and cognitive frameworks, whereas collective knowledge is embedded in organizational routines, cultures, and shared practices that arise through social interactions over time (Ambos et al., 2006; Yamakawa et al., 2008). Managing the interplay between these types of knowledge is central to innovation, particularly in multinational and digitally networked firms where knowledge must be transferred across organisational and geographic boundaries (Laursen & Salter, 2003). This theoretical approach underscores that knowledge is not only a resource but also a capability, as firms differ in how they create, absorb, interpret, and exploit knowledge (Ambos et al., 2006).

The KBV emphasises the critical role of knowledge creation and transfer in collaborations. It highlights that the configuration of resources and the characteristics of partners' knowledge bases, such as complexity, tacitness and similarity determine the success of knowledge sharing activities (Chesbrough, 2003; Mowery et al., 1998; Singh, 2008). Governance structures, partner motives, and external factors such as host country institutions and geographic diversity further shape the dynamics and outcomes of these collaborations (Fu et al., 2022; Oxley & Sampson, 2004).

Inter-organisational collaboration, particularly when international, deepens the link between the RBV and the KBV by providing access to complementary assets and geographically dispersed knowledge, both of which are critical for innovation and sustained competitive advantage (Almeida & Phene, 2004; Mowery et al., 1998; O'Neill et al., 2013; Oxley & Sampson, 2004; Yamakawa et al., 2008). Firms often select international partners based on technological overlap, as this signals the potential for mutual absorptive capacity and successful knowledge exchange. This alignment enhances the potential to learn from and build upon partners' capabilities, enabling firms to acquire novel technological competencies

and shape their innovation trajectories in ways that validate the RBV notion that competitive advantage arises from unique resource combinations (Mowery et al., 1998). Concurrently, R&D collaborations support the KBV assertion that firms constitute systems of knowledge integration. Indeed, R&D models allow separated units to contribute distinct technological expertise. The success of innovation in this context is contingent upon the firm's capacity to effectively integrate knowledge, which represents a dynamic organizational capability aligned with KBV (Gassmann & Von Zedtwitz, 1999).

Furthermore, R&D alliances require firms to address the dual challenge of openness for learning and protection against knowledge appropriation, reinforcing the strategic implications of both RBV and KBV (Oxley & Sampson, 2004). When firms perceive high risks of knowledge leakage, particularly in alliances involving competitors, they respond by narrowing the functional scope of collaboration to pre-competitive R&D activities. This defensive governance choice reflects a resource-protection logic consistent with RBV, while also supporting the KBV view that knowledge integration is contingent on governance mechanisms that regulate access and control (Oxley & Sampson, 2004).

Lastly, inter-organisational collaboration enables firms to integrate diverse knowledge bases, influenced by distinct contexts. Such recombination has been demonstrated to foster the generation of novel technological solutions and breakthrough innovations (Almeida & Phene, 2004). As firms increasingly confront complex problems, from technological disruption to global market expansion, they engage in collaborative arrangements to pool knowledge, resources, and capabilities across organizational boundaries (Heath & Isbell, 2021). These findings serve to reinforce the KBV emphasis on the value of heterogeneous knowledge and support the RBV idea that capabilities rooted in such recombination can be rare, valuable, and difficult to imitate (Almeida & Phene, 2004).

When considered as a whole, these studies demonstrate that the strategic orchestration of internal and external resources, particularly knowledge, is imperative in the digital and global innovation landscape. Inter-organisational collaboration serves not only as a source of resource access but also as a platform for capability building, learning, and reconfiguration (Yamakawa et al., 2008).

1.2.2. Dynamic Capabilities Framework

A firm's ability to deploy, reconfigure and integrate resources determines the quality of its organisational learning and innovation outcomes. Capabilities such as absorptive capacity and managerial skills play a key role in ensuring that inter-organisational collaborations result in valuable innovations. These collaborations not only influence the likelihood and quantity of innovation, but also enhance its quality and diversity, contributing to the firm's long-term competitiveness (Van Wijk et al., 2008).

Thus, the Dynamic Capabilities Framework, developed by Teece et al. (1997), emphasizes firms' capacity to sense and capitalize on opportunities by strategically reallocating resources to align with rapidly changing environments (Teece et al., 1997). Dynamic capabilities refer to an organisation's ability to purposefully adapt, integrate, and reconfigure its internal and external resources in response to a rapidly changing environment (Teece, 2007; Teece et al., 1997). Therefore, in literature, dynamic capabilities are seen as the opposite of ordinary or operational capabilities due to being related to change (Winter, 2003). This theoretical construct emerged in response to the static nature of the resource-based view (RBV), which emphasises the possession VRIN resources, but struggles to explain sustained competitive advantage in volatile settings (Cano-Kollmann et al., 2000; Teece et al., 1997). Rather than focusing solely on resource ownership, the dynamic capabilities framework shifts the focus to how firms can reconfigure these resources in order to sustain innovation and competitiveness (Teece et al., 1997; Winter, 2003).

In order to explain how these capabilities develop, there are three core elements: processes, positions and paths (Teece et al., 1997). Processes refer to the routines and managerial practices that coordinate and integrate activities across the firm, as organisational processes have three functions: coordination, learning, and reconfiguration (Teece et al., 1997). On the other hand, positions encompass the firm's existing asset base, such as technological, financial, reputational, structural and institutional, which shapes what the firm is able to do (Teece et al., 1997). Lastly, paths refer to historical decisions and developmental trajectories that either constrain or enable future action, creating path dependencies that influence the evolution of capabilities (Teece et al., 1997).

Dynamic capabilities are crucial in a global and digital era in order to foster innovation. Indeed, firms' innovative performance are strongly influenced by their internal capabilities. Internal drivers include knowledge intensity, technological capabilities, and strategic orientation (Yip, 1989; Hollender et al., 2017). In this context, firms with stronger technological capabilities as well as strategic flexibility are better equipped to manage complex product development cycles, introduce new features, and reduce time-to-market (Zhang et al., 2024). A key factor enabling firms to benefit from these internal and external inputs is their absorptive capacity, which is the ability to identify, assimilate, and apply external knowledge. In particular, DTs play a crucial role in supporting these capabilities as they enhance visibility across the value chain, support real-time decision-making, and enable adaptive and reconfigurable processes, which are central to innovation in dynamic and uncertain environments (Urbinati et al., 2020; Zhao, 2023).

Winter (2003) builds on this conceptualisation by distinguishing between operational and dynamic capabilities. Operational or 'zero-level' capabilities refer to a firm's existing routines that enable it to generate income in the present, whereas dynamic capabilities (higher-order) enable a firm to innovate and adapt its routines in response to changing conditions (Nayernia, 2025; Winter, 2003). For instance, activities such as new product development or the expansion of market reach are examples of first-order dynamic capabilities, as they intentionally alter these existing routines and require systematic processes to do so (Winter, 2003).

The microfoundations of dynamic capabilities refer to its underlying routines, processes and managerial actions and play a critical role in determining how firms innovate in dynamic environments (Ashiru et al., 2022). The microfoundations encompass a variety of enterprise-level elements, such as distinctive skills, processes, decision-making procedures and organisational structures, that are vital not only for identifying and shaping opportunities and threats, but also for orchestrating internal and external assets to sustain long-term competitive advantage (Teece, 2007). These processes involve analysing and interpreting market and technological signals and integrating external knowledge into internal innovation streams, which illustrates how firms can develop and utilise microfoundations intentionally to shape their ecosystems through innovation and collaboration (Teece, 2007). Furthermore, as highlighted in contemporary literature, feedback loops and issue-selling routines help to maintain strategic alignment and adaptability in the face of environmental complexity (Ashiru

et al., 2022; Nayernia, 2025). These elements are essential for enabling firms to adjust their strategic direction in real time, especially when deploying digital technologies in volatile markets (Ashiru et al., 2022; Nayernia, 2025).

This framework is particularly relevant in the context of DX, internationalisation and inter-organizational collaboration, as firms must perpetually synchronize their technological and organisational resources with external opportunities and threats (Teece, 2007). For instance, the integration of digital tools into collaborative frameworks has been shown to enhance firms' ability to reconfigure knowledge networks, optimize resource allocation, and innovate effectively (Brem et al., 2023). Furthermore, a well-designed product development process, which is a key example of a dynamic capability (Brown & Eisenhardt, 1995), usually relies on cross-functional teams that integrate diverse areas of expertise. Such varied knowledge sources are critical for creating high-quality products, as each contributes to different aspects of product performance and production (Cano-Kollmann et al., 2000). Dynamic capabilities not only facilitate strategic adaptation. but also empower firms to anticipate disruptions and maintain competitiveness in the evolving global landscape (Khan et al., 2023). In internationalisation processes, dynamic capabilities allow firms to develop market-sensing abilities and adapt organisational routines to enter or compete in foreign markets (Garcia Chavez et al., 2025).In terms of innovation, dynamic capabilities support the reconfiguration of knowledge resources and organisational practices to foster new product development or process improvement (Reim et al., 2022). Capabilities such as sensing opportunities, seizing them through appropriate investments, and transforming operations are therefore essential to leverage innovation and international market expansion simultaneously, particularly for SMEs operating under resource constraints (Abdalla & Nakagawa, 2021).

1.2.3. Open Innovation

Open Innovation (OI) was first systematically theorised by Henry Chesbrough (2003), who challenged the traditional closed innovation model, which made the assumption that firms' innovations had to originate and be developed internally, and intellectual property had to be safeguarded until commercialisation, for the firm to remain competitive (Chesbrough, 2003; Chesbrough & Bogers, 2013). Indeed, Chesbrough identified several trends that rendered this model obsolete, including increased mobility of skilled workers, greater availability of venture capital, and shorter product life cycles which encouraged the

dissemination of valuable knowledge beyond the boundaries of firms (Chesbrough, 2003; Chesbrough & Bogers, 2013).

OI is increasingly recognised as a multidimensional and strategically driven approach to managing innovation in interconnected environments as it deliberately uses knowledge inflows and outflows to accelerate internal innovation and facilitate external exploitation of technological assets, thereby creating more dynamic and flexible innovation ecosystems (Chesbrough & Bogers, 2013; H. Zhang et al., 2023). By leveraging external ideas, resources, and partnerships to complement in-house R&D, firms expand innovation capacity and market opportunities (Chen & Kim, 2023; Chesbrough, 2003; Khan et al., 2023; Urbinati et al., 2020). It becomes particularly prominent in the context of the increasing complexity and globalisation of markets, where the presence of a single firm monopolising the knowledge required to sustain competitive advantage is becoming increasingly more unlikely (Chesbrough & Bogers, 2013).

OI practices can be categorised as inbound, where knowledge flows from outside the organisation; outbound, where internal ideas are allowed to flow outward; or coupled, which combines the two through partnerships and alliances (Chesbrough & Bogers, 2013; Urbinati et al., 2020; Zhang et al., 2023). These models allow firms to access a wider knowledge base, speed up time to market, cut R&D costs and boost innovation performance (Urbinati et al., 2020; Zhang et al., 2023).

The advantages of OI are numerous and well documented. By opening their boundaries, firms can enhance organisational flexibility, reduce innovation risks, and increase responsiveness to rapidly changing market conditions (Chesbrough, 2003; Euchner, 2013; Urbinati et al., 2020; Zhang et al., 2023). OI facilitates access to diverse knowledge pools, technological capabilities, and creative contributions that would otherwise remain inaccessible, particularly for firms with limited internal R&D capacity (Chesbrough & Bogers, 2013; Zhang et al., 2023). This external engagement has also been shown to reduce the costs and time associated with internal development because ideas and technologies can be sourced and validated through collaboration, licensing, or acquisition rather than full in-house development (Chesbrough, 2003; Urbinati et al., 2020; Zhang et al., 2023). Moreover, OI contributes to higher innovation performance, both in terms of the number of innovations and their market success. It encourages firms to pursue dual innovation

strategies, which refers to simultaneously engaging in exploratory innovation to discover new markets, technologies, or business models and exploitative innovation to refine and improve existing products and processes (Sun et al., 2019; Zhang et al., 2023). This dual approach is particularly effective when supported by robust knowledge management capabilities, enabling firms to meaningfully integrate external inputs and build upon existing competencies (Sun et al., 2019). Furthermore, outbound OI strategies enable firms to generate value from unused or underutilised internal knowledge by licensing, spinning off or selling technologies, thereby converting potential waste into new revenue streams (Chesbrough & Bogers, 2013; Zhang et al., 2023).

However, the openness that underpins these benefits also introduces a variety of organisational and strategic challenges. Integrating external knowledge into internal processes requires robust absorptive capacity, including mechanisms to identify, assimilate and apply knowledge from outside sources (Urbinati et al., 2020; Zhang et al., 2023). Firms must navigate the complexity of aligning different knowledge domains, organisational cultures and incentive systems, which can lead to coordination difficulties and misaligned expectations among partners (Euchner, 2013; Zhang et al., 2023). Furthermore, managing intellectual property rights becomes more critical and complex as firms must balance openness with the need to protect their core assets (Chesbrough, 2003; Euchner, 2013; Urbinati et al., 2020). Other significant challenges include ensuring strategic coherence across diverse innovation partners and maintaining control over the direction of innovation without stifling external contributions. Open innovation (OI) also requires a shift in internal mindset and routines, moving from hierarchical, closed processes to more networked, participative models. This demands organisational readiness, strong change management practices and leadership commitment (Euchner, 2013; Urbinati et al., 2020).

The relevance of OI is especially pronounced in the context of DTs and internationalisation. Digital platforms and tools facilitate real-time knowledge sharing, collaboration, and the co-creation of value across organisational and geographical boundaries (Khan et al., 2023). By fostering dynamic interactions between diverse actors, OI enhances firms' ability to adapt to market changes and address complex challenges collaboratively (Chesbrough, 2003). Furthermore, OI acts as a bridge between external knowledge environments and the firm's internal innovation processes, which is particularly critical in

international contexts where access to local knowledge, institutional understanding, and technical capabilities may be limited (Kim, 2021; Zhao, 2023).

1.3. Hypotheses Development

In this section, we develop hypotheses to be tested econometrically, based on relevant literature, having present the conceptual and theoretical foundations explained above, as well as relying on a thorough, comprehensive review of the applicable empirical literature, whose results will inform the expectations about the posited hypotheses.

1.3.1. The Link Between DX and Innovation

A growing body of research highlights DX as a powerful enabler of innovation across industries and organisational contexts. DX reconfigures processes and value creation paths, introducing new ways to organise activities and generate competitive advantage through innovation (Vial, 2019; Zaman et al., 2025). The integration of DTs, including AI, big data analytics, and the IoT, into operations has been identified as a key factor in facilitating opportunities for product and service innovation as well as process improvements that were not feasible under traditional configurations (Dilyard et al., 2021; Patrucco et al., 2022). These technologies provide both the infrastructure and the flexibility for experimentation, enabling firms to redesign their offerings and explore new markets.

The extant literature also demonstrates that DX exerts an influence on innovation through learning and knowledge mechanisms. Firms with higher absorptive capacity are better able to integrate external knowledge flows into their routines, thereby amplifying the innovation potential of DTs (Tallarico et al., 2024). Similarly, the collaborative context shaped by DX has been shown to reduce opportunism in asymmetric alliances and supports mutual learning, which can be transformed into innovative outcomes (Cherbib et al., 2021). This indicates that innovation results not only from technology adoption itself but from the organisational capability to absorb, combine, and apply digital knowledge in novel ways. Similarly, Audretsch and Belitski (2024) note that DTs enable firms to expand their innovation capacity by integrating external and internal knowledge more effectively (Audretsch & Belitski, 2024). Lastly, Urbinati et al. (2020) highlight that DTs support all stages of the OI process ranging from idea generation to commercialization by facilitating external collaboration, enabling virtual marketplaces for ideas, and supporting absorptive capacities (Urbinati et al., 2020).

Empirical studies consistently demonstrate a positive association between DX and innovation performance. Chen & Kim (2023) find that DX enhances a firm's innovation capacity by mediating the relationship between digital adoption and innovation outputs (Chen & Kim, 2023). Parallelly, Bilal et al. (2024) provide evidence from manufacturing demonstrating that DX trajectories enable firms to implement smart technologies such as predictive maintenance and real-time monitoring, which foster process innovation and efficiency gains (Bilal et al., 2024). The transformative potential of DTs is further supported by Dilyard et al. (2021), who demonstrate that DTs enhance global value chain resilience, creating opportunities for innovative practices in response to disruptions (Dilyard et al., 2021).

Although empirical evidence strongly supports the view that DX, when effectively implemented, enhances a firm's ability to innovate, there are still some challenges that indicate that DX may not have a uniform beneficial impact on innovation. Lack of digital skills, organisational resistance, and cultural barriers are shown to possibly undermine the innovation benefits of DX (Bilal et al., 2024; Paul et al., 2024; Vial, 2019). Furthermore, Khan et al. (2023) caution against the potential for unintended knowledge spillovers and the risks of power concentration in digital ecosystems, which could disrupt traditional innovation processes (Khan et al., 2023). Audretsch and Belitski (2024) highlight that the impact of DX on innovation is contingent on factors such as firm productivity, where lower-productivity firms may encounter difficulties in leveraging DTs effectively (Audretsch & Belitski, 2024). Schöggl, Stumpf and Baumgartner (2024) additionally point to the impact of DX on innovation is dependent on organisational capabilities and external contexts. Organisations with strong dynamic capabilities are better positioned to harness the innovative potential of DTs (Schöggl et al., 2024).

Taking into consideration the above reviewed studies focused on the relationship between DX and firm's innovation, the following hypothesis is formulated:

Hypothesis 1: Digital transformation is positively associated with firms' innovation.

1.3.2. The Link Between Exporting Status and Innovation

Exporting status has been widely associated with higher levels of innovation, as firms exposed to international markets face competitive pressures and knowledge spillovers that stimulate novel activities (Fassio, 2018; Golovko & Valentini, 2014).

The mechanisms through which exporting enhances innovation can be explained by two main effects: the *learning-by-exporting effect* (or *technological learning effect*) and the *foreign demand effect*. According to the learning-by-exporting effect, firms entering foreign markets are exposed to advanced technologies, international competition, and demanding customers, thereby improving their innovative capabilities (Fassio, 2018; Golovko & Valentini, 2014). By operating in more technologically sophisticated markets, exporters acquire external knowledge and adapt their products or processes, accordingly, thus driving innovation (Fassio, 2018). The foreign demand effect highlights that access to larger and more diverse markets increases the profitability of developing new products and processes, thereby stimulating firms' incentives to innovate (Fassio, 2018).

Furthermore, innovative firms are significantly more likely to export, but exporters tend to be more innovative due to exposure to international markets (Wakelin, 1998). Zaman & Tanewski (2024) demonstrate that R&D investment, innovation, and exporting are mutually reinforcing processes, with firm size influencing the strength of these relationships. Their findings indicate that exporters, particularly larger firms, have stronger innovation performance as exporting facilitates greater knowledge integration (Zaman & Tanewski, 2024).

Ayllón & Radicic (2019), provide further evidence showing that exporting firms are more likely to undertake innovation in the current period, highlighting a contemporaneous complementarity between the two activities. However, past exporting does not significantly increase current innovation, suggesting that the positive effect of exporting on innovation is primarily immediate rather than driven by long-term feedback effects (Ayllón & Radicic, 2019).

Nevertheless, the literature also highlights boundary conditions. The impact of exporting on innovation has been shown to depend on the destination of exports, as technologically advanced markets provide greater learning opportunities, while developing

markets stimulate demand-driven innovation (Fassio, 2018). Additionally, firm size moderates these effects, as smaller firms may lack the absorptive capacity to fully benefit from international exposure (Zaman & Tanewski, 2024). Anwar (2024) also shows that restrictions on exports (export controls) have complex effects on firms' innovation performance: while sanctioned firms may be pushed to innovate as a survival strategy by developing substitute technologies, suppliers and indirectly affected firms often face reduced innovation due to the loss of access to global markets and technological exchanges (Anwar et al., 2024). These caveats suggest that although the relationship between exporting and innovation is generally positive, its strength and form depend on contextual and institutional factors, as well as policy.

Taken together, the evidence demonstrates that exporting status provides firms with knowledge spillovers, resource advantages, and demand incentives that significantly enhance their innovative capabilities. Thus, the following hypothesis is proposed:

Hypothesis 2: Exporting status is positively associated with firms' innovation.

1.3.3. The Link Between Inter-organisational Collaboration and Innovation

Inter-organisational collaboration has been identified as a key driver of firms' innovation, as it enables access to external knowledge, additional resources, and diverse perspectives. By engaging in collaborative networks, firms can combine knowledge bases, share risks, and accelerate the generation of novel ideas and technologies, ultimately leading to enhanced innovation outcomes (Garcia Chavez et al., 2025). This is aligned with the knowledge-based view of the firm, which emphasises that the recombination of knowledge across organisational boundaries provides a foundation for competitive advantage and innovation (Ambos et al., 2006).

Empirical studies provide strong support for the innovation benefits of inter-organisational collaboration. Garcia Chavez et al. (2025) show that collaboration at both intra- and inter-organisational levels is positively associated with higher innovation performance, as it facilitates access to knowledge, resources, and capabilities that firms cannot develop independently (Garcia Chavez et al., 2025). Similarly, research on international collaboration demonstrates that such ties improve the quality of firms'

innovation outputs by integrating knowledge from diverse institutional and cultural contexts, particularly in product and process innovations (Audretsch & Belitski, 2024; Fu et al., 2022). Mechanisms of knowledge transfer and learning are central to this relationship. Reverse knowledge transfers within multinational corporations, whereby subsidiaries contribute knowledge back to headquarters, have been found to enrich innovation by integrating dispersed and locally embedded expertise (Ambos et al., 2006). Further evidence shows that inter-organisational collaboration can facilitate knowledge spillovers, thereby enhancing productivity and innovation. Knowledge collaboration has a positive effect on firm-level productivity and innovative outputs, especially when firms effectively integrate external and internal sources of knowledge (Audretsch & Belitski, 2024). Collaborative contexts also mitigate opportunistic behaviour in asymmetric alliances, fostering trust and joint learning which lead to innovation (Cherbib et al., 2021).

Nonetheless, the effectiveness of collaboration in driving innovation is subject to contextual conditions. Fu et al. (2022) note that cultural and geographic distance can moderate the benefits of international collaboration (Fu et al., 2022). Conversly, Audretsch and Belitski (2024) highlight that firms' productivity levels influence their ability to turn collaboration into innovative performance (Audretsch & Belitski, 2024).

In summary, the literature provides robust evidence that inter-organisational collaboration positively influences firms' innovation by enabling knowledge exchange, resource complementarity, and capability development. These findings support the following hypothesis:

Hypothesis 3: Inter-organisational collaboration is positively associated with firms' innovation.

1.3.4. The Interplay of DX and Inter-organisational Collaboration in Innovation

We address the indirect effect of DX on innovation by studying the moderating effect of inter-organisational collaboration.

The relationship between DX and innovation has often been examined by treating collaboration as a mediating mechanism and still lacks research regarding its moderating

effect. Nevertheless, more recent empirical research provides evidence that collaboration also plays a moderating role, conditioning the extent to which DX leads to innovation.

Duan et al. (2024) provide direct evidence that inter-organisational collaboration strengthens the relationship between DX and innovation. The findings demonstrate that the composition of firms' R&D collaboration portfolios moderates the effect of DX on innovation (Duan et al., 2024). Organisational diversity in collaboration, specifically in R&D collaboration portfolios, steepens the positive link between DX and radical innovation, while also intensifying the relationship between DX and incremental innovation (Duan et al., 2024). Geographic diversity, in contrast, was found to flatten the curve for incremental innovation, illustrating that collaboration not only conditions the strength but also the form of the DX-innovation relationship (Duan et al., 2024). These findings provide substantial support for the idea that the scope and structure of collaboration play a critical role in determining the innovation payoffs from DX. Related research is conducted by Abdalla & Nakagawa (2021), who examine collaborative innovation in supply chain contexts. Their study shows that collaboration with different types of partners amplifies the impact of DX on supply chain adaptability and efficiency. In this way, collaboration strengthens the ability of DX to translate into improved outcomes (Abdalla & Nakagawa, 2021).

Based on these insights, the following hypothesis is proposed:

Hypothesis 4: Inter-organisational collaboration strengthens the relationship between digital transformation and firm's innovation.

1.3.5. The Interplay of Exporting Status and Inter-organisational Collaboration and Innovation

We also address the indirect effect of exporting status on innovation by studying the moderating effect of inter-organisational collaboration.

Firstly, Moreno-Menéndez (2018) develop a close study to our research topic, which emphasises that exporting increases the likelihood of firms cooperating on innovation, particularly with international partners, while diverse cooperation arrangements in turn enrich firms' innovative capacity. This finding suggests a mutually reinforcing relationship between exporting status and collaboration, although the study frames the link as reciprocal

rather than explicitly moderating (Moreno-Menéndez, 2018). Similarly, Gkypali et al. (2018) conducted an analysis of the reciprocal relationships between absorptive capacity, exporting activities, the diversity of R&D collaborations, and innovation performance. The results show that exporting fosters broader collaboration portfolios, which in turn contribute positively to innovation (Gkypali et al., 2018). Once more, the findings highlight complementarities between exporting and collaboration and do not model collaboration as a moderator.

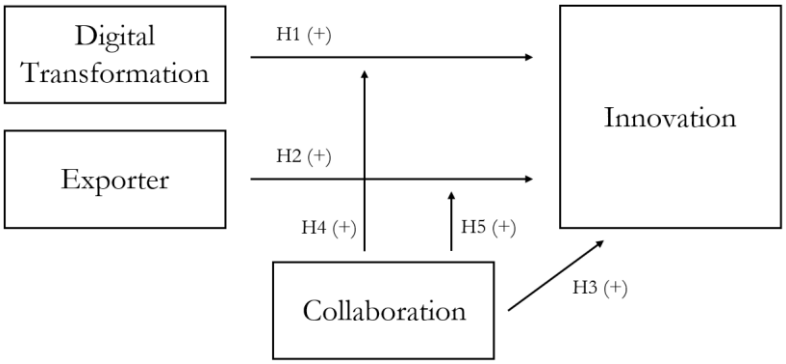
Empirical evidence for a moderating effect is provided by Fredrich et al. (2022), who examine SMEs' internationalisation and collaborative intensity. The study's findings indicate that the degree of collaboration positively moderates the relationship between internationalisation and firm growth (Fredrich et al., 2022). This suggests that the benefits of international expansion are stronger when firms collaborate more intensively with external partners (Fredrich et al., 2022). Despite the fact that the independent variable in this study is growth rather than innovation, it demonstrates empirically that collaboration strengthens the returns from internationalisation, supporting the expectation that exporters will achieve higher innovation outcomes when embedded in collaborative networks.

This leads to the following hypothesis:

Hypothesis 5: Inter-organisational collaboration strengthens the relationship between being an exporter and firms' innovation.

Figure 1 illustrates the relationships between DX, internationalisation, inter-organizational collaboration and innovation that we analyse in this dissertation.

Figure 1. Theoretical Framework



Source: Own elaboration.

Chapter 2. Econometric Analysis

Chapter 2 provides an empirical answer to the research question, and it is structured into four sections. Section 2.1. gives an overview of the database, the data selection criteria as well as pertinent descriptive statistics. Section 2.2. analyses the variables and methodology employed in this study. Section 2.3. presents the estimations, results and their discussion. Finally, section 2.4 presents the relevant robustness checks undertaken.

2.1. Data

The empirical analysis relies on the *Flash Eurobarometer 486: SMEs, Start-ups, Scale-ups and Entrepreneurship* dataset, published by the European Commission (European Commission, 2020). This survey was carried out in 2020 and provides information regarding innovation, internationalisation, digital transformation and collaboration from a wide sample of firms in the 27 Member states of the European Union and 12 non-EU countries (Bosnia and Herzegovina, Brazil, Canada, Iceland, Japan, North Macedonia, Norway, Serbia, Turkey, UK, USA and Kosovo). This database focuses mostly on SMEs (accounting for around 95% of firms), and the respondents were managers who had overall decision-making responsibilities (managing director, CEO) or who led the firm's commercial activities (commercial manager and equivalent positions).

Our analysis includes the full sample (all the geographies and sectors), having removed observations with missing data and incomplete observations on the variables referring to DX, exports, collaboration, innovation and core controls (size, age, sector). After this listwise deletion, the final sample used in the empirical models comprises 15,839 firms. Industry is coded at the NACE Section level, and we include country and sector controls in all models.

The majority of firms in the sample are micro-enterprises with 1 to 9 employees (55.44%), followed by small firms with 10 to 49 employees (25.54%). Medium-sized firms (50 to 249 employees) account for 14.19% of the sample, while only 4.83% of firms employ 250 workers or more. This distribution confirms that the sample is largely composed by SMEs (approximately 95% of the total sample), in line with the focus of the *Flash Eurobarometer 486* survey.

Table 1. Size of Firms by Clusters of Number of Employees.

No. Employees	No. Observations	Percentage (%)
1 to 9 employees	8,781	55.44
10 to 49 employees	4,046	25.54
50 to 249 employees	2,247	14.19
250 employees or more	765	4.83
Total	15,839	100.00

Source: Own elaboration using Stata 18.0.

As can be observed in Table 2 below, the sample consists of 5,159 exporting firms (32.57%) and 10,680 non-exporting firms (67.43%), which reflects the predominance of domestically oriented SMEs in the dataset. In terms of innovation, the sample is almost perfectly balanced, with 7,934 firms identified as innovators (50.09%) and 7,905 firms as non-innovators (49.91%). This sample provides a robust basis for testing the hypotheses on the role of digital transformation, internationalisation, and collaboration in fostering innovation.

Table 2. Number of Firms and Observations According to Key Variables.

	Type of firm			
	Exporter	**Non-Exporter**	**Innovative**	**Non-Innovative**
No. Firms (% of total observations)	5,159 (32.57%)	10,680 (67.43%)	7,934 (50.09%)	7,905 (49.91%)

Source: Own elaboration using Stata 18.0.

2.1.1. Descriptive Statistics

This section provides a detailed analysis of the observations collected from the *Flash Eurobarometer 486* database. Stata 18.0 was used to assess measures of central tendency, such as mean, median, minimum, and maximum values, as well as standard deviation. Table 6 on Annex 1 provides these descriptive statistics.

The descriptive statistics offer an overview of the variables used in the analysis. The mean value indicates that approximately half of the firms in the sample are innovators (mean = 0.50), while approximately one third are exporters (mean = 0.32). Firms adopt, on average, 1.4 DTs (out of a maximum of seven), and the mean score for collaboration stands at 2.65 on a four-point scale, suggesting that most firms report moderate levels of collaborative activity with business partners. With regard to the firm characteristics under consideration,

the average firm size has approximately 62 employees; however, the standard deviation is very high, which is indicative of a skewed distribution with a few very large firms. The mean age of the firms in question was approximately 25 years at the time the survey was conducted, with a wide range of age levels, from recently established firms to those founded over a century before.

For the categorical variables, frequency distributions rather than means or standard deviations are more appropriate. Therefore, Tables 7 and 8 on Annex 1 present frequency distribution of sector and country respectively. The most represented sector in the sample is Wholesale and Retail Trade, while the representation of counties is quite balanced with most hovering around 3% of the sample each.

Moreover, Tables 9 and 10, as well as Tables 11 and 12 on Annex 1, compare the descriptive statistics of exporter vs. non-exporters and innovative vs. non-innovative firms, respectively. The descriptive statistics indicate systematic differences between exporters and non-exporters, as well as between innovative and non-innovative. Exporting firms display a higher share of innovators (61% vs. 45%), report a greater mean value of DX, collaborate more extensively, and are considerably larger in size compared to non-exporting firms. Similarly, innovative firms have on average higher adoption of DTs (1.84 vs. 1.02), higher levels of collaboration, and include a greater proportion of exporters (40% vs. 25%). In contrast, firm age does not differ substantially across groups (exporter vs. non-exporter and innovative vs. non-innovative). These descriptive patterns suggest that innovation and exporting are positively associated with DX, collaboration, and firm size.

2.2. Methodology

2.2.1 Variables

This section describes the variables employed in the model. Table 3 summarises and defines them, as well as mentions the expected relationship with the dependent variable.

The dependent variables is *Innovation*. It is measured as a binary variable that we constructed using question 19 of the questionnaire, that asks if the firm introduced different types of innovation during the previous 12 months. For this dissertation we followed the most accepted literature (OECD, 2005) and selected the following type of innovations:

product innovation, process innovation, business model innovation (similar to what OECD (2005) refers to as organisational innovation) and new way of selling goods or services (referring to what OECD (2005) defines as marketing innovation). We follow the OECD definition of *innovative firm* (OECD, 2005) and, therefore, the variable *Innovation* takes the value 1 if the firm introduced at least one of the types of innovation, and 0 otherwise.

The main independent variables are *Digital Transformation*, *Exporting Status* and *Collaboration*, as detailed below.

Digital Transformation (DX) is measured via an index of digital technology adoption, capturing the firm's implementation of such DTs. For this, we used question 23 related with the usage of the following 7 DTs: Artificial intelligence; Cloud computing; Robotics; Smart devices; Big data analytics; High speed infrastructure and Blockchain. In this question firms indicate which of these DTs they have adopted and, therefore, for each DT we consider 1 if the firm reports having used it and 0 if it doesn't. Therefore, the DX index ranges from 0 to 7, referring to the number of DTs the company uses. It will take value 0 when the firm is not using any DT and it will increase as the firm is adopting more DTs. According to section 1.3.1., we expect this variable to have a positive sign (Bilal et al., 2024; Chen & Kim, 2023; Vial, 2019).

On the other hand, *Exporting Status* (Exporter) refers to question 11 where firms answer to which international markets they exported goods or services. This is a binary variable and, if the firm selects any of the markets on the question, it is considered an exporter and this variable takes the value 1; if it does not export to any of them it takes the value 0. This variable acts as a *proxy* to capture the effect of internationalisation, and we expect the signal of this variable to be positive. According to the empirical findings examined on section 1.3.2., we expect a positive sign (Ayllón & Radicic, 2019; Fassio, 2018; Golovko & Valentini, 2014).

Another important independent variable is *Inter-organisational Collaboration* (Collaboration), and it is captured using question 16.4 that asks to rank the business environment in terms of "Access to and collaboration with business partners, including other enterprises, public sector, educational institutions, research organisations, etc.". For this we used a scale that ranges from 1 to 4 depending on if the company answered Very good (4), Fairly good (3), Fairly Poor (2), Very Poor (1) or DK/NA (0). This variable is included in

the models both in term of its direct effect on innovation, and also as a moderator variable. In line with section 1.3.3., we expect the signal of this variable to be positive (Audretsch & Belitski, 2024; Garcia Chavez et al., 2025).

Additionally, we consider firm *Size* (log_Size) as it is widely used as predictor of a firms' probability of innovating (Cohen & Klepper, 1996). To measure it we used the number of employees, excluding the owners (question 2A). We used this variable as it is one of the most common and defensible measure of firm size used in innovation-related studies (OECD, 2018). Research on the relationship between firm size and innovation is mixed, with some arguing that large firms are more innovative (Schumpeter, 1976), and others noting that small and large firms are more innovative than intermediate-sized firms (Bertschek, 1996). We do not have a clear expectation for this signal.

The firm's *Age* (log_Age) is also relevant to be consider as a control variable. For this we built the independent variable that refers to the number of years since the firm was founded, based on question 1 (calculated by "=2020-year of registration"). Firms founded in 2020 (Age=0) were recoded to Age=1 to allow logarithmic transformation, since log(0) is undefined. This gives a more realistic and interpretable result. It is important to note that older companies often build up more experience over time and this accumulated learning can strengthen both their capacity to innovate and the results they achieve (Huergo & Jaumandreu, 2004). On the other hand, younger firms may be more agile, since they tend to face less organisational inertia and usually carry lower adjustment and sunk costs (OECD, 2018). Even though there are conflicting findings, firm age tends to be seen as inversely related to innovative output (Hansen, 1992). Thus, we expect a negative sign.

It is also common to include controls for the firms' *Sector* and *Country* since each industry and country in which the company is based has its own environment, which can affect the probability of innovation. Thus, we included all the existing sectors on the questionnaire (NACE codes). Country dummies were also included (39 different countries). The sign of these coefficients is unpredictable due to the complexity of each environment.

Table 3. Variables' Description and Expected Results.

Measure	Variable	Description	Expected Signal
Innovation	Innovation	Binary variable: 1 if the firm introduced at least one type of innovation; 0 if it did not.	n.a.
Digital Transformation	Digital Transformation	Index: Range from 0 to 7, referring to the number of DTs the firm has adopted.	(+)
Inter-organisational Collaboration	Collaboration	Scale: Range from 0 to 4, referring to the degree of collaboration.	(+)
Internationalisation	Exporter	Binary variable: 1 if the firm exports; 0 if it does not.	(+)
Moderating role	Collaboration x DX	Interaction term between collaboration and DX.	(+)
	Collaboration x Exporter	Interaction term between collaboration and exporting status.	(+)
Size	Employment	Log of the number of employees of the firm.	(?)
Age	Age	Log of years since the firm's foundation.	(-)
Sector	NACE Code	Dummy variables	(?)
Country	Country	Dummy variables	(?)

Source: Own elaboration.

2.2.2. Model Specification

As the dependent variable (Innovation) is dichotomous, a Probit Model was used to test our hypotheses.

The purpose of this dissertation is to examine the direct effect of Digital Transformation, Internationalisation and Collaboration on Innovation, as well as the moderating role of Collaboration on the first two relationships, as per the posited hypotheses developed according to state-of-the-art theoretical and empirical literature.

Therefore, the model employed to analyse the relationships was the following Equation (2.1):

$$\textbf{(2.1)}\ Innovation_{i,t} = \beta_0 + \beta_1 \times DX_{i,t-1} + \beta_2 \times Exporter_{i,t} + \beta_3 \times Collaboration_{i,t} + \beta_4 \times log(Age)_{i,t} + \beta_5 \times log(Size)_{i,t} + \beta_6 \times Country_{i,t} + \beta_7 \times Sector_{i,t} + \varepsilon_{i,t}$$

To test the moderating effects of collaboration we did as follows:

(i) to test the moderating role of collaboration on the relationship between DX and innovation we included the interaction term between collaboration and DX in the model described above (DX * Collaboration). The rest remained the same.

(ii) to test the moderating role of collaboration on the relationship between being an exporter and innovation we included the interaction term between collaboration and exporting status (Exporter * Collaboration). The rest remained the same.

2.3. Estimations and Results

This section presents the estimation results of Equation (2.1) using Stata 18.0. and their interpretation. We started by analysing the correlation between the variables to check for potential correlation and multicollinearity issues among explanatory variables.

We report the correlation matrix and VIF analysis in Table 4. It displays the pairwise correlation coefficients among the main explanatory and control variables included in the empirical analysis. The correlations are generally low to moderate. As expected, some positive associations are observed, such as between firm size and age, or between DX and exporter status, while all coefficients remain below the conventional threshold of 0.7. Even though the results do not show any concern for correlation, we did an analysis of the Variance Inflation Factor (VIF) to assess multicollinearity issues between the regressors. It confirms the absence of multicollinearity in the models, as the highest VIF value in our models is 1.23, and the mean VIF is 1.10. This is significantly below the threshold for this type of analysis.

Following this, we estimated our regression using a Probit Model on Stata 18.0. The results of the probit model employed to test the hypotheses are displayed on Table 5. Specifically, we estimated five models to test the direct and moderated relations posited in our study. Thus, Model 1 only includes the control variables. Model 2 analyses the direct relations between DX, exporting status, collaboration and innovation. Models 3 and 4 incorporate the interaction terms to assess the moderating effects of collaboration on the relationship between DX and innovation as well as exporter status and innovation,

respectively. Lastly, Model 5 (the full model) jointly reports all the direct effects and interaction terms.

To test Hypotheses 1, 2 and 3, we analyse the results shown in Model 2 that examines the direct relationships between DX, exporting status, collaboration, and innovation, while controlling for firm size, firm age, as well as country and sector heterogeneity. Firstly, the results provide strong support for Hypothesis 1, as DX is found to be positively and significantly associated with innovation ($\beta = 0.219$, $p < 0.01$). This indicates that firms adopting more DTs exhibit a higher probability of being innovative. Secondly, Hypothesis 2 is also supported, with exporting status displaying a positive and highly significant coefficient ($\beta = 0.276$, $p < 0.01$), confirming that exporters are more likely to innovate compared to non-exporters. Similarly, Hypothesis 3 is supported, as collaboration shows a positive and significant relationship with innovation ($\beta = 0.072$, $p < 0.01$), suggesting that inter-organisational collaboration enhances the likelihood of innovation. Lastly, regarding the control variables, firm age is negatively associated with innovation ($\beta = -0.073$, $p < 0.01$), while firm size is positively associated with innovation ($\beta = 0.055$, $p < 0.01$). Overall, Model 2 validates the core direct hypotheses we proposed on this study.

Models 3, 4, and 5 incorporate interaction terms to test the moderating role of collaboration. In Model 3, the interaction between DX and collaboration (Collab_DX) is negative and statistically significant ($\beta = -0.017$, $p < 0.05$). This finding runs counter to Hypothesis 4, which expected collaboration to strengthen the positive effect of DX on innovation. Instead, the results suggest that while DX and collaboration are individually beneficial, their joint effect exhibits a degree of substitutability, such that the marginal innovation benefit of digital adoption is weaker in firms already engaged in high levels of collaboration. In Model 4, the interaction between exporter status and collaboration (Collab_Exp) is negative but statistically insignificant ($\beta = -0.011$, n.s.), providing no evidence in support of Hypothesis 5. This suggests that inter-organisational collaboration does not significantly alter the relationship between exporting and innovation. Model 5, which includes all direct and interaction terms simultaneously, confirms these results: the interaction of collaboration with DX remains negative and significant ($\beta = -0.017$, $p < 0.05$), while the interaction with exporter status remains insignificant.

The results indicating a negative and significant moderating effect of IOC on the relationship between DX and innovation can be explained, particularly in the cases of SMEs by the trade-off in the allocation of scarce resources, increased complexity and power asymmetry. Engagement in collaboration networks can be demanding in terms of time, financial and human resources investment. This may lead firms to an increased level of operational complexity. Altogether, the operational challenges and the resources reallocation can cause firms to focus more on managing technology integration and less on collaboration initiatives. Indeed, SMEs have resource constraints that may condition collaboration and innovation practices, as there are limited time and resources to engage in different strategies and experiment with business models and implementing new strategies, requiring them to focus their efforts (Merín-Rodrigáñez et al., 2025; Reim et al., 2022; Zain & Ng, 2006). Additionally, differences in objectives, shared power, and lack of trust care essential to successful collaboration (Camarinha-Matos & Afsarmanesh, 2008; Heath & Isbell, 2021; Soliman et al., 2005). Therefore, its absence, particularly when smaller firms interact with larger or more technologically advanced partners can, therefore, create barriers to effective collaboration, ultimately weakening the synergy between DX efforts and innovation outcomes. In the context of SMEs, these limitations may neutralise or even reverse the expected benefits, particularly when collaboration introduces complexity that outweighs the advantages of DX.

Table 4. Correlation Matrix and Collinearity Diagnostic for the Variables of Equation (2.1) (full sample).

	Innov	DX	Collab	Exp	log(Size)	log(Age)	Sector	Country	VIF
Innov	1.0000								
DX	0.2890*	1.0000							1.14
Collab	0.0916*	0.1204*	1.0000						1.03
Exp	0.1519*	0.1969*	0.0482*	1.0000					1.13
log(Size)	0.1546*	0.2998*	0.1206*	0.2144*	1.0000				1.23
log(Age)	0.0034	0.0604*	-0.0057	0.0392*	0.2796*	1.0000			1.09
Sector	-0.0660*	0.0300*	0.0298*	-0.2020*	-0.0598*	-0.0675*	1.0000		1.06
Country	-0.0120	-0.0240*	0.0555*	-0.0785*	-0.0180*	-0.0365*	-0.0727*	1.0000	1.02
Mean VIF									1.10

Source: Own elaboration using Stata 18.0

Note: * statistically significant at 10% level.

Table 5. Results of Probit Models for Equation (2.1)

Innovation	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
DX		0.219***	0.266***	0.219***	0.265***
		(0.009)	(0.022)	(0.009)	(0.022)
Exporter		0.276***	0.276***	0.306***	0.287***
		(0.025)	(0.025)	(0.060)	(0.061)
Collaboration		0.072***	0.094***	0.075***	0.094***
		(0.010)	(0.013)	(0.011)	(0.014)
Collab_DX			-0.017**		-0.017**
			(0.007)		(0.007)
Collab_Exp				-0.011	-0.004
				(0.021)	(0.021)
log_age	-0.098***	-0.073***	-0.073***	-0.073***	-0.073***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
log_size	0.131***	0.055***	0.055***	0.055***	0.055***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Country Dummies	included	included	included	included	included
Sector Dummies	included	included	included	included	included
Constant	-0.075	-0.541***	-0.603***	-0.549***	-0.605***
	(0.155)	(0.159)	(0.161)	(0.160)	(0.162)
Observations	15839	15839	15839	15839	15839
Wald chi2	1583.59***	2537.37***	2543.07***	2537.65***	2543.10***
Log.Likelihood	-10186.9	-9710.1	-9707.2	-9709.9	-9707.2

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Own elaboration using Stata 18.0.

2.4. Robustness Checks

In order to evaluate the potential sensitivity of the results to our methodological choices and the operationalisation of the variables in our empirical model, robustness checks and additional analyses were conducted. We considered alternative measurements of the variables of interest. These analyses have similar results and, therefore, support similar conclusions to the ones derived from the main model presented.

Firstly, we estimated the models using an alternative measure of inter-organisational collaboration. Specifically, we consider if the firms are a part of a global value chain (GVC) which capture to what extent the firm is open to, and may benefit from, such domestic or international networks. GVCs are defined as internationally dispersed networks of firms that participate in different stages of the production, distribution, and innovation of goods and services (Qin & Sun, 2024). GVCs are increasingly structured as global value networks, in which firms are embedded in dynamic and complex webs of inter-firm relationships that extend beyond simple, linear supply chains (Ricciotti, 2020). These networks facilitate the exchange of not only products but also knowledge, capabilities, and innovation inputs across geographical and organisational boundaries (Qin & Sun, 2024; Ricciotti, 2020).

GVC it is a dichotomous variable that can be captured through question 9.5, which asks if the firm is a part of a GVC. It is a binary variable which takes the value 1 if the firm is a part of a GVC, and 0 otherwise.

The model employed to analyse the relationships was the following Equation (2.2):

$$\textbf{(2.2)}\ Innovation_{i,t} = \beta_0 + \beta_1 \times DX_{i,t-1} + \beta_2 \times Exporter_{i,t} + \beta_3 \times GVC_{i,t} + \beta_4 \times log(Age)_{i,t} + \beta_5 \times log(Size)_{i,t} + \beta_6 \times Country_{i,t} + \beta_7 \times Sector_{i,t} + \varepsilon_{it}$$

To test the moderating effects of GVC we followed the same procedure as described before in the former section with the main estimations, including interaction terms between GVC and DX (GVC * DX), as well as between GVC and exporting status (GVC * Exp).

The robustness analysis using GVC as an alternative operationalisation of collaboration confirms the stability of the results. As shown in Table 14 on Annex 2, GVC participation is positively and significantly associated with innovation across all model specifications, which suggests that firms integrated into GVCs benefit from exposure to domestic or international

networks and knowledge flows, enhancing their likelihood of innovating. Importantly, the interaction between DX and GVC (GVC_DX) is negative and statistically significant, consistent with the results obtained in the main models with the collaboration index. This finding indicates that while both DX and GVC participation individually foster innovation, their joint effect is not complementary but rather substitutive, as the marginal benefit of digital adoption is weaker among firms already embedded in GVCs. Moreover, the interaction between exporting and GVC participation (GVC_Exp) is once again negative but not statistically significant, suggesting that GVC membership does not moderate the exporter–innovation relationship. The control variables remain consistent with the main specification: firm age is negatively associated with innovation, while firm size is positively associated. Taken together, these results demonstrate that the core findings are robust to alternative measures of collaboration, reinforcing the conclusion that DX, exporting, and inter-organisational collaboration are independent and significant drivers of innovation, while their combined effects do not provide the expected complementarities.

Secondly, we conducted another robustness test, estimating the models using a different measure of Digital Transformation. This time we use the question 9.8 on whether the firm has a strategy or action plan to digitalise. In this case, it is a dichotomous variable (*Dig_Plan*) that takes value 1 if the firm has a strategy or action plan to digitalise and 0 if it does not.

Equation (2.3) analyses these relationships:

$$\textbf{(2.3)}\ Innovation_{i,t} = \beta_0 + \beta_1 \times Dig_Plan_{i,t-1} + \beta_2 \times Exporter_{i,t} + \beta_3 \times Collaboration_{i,t} + \beta_4 \times log(Age)_{i,t} + \beta_5 \times log(Size)_{i,t} + \beta_6 \times Country_{i,t} + \beta_7 \times Sector_{i,t} + \varepsilon_{i,t}$$

Once again, to test the moderating effects of collaboration we included the interaction terms between collaboration and, this time, digitalisation plan (Collab * Dig_Plan), as well as Collaboration and exporting status (Collab * Exp).

The results, presented in Table 16, remain broadly consistent with those obtained in the main analysis. Indeed, Dig_Plan is strongly and positively associated with innovation across all specifications, indicating that firms that adopt a digitalisation plan or strategy are significantly more likely to innovate compared to those without such a plan. Exporter status

continues to demonstrate a positive and significant relationship with innovation, while inter-organisational collaboration remains a robust predictor of innovation outcomes as well.

Turning to the interaction effects, the coefficients for the interactions between collaboration and having a digitalisation plan (Collab_Dig_Plan) as well as between collaboration and exporting (Collab_Exp) are negative but statistically insignificant across all models. With regard to the control variables, the age of the firm remains negatively associated with innovation, while the firm size has a positive and significant effect. The results confirm that the main findings are not sensitive to the operationalisation of DX, as both the adoption of DTs (DX index) and the existence of a digitalisation plan (Dig_Plan) emerge as significant drivers of firms' innovation. However, this time no evidence is found for the hypothesised moderation effects of collaboration.

Conclusion

This dissertation aimed to explore how DX and internationalisation contribute to firm-level innovation, with a particular focus on the moderating effect of inter-organisational collaboration. This study contributes to the literature by empirically examining how these strategic levers interact to shape product, process and business model innovation, particularly in the context of European small and medium-sized enterprises (SMEs).

Building on the theoretical foundations of the Resource-Based View, Knowledge-Based View, Open Innovation and International Business literature, the study proposed and empirically tested a conceptual model using data from *Flash Eurobarometer 486: SMEs, Start-ups, Scale-ups and Entrepreneurship* dataset.

The literature review revealed that DX can be a powerful enabler of innovation by enhancing a firm's ability to gather, process, and integrate knowledge. Similarly, internationalisation was shown to expose firms to new knowledge sources, markets, and learning opportunities that are critical for innovation. Inter-organisational collaboration emerged as possible moderator of such relationships as well as having a direct effect on innovation, facilitating the transfer, adaptation, and recombination of internal and external knowledge to maximise innovation outcomes. These relationships were supported by previous empirical studies.

Using data from the large-scale dataset *Flash Eurobarometer 486: SMEs, Start-ups, Scale-ups and Entrepreneurship* across multiple countries and industries, the empirical results reveal that DX, internationalisation (particularly exporting) and inter-organisational collaboration are significantly and positively associated with innovation, confirming our expectations. These findings support the central idea underlying this dissertation, that firms leveraging digital tools and operating internationally are better positioned to generate product, process, or business model innovations.

However, the results also unveiled a negative moderating effect of inter-organisational collaboration on the relationship between DX and innovation, contrary to our initial expectation. While collaboration was hypothesised to amplify innovation outcomes by facilitating access to external knowledge and resources, the findings suggest that in SME contexts, it may introduce coordination complexity and resources' allocation trade-off, ultimately dampening the positive effects of DX on innovation. Although this was not our

initial expectation, these findings highlight a well-documented characteristic of SMEs, which is their lack of strategic, financial, and technical resources (Merín-Rodrigáñez et al., 2025; Reim et al., 2022; Zain & Ng, 2006). Therefore, this represents a very important contribution to extant literature: even though inter-organisational collaboration and DX have been widely documented as being drivers of innovation (which is supported by this dissertation), there are trade-offs and resource-related barriers that may prevent firms from innovating when collaboration is introduced to a DX-innovation relationship. Therefore, as inter-organisational collaboration increases, the positive effect of DX on innovation decreases for the SMEs reflecting a clear resource allocation challenge.

Furthermore, it should be noted that the moderating effect of inter-organisational collaboration on the relationship between exporting and innovation was not found to be statistically significant. This suggests that, for the SMEs, IOC does not appear to strengthen or weaken the effect of internationalisation on the probability of innovation. One potential explanation for this finding is that innovation may be impacted by internationalisation primarily due to internal learning and market exposure, rather than from collaborative mechanisms or networks. Additionally, as noted before, SMEs often face resource constraints that may limit their ability to engage in or benefit from structured collaborative arrangements internationally (Reim et al., 2022). Thus, this highlights the importance of not overestimating inter-organisational collaboration as a one-size-fits-all mechanism, as its role can be different in nature for SMEs.

In all, given these results and conclusions, this study makes a significant contribution to the extant literature on innovation and international business by highlighting how the interplay between internal capabilities (DX), international presence (exporting status), and relational mechanisms (inter-organisational collaboration) shape innovation trajectories.

Managerial and Policy Implications

The study also has implications for management and policy public design. From the point of view of practitioners, this dissertation calls managers to be aware of the need to consider internationalisation (particularly exportation), digital transformation and inter-organisational collaboration to facilitate the innovation in their firms. This should be seen as an imperative for companies' growth. Our findings provide evidence that may help managers to understand the relevance of pursuing DX, inter-organisational and internationalisation as

tools to cope with contemporary global economy challenges, as they are associated directly with the probability of innovation. Nonetheless, managers should be aware that there can be trade-offs for SMEs when employing DX and IOC for innovation and, therefore, this indicates that they must be cautious when managing collaborative efforts, especially when pursuing innovation through digital technologies.

From a policy standpoint, the results point to the need for integrated support mechanisms that combine digitalisation, internationalisation, and innovation incentives. Public policy should be focused in promoting firms' digital transformation and internationalisation, particularly for SMEs, focussing on export promotion or GVC insertion. Furthermore, given the complex relationship between inter-organisational collaboration and innovation in SMEs, public policy should support the development of inter-organisational collaboration management capabilities, especially among smaller firms that may lack the experience or resources to engage in beneficial collaboration.

Limitations and Avenues for Future Research

Despite its contributions, this dissertation is not free of limitations that open possible and interesting paths for future research. Firstly, a limitation is that the database relies on a cross-sectional survey, the only available so far, which may limit the causal inference and, therefore, a relevant development could be testing the same hypotheses but with a panel data model, allowing for more robust estimations and inferences. Furthermore, it would be very interesting to test these hypotheses with another *proxy* of Collaboration (even better if it could be a measure of outright international collaboration), for example having information about the different kind of collaboration that the firms engaged in (with clients, competitors, suppliers, Universities, etc). The *Flash Eurobarometer 486* does not have information on that variable, which prevented us from testing the relevance of international collaboration as a moderator of the relationship between DX and the probability of innovation. Yet, we trust a good approach was allowed for, with the consideration of a reliable *proxy*, and the international dimension of the dissertation being catered for by considering the variable Internationalisation (proxied by exporter status). It is worth noting that it would be relevant to consider alternative proxies for the internationalisation variable, such as multinational enterprise (MNE) status. Lastly, it would also be relevant to investigate the same research questions in the context of emerging economies.

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Annexes

Annex 1. Variables' Descriptive Statistics

Table 6. Descriptive Statistics of Variables (full sample).

Variable	No. Observations	Mean	Standard Deviation	Min. Value	Max. Value
Innov	15,839	0.5009	0.5000	0	1
DX	15,839	1.4331	1.4276	0	7
Collab	15,839	2.6559	1.1395	0	4
Exp	15,839	0.3257	0.4687	0	1
Size	15,839	62.3608	300.0683	1	9900
Age	15,839	24.6763	21.4130	1	170

Source: Own elaboration using Stata 18.0.

Table 7. Frequency Distribution of Sectors.

Sector of Activity (NACE)	Freq.	Percent	Cum.
B – Mining and quarrying	90	0.57	0.57
C - Manufacturing	3,092	19.52	20.09
D – Electricity, gas, steam and air conditioning supply	94	0.59	20.68
E – Water supply, sewerage, waste management	160	1.01	21.69
F - Construction	1,532	9.67	31.37
G – Wholesale and retail trade	4,402	27.79	59.16
H - Transportation and storage	901	5.69	64.85
I - Accommodation and food service activities	878	5.54	70.39
J - Information and communication	604	3.81	74.20
K - Financial and insurance activities	338	2.13	76.34
L - Real estate activities	365	2.30	78.64
M - Professional, scientific and technical activities	1,489	9.40	88.04
N - Administrative and support service activities	692	4.37	92.41
P - Education	354	2.23	94.65
Q - Human health and social work activities	585	3.69	98.34
Arts, entertainment and recreation	263	1.66	100.00
Total	15,839	100.00	

Source. Own elaboration using Stata 18.0

Table 8. Frequency Distribution of Countries.

Country	Freq.	Percent	Cum.
FR - France	486	3.07	3.07
BE - Belgium	487	3.07	6.14
NL - The Netherlands	483	3.05	9.19
DE - Germany	490	3.09	12.29
IT - Italy	457	2.89	15.17
LU - Luxembourg	197	1.24	16.42
DK - Denmark	488	3.08	19.50
IE - Ireland	462	2.92	22.41
GB - United Kingdom	460	2.90	25.32
GR - Greece	479	3.02	28.34
ES -Spain	486	3.07	31.41
PT - Portugal	477	3.01	34.42
FI - Finland	496	3.13	37.55
SE - Sweden	491	3.10	40.65
AT - Austria	491	3.10	43.75
CY - Cyprus (Republic)	197	1.24	45.00
CZ - Czech Republic	488	3.08	48.08
EE - Estonia	471	3.97	51.05
HU - Hungary	490	3.09	54.14
LV - Latvia	487	3.07	57.22
LT - Lithuania	490	3.09	60.31
MT - Malta	199	1.26	61.57
PL - Poland	488	3.08	64.65
SK - Slovakia	485	3.06	67.71
SI - Slovenia	493	3.11	70.83
BG - Bulgaria	464	3.93	73.75
RO - Romania	496	3.13	76.89
TR - Turkey	291	1.84	78.72
HR - Croatia	492	3.11	81.83

MK - Makedonia/FYROM	200	1.26	83.09
RS - Serbia	199	1.26	84.35
NO - Norway	297	1.88	86.22
IS - Iceland	199	1.26	87.48
JP - Japan	276	1.74	89.22
US - USA	483	3.05	92.27
BR - Brazil	339	2.14	94.41
BA - Bosnia and Herzegovina	199	1.26	95.67
RS-KM - Kosovo	200	1.26	96.93
CA - Canada	486	3.07	100.00
Total	15,839	100.00	

Source. Own elaboration using Stata 18.0

Table 9. Descriptive Statistics of Exporter Firms.

Variable	No. Observations	Mean	Standard Deviation	Min	Max
Innov	5,159	0.6101958	0.487753	0	1
DX	5,159	1.837565	1.564305	0	7
Collab	5,159	2.735026	1.067405	0	4
Size	5,159	97.937	1203.208	1	78399
Age	5,159	25.62764	22.15711	1	170

Source: Own elaboration using Stata 18.0.

Table 10. Descriptive Statistics of Non-exporter Firms.

Variable	No. Observations	Mean	Standard Deviation	Min	Max
Innov	10,680	0.4481273	0.4973252	0	1
DX	10,680	1.237828	1.312845	0	7
Collab	10,680	2.61779	1.170934	0	4
Size	10,680	34.93773	170.2384	1	7465
Age	10,680	24.21779	21.04883	1	170

Source: Own elaboration using Stata 18.0.

Table 11. Descriptive Statistics of Innovative Firms.

Variable	No. Observations	Mean	Standard Deviation	Min	Max
DX	8,188	1.844971	1.521861	0	7
Collab	8,188	2.760146	1.063149	0	4
Exp	8,188	0.3967734	0.4892591	0	1
Size	8,188	73.68452	965.2513	1	78399
Age	8,007	25.0784	22.15548	1	170

Source: Own elaboration using Stata 18.0.

Table 12. Descriptive Statistics of Non-innovative Firms.

Variable	No. Observations	Mean	Standard Deviation	Min	Max
DX	7,905	1.019861	1.190905	0	7
Collab	7,905	2.551423	1.202401	0	4
Exp	7,905	0.254396	0.4355487	0	1
Size	7,905	37.16369	223.2796	1	12143
Age	7,905	24.27413	20.6329	1	170

Source: Own elaboration using Stata 18.0.

Annex 2. Robustness Checks

Table 13. Descriptive Statistics, Correlation Matrix and Collinearity Diagnostic for the Variables of Equation (2.2) (full sample).

	Innov	DX	GVC	Exp	log(Size)	log(Age)	Sector	Country	VIF
Innov	1.0000								
DX	0.2890*	1.0000							1.16
GVC	0. 1409*	0.2220*	1.0000						1.07
Exp	0.1519*	0.1969*	0.1383*	1.0000					1.13
log(Size)	0.1546*	0.2998	0.1625*	0.2144*	1.0000				1.23
log(Age)	0.0034	0.0604*	0.0331*	0.0392*	0.2796*	1.0000			1.09
Sector	-0.0660*	0.0300*	-0.0648*	-0.2020*	-0.0598*	-0.0675*	1.0000		1.07
Country	-0.0120	-0.0240*	-0.0244*	-0.0785*	-0.0180*	-0.0365*	-0.0727*	1.0000	1.02
Mean	0.5009	1.4332	0.0944	0.3257	2.3421	2.8698	7.0859	24.4334	
Stand. Dev.	0.5000	1.4276	0.2924	0.4687	1.6236	0.8781	3.9275	19.7281	
Min. Value	0	0	0	0	0	0	n.a.	n.a.	
Max. Value	1	7	1	1	9.2003	5.1358	n.a.	n.a.	
Mean VIF									1.11

Source: Own elaboration using Stata 18.0.

Note: * statistically significant at 10% level.

Table 14. Results of Probit Models for Equation (2.2).

Innovation	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
DX		0.218***	0.224***	0.218***	0.224***
		(0.009)	(0.009)	(0.009)	(0.009)
Exporter		0.264***	0.264***	0.267***	0.265***
		(0.025)	(0.025)	(0.026)	(0.026)
GVC		0.255***	0.359***	0.268***	0.362***
		(0.040)	(0.066)	(0.054)	(0.072)
GVC_DX			-0.050**		-0.050**
			(0.025)		(0.025)
GVC_Exp				-0.027	-0.008
				(0.077)	(0.077)
log_age	-0.098***	-0.072***	-0.071***	-0.071***	-0.071***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
log_size	0.131***	0.054***	0.054***	0.054***	0.054***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Country Dummies	included	included	included	included	included
Sector Dummies	included	included	included	included	included
Constant	-0.075	-0.396**	-0.408***	-0.397**	-0.408***
	(0.155)	(0.157)	(0.157)	(0.157)	(0.157)
Observations	15839	15839	15839	15839	15839
Wald chi2	1583.59***	2522.14***	2526.08***	2522.27***	2526.09***
Log.Likelihood	-10186.9	-9717.7	-9715.7	-9717.6	-9715.7

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Own elaboration using Stata 18.0.

Table 15. Descriptive statistics, Correlation Matrix and Collinearity Diagnostic for the Variables of Equation (2.3) (full sample).

	Innov	Dig_Plan	Collab	Exp	log(Size)	log(Age)	Sector	Country	VIF
Innov	1.0000								
Dig_Plan	0.2523*	1.0000							1.05
Collab	0.0916*	0.0697*	1.0000						1.03
Exp	0.1519*	0.0846*	0.0482*	1.0000					1.11
log(Size)	0.1546*	0.1774*	0.1206*	0.2144*	1.0000				1.18
log(Age)	0.0034	0.0851*	-0.0057*	0.0392*	0.2796*	1.0000			1.09
Sector	-0.0660*	0.0575*	0.0298*	-0.2020*	-0.0598*	-0.0675*	1.0000		1.06
Country	-0.0120	-0.0599*	0.0555*	-0.0785*	-0.0180*	-0.0365*	-0.0727*	1.0000	1.02
Mean	0.5009	0.2246	2.6559	0.3257	2.3421	2.8698	n.a.	n.a.	
Stand. Dev.	0.5000	0.4174	1.1395	0.4687	1.62357	0.8781	n.a.	n.a.	
Min. Value	0	0	0	0	0	0	n.a.	n.a.	
Max. Value	1	1	4	1	9.20029	5.135798	n.a.	n.a.	
Mean VIF									1.08

Source: Own elaboration using Stata 18.0

Note: * statistically significant at 10% level.

Table 16. Results of Probit Models for Equation (2.3).

Innovation	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Dig_Plan		0.626***	0.695***	0.626***	0.693***
		(0.028)	(0.070)	(0.028)	(0.070)
Exporter		0.325***	0.325***	0.352***	0.350***
		(0.025)	(0.025)	(0.060)	(0.060)
Collaboration		0.079***	0.083***	0.082***	0.086***
		(0.010)	(0.011)	(0.011)	(0.012)
Collab_Dig_Plan			-0.025		-0.025
			(0.024)		(0.024)
Collab_Exp				-0.010	-0.009
				(0.020)	(0.020)
log_age	-0.098***	-0.092***	-0.092***	-0.092***	-0.092***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
log_size	0.131***	0.082***	0.082***	0.082***	0.082***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Country Dummies	included	included	included	included	included
Sector Dummies	included	included	included	included	included
Constant	-0.075	-0.414***	-0.427***	-0.422***	-0.434***
	(0.155)	(0.160)	(0.160)	(0.160)	(0.161)
Observations	15839	15839	15839	15839	15839
Wald chi2	1583.59***	2399.97***	2401.11***	2400.22***	2401.31***
Log.Likelihood	-10186.9	-9778.7	-9778.2	-9778.6	-9778.1

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Own elaboration using Stata 18.0.