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Adopting Digitalisation: The Impact on SME Performance in Evidence from Italy and Spain.

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Dedication

I dedicate this work to my family: my parents, who have always guided me with love and wisdom; my brother, whose unwavering support and belief in me have been a constant source of strength; my fiancée, whose patience, encouragement, and inspiration have sustained me throughout; and my extended family, including my sister-in-law, mother-in-law, and father-in-law, whose kindness and support have been invaluable. Your collective belief in me and your steadfast encouragement have been the cornerstone of this journey.

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Statement of Conjoint Work

I confirm that this thesis is a collection of papers and chapters that are co-authored and published.

In Chapter 1, the section on Digital Innovation is co-authored with Prof. Isidoro Romero and is part of the chapter published in the International Business Encyclopaedia by Elsevier. DOI: https://doi.org/10.1016/B978-0-443-13701-3.00067-0

Chapter 2 is co-authored with Prof. Isidoro Romero and Prof. Mara del Baldo and is expected to be published by the Italian Chapter of the Association for Information Systems (ITAIS).

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I would like to state that Chapters1,3,4 and 5 are part of the research project entitled “Entrepreneurial factors, digital ecosystems, and digital transformation of SMEs” -DIGIPYME-(PID2020-113384GB-I00), which was funded by MICIU/AEI/10.13039/501100011033. Moreover, Chapter 5 has been partially supported by the “ARTIFACTS: Generation of Reliable Synthetic Health Data for Federated Learning in Secure Data Spaces” Research Project (PID2022-1410450B-C42), funded by both MCIN/AEI/1243 10.13039/501100011033 and “ERDF A way of making Europe” by the “European Union”. I would like to take this opportunity to thank those who have contributed to the data collection.

Abstract

This dissertation integrates insights derived from the four analyses presented throughout the work, which correspond to the digitalisation of Small and Medium-sized Enterprises (SMEs). The objective is to interweave the understanding developed in each chapter, presenting a coherent narrative that elucidates the intricate dynamics involved in the digitalisation process of SMEs. The contents are a collection of papers structured into six chapters. Chapter 1 introduces the research project and discusses the motivation, conceptual issues, and research strategy. Chapters 2, 3, 4, and 5 employ different methodologies to provide a broad and variegated view of the digitalisation process in SMEs. Moreover, Chapters 3,4 and 5 used a dataset from a survey carried out in 2022 among Spanish SMEs. Chapter 6 concludes the thesis.

Chapter 2, titled “Bibliographic Analysis of Digitalisation in SMEs: A Comparative Study from Italy and Spain”, introduces a comparative bibliographic analysis, a novel approach that has not been previously used. This methodology seeks to generate scholarly interest in both countries, where national-level bibliometric studies are rare, and no prior comparative research exists. The data is obtained from the Scopus database. This method reveals the primary developments, key research themes, and the prevailing collaboration trends at individual, university and country levels in the field of digitalisation in SMEs. The findings reveal a growing interest in SME digitalisation in both countries. Italy leads in publication and citation volume, but research in both countries lacks thematic diversity. The literature remains largely theoretical, highlighting the need for more empirical studies.

Chapter 3, titled “Digital Transformation of Small and Medium-Sized Enterprises as an Innovation Process: A Holistic Study of its Determinants”, employs a novel holistic theoretical framework and an econometric methodology to examine the challenges SMEs face during their digital transformation. Digital transformation is explored in this analysis as an innovation process. The findings indicate that human capital and organisational factors, rather than technological constraints, are key to digital transformation. SMEs must adopt formal strategies for digitalisation, integrating internal digital skills and fostering collaboration with external partners, such as ICT consultants and universities.

Chapter 4, titled “Addressing Challenges and Catalysts for E-Commerce Adoption in SMEs”, investigates the internal and external factors influencing the adoption of e-commerce technologies. The analysis highlights that financial constraints, limited digital skills, and weak external collaboration are the main obstacles to e-commerce adoption in SMEs. Investment in ICT, R&D, and innovation, along with stronger connections to external advisors and competitors, is crucial for overcoming these barriers.

Chapter 5, titled “Adoption of Artificial Intelligence in Small and Medium-Sized Enterprises: The Role of Competencies and Skills”, investigates the role of competencies and skills in the process of the adoption of AI within SMEs. According to the results of this paper, SMEs with university-educated leaders, IT expertise, and advanced digital management systems (e.g., ERP, marketing analytics) are more likely to implement AI. Partnerships with universities also facilitate AI integration by providing access to expertise and innovation resources.

Chapter 6, “Conclusion”, summarises and discusses the findings of the project, and the managerial and policy implications derived from the individual chapters. Moreover, this chapter highlights the theoretical, managerial and empirical contributions of this dissertation, mentions the limitations of the current study, and formulates potential avenues for further research.

Keywords: Digitalisation, Digital Transformation, SMEs, Digital Innovation, Product Innovation, Process Innovation, E-commerce, Artificial Intelligence (AI)

Abstract (Italiano)

Questa tesi integra le intuizioni derivanti dalle quattro analisi presentate nel lavoro, che riguardano la digitalizzazione delle Piccole e Medie Imprese (PMI). L'obiettivo è intrecciare la comprensione sviluppata in ciascun capitolo, presentando una narrazione coerente che chiarisca le dinamiche complesse coinvolte nel processo di digitalizzazione delle PMI. Il contenuto è una raccolta di articoli strutturati in sei capitoli. Il Capitolo 1 introduce il progetto di ricerca e discute le motivazioni, le questioni concettuali e la strategia di ricerca. I Capitoli 2, 3, 4 e 5 impiegano metodologie diverse per fornire una visione ampia e variegata del processo di digitalizzazione delle PMI. Inoltre, i Capitoli 3, 4 e 5 utilizzano un set di dati derivante da un sondaggio condotto nel 2022 tra le PMI spagnole. Il Capitolo 6 conclude la tesi.

Il Capitolo 2, intitolato “Analisi Bibliografica della Digitalizzazione nelle PMI: Uno Studio Comparativo tra Italia e Spagna”, introduce un'analisi bibliografica comparativa, un approccio nuovo che non è stato precedentemente utilizzato. Questa metodologia mira a generare interesse accademico in entrambi i paesi, dove gli studi bibliometrici a livello nazionale sono rari e non esiste una precedente ricerca comparativa. I dati sono ottenuti dal database Scopus. Questo metodo rivela gli sviluppi principali, i temi chiave della ricerca e le tendenze di collaborazione prevalenti a livello individuale, universitario e nazionale nel campo della digitalizzazione delle PMI. I risultati rivelano un crescente interesse per la digitalizzazione delle PMI in entrambi i paesi. L'Italia è leader in termini di volume di pubblicazioni e citazioni, ma la ricerca in entrambi i paesi manca di diversità tematica. La letteratura rimane in gran parte teorica, evidenziando la necessità di studi più empirici.

Il Capitolo 3, intitolato “Trasformazione Digitale delle Piccole e Medie Imprese come Processo di Innovazione: Uno Studio Olistico dei suoi Determinanti”, impiega un nuovo quadro teorico olistico e una metodologia econometrica per esaminare le sfide che le PMI affrontano durante la loro trasformazione digitale. In questa analisi, la trasformazione digitale è esplorata come un processo di innovazione. I risultati indicano che il capitale umano e i fattori organizzativi, piuttosto che i vincoli tecnologici, sono fondamentali per la trasformazione digitale. Le PMI devono adottare strategie formali per digitalizzazione, integrando competenze digitali interne e favorendo la collaborazione con partner esterni, come consulenti ICT e università.

Il Capitolo 4, intitolato “Affrontare le Sfide e i Catalizzatori per l’Adozione dell’E-Commerce nelle PMI”, indaga i fattori interni ed esterni che influenzano l'adozione delle tecnologie di e-commerce. L'analisi evidenzia che i principali ostacoli all'adozione dell'e-commerce nelle PMI sono i vincoli finanziari, le competenze digitali limitate e una debole collaborazione esterna. Gli investimenti in ICT, R&S e innovazione, insieme a collegamenti più forti con consulenti esterni e concorrenti, sono fondamentali per superare queste barriere.

Capitolo 5, intitolato “Adozione dell'Intelligenza Artificiale nelle Piccole e Medie Imprese: Il Ruolo delle Competenze e delle Abilità”, indaga il ruolo delle competenze e delle abilità nel processo di adozione dell'IA all'interno delle PMI. Secondo i risultati di questo capitolo, le PMI con leader laureati, competenze IT e sistemi di gestione digitale avanzati (ad esempio, ERP, analisi di marketing) hanno maggiori probabilità di implementare l'IA. Le collaborazioni con le università facilitano inoltre l'integrazione dell'IA, fornendo accesso a competenze e risorse innovative.

Capitolo 6, “Conclusione”, riassume e discute i risultati del progetto e le implicazioni manageriali e politiche derivate dai singoli capitoli. Inoltre, questo capitolo evidenzia i contributi teorici, manageriali ed empirici di questa tesi, menziona i limiti dello studio attuale e formula potenziali direzioni per ulteriori ricerche.

Parole chiave: Digitalizzazione, Trasformazione Digitale, PMI, Innovazione Digitale, Innovazione di Prodotto, Innovazione di Processo, E-commerce, Intelligenza Artificiale (IA).

Resumen (Español)

Esta tesis integra los resultados derivados de los cuatro análisis presentados a lo largo del trabajo, que corresponden a la digitalización de las Pequeñas y Medianas Empresas (PYMEs). El objetivo es entrelazar la comprensión desarrollada en cada capítulo, presentando una narrativa coherente que aclare las dinámicas complejas involucradas en el proceso de digitalización de las PYMEs. El contenido es una colección de artículos estructurados en seis capítulos. El Capítulo 1 introduce el proyecto de investigación y discute la motivación, los aspectos conceptuales y la estrategia de investigación. Los Capítulos 2, 3, 4 y 5 emplean diferentes metodologías para proporcionar una visión amplia y variada del proceso de digitalización en las PYMEs. Además, los Capítulos 3, 4 y 5 utilizaron un conjunto de datos de una encuesta realizada en 2022 entre las PYMEs españolas. El Capítulo 6 concluye la tesis.

El Capítulo 2, titulado "Análisis Bibliográfico de la Digitalización en las PYMEs: Un Estudio Comparativo entre Italia y España", introduce un análisis bibliográfico comparativo, un enfoque novedoso que no ha sido utilizado previamente. Esta metodología busca generar interés académico en ambos países, donde los estudios bibliométricos a nivel nacional son escasos y no existen investigaciones comparativas previas. Los datos se obtienen de la base de datos Scopus. Este método revela los principales desarrollos, los temas clave de investigación y las tendencias de colaboración predominantes a nivel individual, universitario y nacional en el campo de la digitalización en las PYMEs. Los resultados revelan un creciente interés en la digitalización de las PYMEs en ambos países. Italia lidera en términos de volumen de publicaciones y citas, pero la investigación en ambos países carece de diversidad temática. La literatura sigue siendo mayormente teórica, lo que resalta la necesidad de más estudios empíricos.

El Capítulo 3, titulado "Transformación Digital de las Pequeñas y Medianas Empresas como un Proceso de Innovación: Un Estudio Holístico de sus Determinantes", emplea un nuevo marco teórico holístico y una metodología econométrica para examinar los desafíos que enfrentan las PYMEs durante su transformación digital. En este análisis, la transformación digital se explora como un proceso de innovación. Los resultados indican que el capital humano y los factores organizacionales, más que las limitaciones tecnológicas, son clave para la transformación digital. Las PYMEs deben adoptar estrategias formales para la digitalización, integrando habilidades digitales internas y fomentando la colaboración con socios externos, como consultores TIC y universidades.

El Capítulo 4, titulado "Abordando los Desafíos y Catalizadores para la Adopción del Comercio Electrónico en las PYMEs", investiga los factores internos y externos que influyen en la adopción de tecnologías de comercio electrónico. El análisis destaca que las principales barreras para la adopción del comercio electrónico en las PYMEs son las limitaciones financieras, las habilidades

digitales limitadas y una débil colaboración externa. La inversión en TIC, I+D e innovación, junto con conexiones más fuertes con asesores externos y competidores, es crucial para superar estas barreras.

Capítulo 5, titulado “Adopción de la Inteligencia Artificial en Pequeñas y Medianas Empresas: El Rol de las Competencias y Habilidades”, investiga el papel de las competencias y habilidades en el proceso de adopción de la IA dentro de las PYMEs. Según los resultados de este capítulo, las PYMEs con líderes universitarios, experiencia en TI y sistemas avanzados de gestión digital (por ejemplo, ERP, análisis de marketing) tienen más probabilidades de implementar IA. Las alianzas con universidades también facilitan la integración de la IA al proporcionar acceso a conocimientos especializados y recursos de innovación.

Capítulo 6, “Conclusión”, resume y discute los hallazgos del proyecto, así como las implicaciones gerenciales y políticas derivadas de los capítulos individuales. Además, este capítulo destaca las contribuciones teóricas, gerenciales y empíricas de esta disertación, menciona las limitaciones del estudio actual y formula posibles líneas para futuras investigaciones.

Palabras clave: Digitalización, Transformación Digital, PYMEs, Innovación Digital, Innovación de Producto, Innovación de Proceso, Comercio Electrónico, Inteligencia Artificial (IA).

"*When digital transformation is done right, it's like a caterpillar turning into a butterfly, but when done wrong, all you have is a really fast caterpillar.*"

George Westerman

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Chapter 1

Introduction

1.1. Research background and motivation

The concept of digitalisation can be traced back to the 1980s and early 1990s when scientists undertook a comprehensive exploration of the implications of technology adoption on organisational structures, innovation, and performance (Robey, 1981; Drucker, 1988; Johnston & Vitale, 1988; Bloomfield & Coombs, 1992). Understanding the progression of research on digitalisation in businesses is imperative to discern this concept from other related terms often used interchangeably (Hagberg et al., 2016; Hess et al., 2016; Parviainen et al., 2017; Horváth & Szabó, 2019). In this regard, the distinction between digitisation, digitalisation and digital transformation is crucial.

On the one hand, according to the prior literature, the automation of processes through information technologies is an integral part of digitisation (Hess et al., 2016; Horváth & Szabó, 2019). Moreover, digitisation is about data conversion where the process of converting analogue information into digital formats. On the other hand, digitalisation refers to the utilisation of digital technologies and data, including those that have been digitised and those which are natively digital, directed towards generating revenue, enhancing business operations, and substituting or transforming business processes rather than merely digitising them. This approach also fosters a digital business environment (Schwarzmueller et al., 2018). When it comes to digital transformation, it can be defined as the integration of digital technologies into all aspects and operations of an organisation, consequently resulting in infrastructural modifications in the organisation's mode of operation and its delivery of value to its customers (McGrath & Maiye, 2010; Vial, 2019). Moreover, it reshapes business operations, products, and developments, and gives rise to entirely new business models (Vial, 2019; Bouncken, et al., 2021). Furthermore, organisations, irrespective of their nature and scale, must be primed to realign or even supplant their current business processes with unfamiliar ones, necessitating an accelerated pace of adaptation. In addition to this point, it is imperative to have leadership, cultural, and attitudinal shifts, as well as embrace new work methodologies, technologies, and a disposition toward tolerating ambiguity and continual change as essential facets of digital transformation (Kane et al., 2015).

Companies drive digital transformation when they leverage digital technologies to innovate or adapt their business models, processes, and organizational structures while enhancing relationships with internal and external stakeholders (Loebbecke & Picot, 2015; Frank et al., 2019; Vial, 2019). In this regard, digital technologies (Artificial Intelligence (AI), Internet of Things (IoT), Information and Communication Technologies (ICT), Electronic Commerce, Big Data and more) serve as the key drivers of the Fourth Industrial Revolution, predominantly facilitated by the process of business digital transformation (Nwaiwu, 2018). Notably, these technologies have not simply altered traditional business frameworks but have also redefined the nature of customer relationships and fundamentally transformed individual lifestyles and interactions (Berman et al., 2016). The integration of digital technologies has a profound impact on the various aspects of modern businesses, encompassing production, organizational structures, and interactions with partners, rivals, suppliers, and customers (Autio et al., 2018; Beverungen et al., 2019; Warner & Wager, 2019; Kretschmer et al., 2022; Majumder et al., 2022).

As we navigate the digital world, the critical task of adopting and leveraging ICT will become an even greater priority for many enterprises in the coming decades. Digital technologies are making a profound impact across nearly every economic sector, driving the creation of new markets and revolutionising production and distribution processes. The process of digitalisation has emerged as a powerful catalyst for entrepreneurial ventures and productivity growth, thereby playing a pivotal role in strengthening the viability and expansion of businesses (OECD, 2020; Reuschke et al., 2021; Gartner et al., 2022; Zahra et al., 2023; Zhiyong et al., 2023). Furthermore, the COVID-19 era has accelerated the pace of digital transformation for many enterprises, particularly small and medium-sized enterprises (SMEs) (Mandviwalla and Flanagan, 2021). In the European Union (EU), SMEs have a crucial role where they serve as the predominant form of business, encompassing approximately 95% to 99% of all companies. This underscores the fundamental role of SMEs as the backbone of the economy (Jadhav et al., 2023).

The literature has extensively examined the issue related to digitalisation in enterprises (Vial, 2019; Hanelt et al., 2021; Rêgo et al., 2021), with particular emphasis on specific factors and technologies such as big data (Ciampi et al., 2021), AI (Anica-Popa et al., 2021), blockchain (Morkunas et al., 2019), and IoT (Ben-Daya et al., 2017). Nonetheless, a comprehensive understanding of the holistic nature and determinants of digitalisation within enterprises remains elusive. Moreover, the existing empirical literature is lacking, predominantly qualitative, and focuses on large enterprises (Rêgo et al., 2021; Reuschke et al., 2021; Ghosh et al., 2022). Nevertheless, SMEs often encounter a

notable lag in their progress toward digitalisation (OECD, 2020; Reuschke et al., 2021) owing to the barriers they encounter in this process. The access of these companies to financial, technological, and human resources may be restricted due to their particular characteristics, including their small size and inadequately professionalised management (Li et al., 2018; Meier et al., 2022). Hence, it is imperative to investigate the nuanced factors influencing digitalisation in SMEs.

The dissertation covers several aspects of digitalisation in SMEs by focusing on Italy and Spain. The selection of Italy and Spain is based on their shared cultural and regional diversity, providing a compelling comparative basis for examining the unique challenges and opportunities that SMEs face in different European contexts. These countries offer a wide range of economic, political, and social conditions that influence how digitalisation efforts are implemented. Moreover, exploring the progressive initiatives within the research on digitalisation in SMEs is essential, given the substantial economic significance of SMEs: 78.1% employment in Italy and 71.9% employment in Spain (European Commission, 2019). SMEs are vital to the economies of both countries, contributing significantly to employment, innovation, and overall economic output. As a result, advancements in digital tools and technologies hold tremendous potential to enhance productivity, competitiveness, and long-term sustainability for these businesses. By focusing on Italy and Spain, this research can highlight the specific pathways and obstacles to digital transformation within their unique contexts, ensuring that SMEs in both nations remain resilient and competitive in the evolving digital landscape.

The thesis begins with an analysis of current academic trends in the digitalisation of SMEs from Italy and Spain. This chapter introduces a comparative bibliographic analysis, a novel approach that has not been previously explored. This methodology concerning its comparative results aims to generate scholarly interest in both countries, where bibliometric studies on this subject are scarce, particularly at the national level, and no prior research has provided comparative findings. In this chapter, the following research question is formulated: Q1) How has the digitalisation of SMEs been studied in the context of Italy and Spain?

Building on this, three analyses are presented for different dimensions of the digitalisation of SMEs in Spain. Those analyses are based on a dataset obtained from a survey of SMEs in Spain carried out in the framework of the project entitled “Entrepreneurial factors, digital ecosystems, and digital transformation of SMEs” -DIGIPYME-

(PID2020-113384GB-I00), which was funded by the Ministry of Science and Innovation of Spain (MICIU/AEI/10.13039/501100011033).

The chapter 3 employs a holistic theoretical framework and an econometric methodology to examine the challenges SMEs face during digital transformation. Digital transformation is explored in this analysis as an innovation process, leading to the formulation of a second key research question: Q2) What are the main determinants that explain the product and digital innovations of SMEs?

Following the identification of these challenges and their implications, the thesis continues with a chapter focused on the adoption of e-commerce technologies by SMEs. This chapter investigates the internal and external factors influencing this adoption process and poses the following question: Q3) What are the challenges and catalysts for e-commerce adoption in SMEs? As e-commerce and digitalisation become increasingly crucial for the competitiveness of SMEs, this chapter distinguishes itself by studying not only the technological and organisational aspects of e-commerce adoption but also incorporating the environmental dimension, adding a unique contribution to the research.

After addressing the significance of getting online and the obstacles faced by SMEs, the thesis concludes with a chapter on one of the most prominent topics in the digital era: the adoption of Artificial Intelligence (AI). This chapter fills a gap by examining the role of competencies and skills within the firm and addresses the following research question: Q4) What are the main determinants of the adoption of AI in SMEs? In addition to focusing on AI adoption, this chapter also employs a novel AI technique, Generative Adversarial Networks (GANs).

1.2. The Significance of the Chosen Topics

This section highlights the significance of the selected topics within the dissertation, emphasizing their relevance to the digitalisation process. It begins by defining Digital Innovation (DI) and outlining its importance (Section 2.1). The discussion then shifts to the role of e-commerce in digitalisation (Section 2.2). Finally, the section concludes with the impact of AI on digitalisation (Section 2.3).

1.2.1. Digital Innovation and Digitalisation

The concept of DI has evolved to meet the challenges due to the advancements and transformations in the digital era. From a particular perspective, DI is described as a product-centred approach that integrates physical and digital elements to create advanced and innovative products (Lee & Berente, 2012). Within this paradigm, DI plays a crucial role in shaping the development of new information technology products and influencing how companies organise and drive innovation. Though DI is linked to design, it encompasses beyond design science to include a wide variety of concepts, making it a powerful force for driving progress and change in the business world (Kohli and Melville, 2019).

The idea has evolved to encompass a comprehensive understanding of DI, which entails the formation, advancement, and adoption of digital technologies and applications for the introduction of innovative products, production methods, organisational structures, marketing approaches, and business models. Embracing DI is about generating, implementing, and leveraging an endless stream of value-creating advancements by incorporating digital technology to drive substantial transformation (Hund et al., 2021). The impact of this transformative force encompasses not only technological progress but also organisational, cultural, and strategic aspects that are essential for the effective integration of DI.

DI is a powerful and evolving influence that utilises advanced digital technologies, including artificial intelligence, the Internet of Things, cloud computing, and blockchain, to bring about significant changes in the operations of both enterprises and society as a whole. This change is accomplished by strategically combining these digital technologies with innovative business concepts and adaptive methods, resulting in significant and impactful consequences. DI plays a crucial role in improving operational efficiency, optimising customer-business involvement, and accelerating the speed of innovation. However, like any thrilling experience, challenges arise. Organisations have several issues, such as dealing with opposition to transformation, preserving data privacy, and ensuring that the staff is knowledgeable about the latest advances in technology.

Through the adoption of DI, companies can enhance client loyalty and elevate satisfaction levels. Leveraging data analytics, AI, and digital platforms empowers organisations to deliver personalised, continuous, and immersive practices to consumers. This approach provides essential insights into customer preferences, enabling the provision of

personalised services and exceptional customer experiences. From a marketing perspective, the implementation of digital tools and analytics facilitates aimed and profitable advertising, thereby enabling firms to effectively engage the appropriate audience at the opportune moment. DI also facilitates companies to quickly engage in experimentation, repetition, and adaptation to the perpetually evolving dynamics of the market. This encourages an atmosphere of innovation that empowers staff to present conceptual, sample, and professional innovative products and services. Moreover, it augments the adaptability of companies, allowing them to promptly respond to altering market environments and conditions, ensuring they stay ahead of the curve and remain competitive in a fast-evolving business landscape.

To summarise, in today's fast-paced business environment, DI has the potential to completely transform the operations of firms, resulting in enhanced productivity, higher consumer engagement, and improved competitiveness. Embracing DI is now imperative for achieving business success in the modern era.

1.2.2. E-commerce and Digitalisation

E-commerce has become a critical tool for companies to connect with customers, expand their reach, adapt to market demands, and streamline operations (Martin & Matlay, 2003; Wymer et al., 2005). The rise of e-commerce has prompted companies to establish a digital presence and leverage the vast opportunities presented by the Internet (Abebe, 2014). The recent boom in e-commerce has triggered a significant transformation in global market dynamics. Driven by technological advancements, this new framework has introduced a fresh approach to commerce, encouraging companies to leverage online marketplaces to remain competitive.

E-commerce, characterized as the buying and selling of goods and services over the Internet (Turban et al., 2000), has emerged as a transformative platform that significantly boosts international competitiveness and drives business growth (Ha, 2020; Susanty et al., 2020). The increasing prevalence of technological innovations and the development of user-friendly e-commerce platforms have played a key role in enabling SMEs to build a digital presence. E-commerce provides SMEs with unparalleled access to global markets, offering them opportunities to expand their reach beyond traditional geographical limitations while simultaneously lowering operational costs.

Additionally, e-commerce allows SMEs to adopt more efficient business practices, automating various processes such as inventory management, customer service, and logistics. These platforms also offer valuable customer data analytics, allowing SMEs to refine their marketing strategies and offer personalised services, thereby improving customer retention. Moreover, the digital nature of e-commerce reduces the need for physical infrastructure, making it more feasible for smaller enterprises with limited capital to compete on a larger scale. However, despite these significant advantages, SMEs often trail behind larger corporations in adopting e-commerce solutions (Alam et al., 2011; Govindaraju et al., 2015). This slower uptake is largely attributed to several barriers, including limited financial resources, lack of digital skills, and the substantial initial investment required to implement advanced digital technologies (Scupola, 2009).

1.2.3 AI and Digitalisation

AI is an advanced and transformative technology driving digitalisation and innovation in today's world. It stands at the forefront of digital transformation, revolutionising customer experience, facilitating real-time decision-making, and driving sales growth (Hajishirzi & Costa, 2021). AI, combined with machine learning and big data, lies at the heart of digital twinning, offering unprecedented possibilities and complexities in industrial applications (Rathore et al., 2021). The incorporation of AI into business processes leads to streamlined automation, tailored personalisation, accurate forecasting, and robust data protection, necessitating strategic approaches to mitigate security and privacy concerns (Timofeev et al., 2023). Technological advancements fuelling digital transformation exert a profound influence on internal operations, efficiency, and overall effectiveness within organisations (Ayoko, 2021). This transformation holds immense promise in advancing sustainable development goals, notably in education and industrial collaboration, contingent upon unwavering stakeholder commitment and superior e-governance performance (Ayoko, 2021). Ultimately, AI and digitalisation are revolutionising business practices and decision-making processes across diverse sectors, presenting both unparalleled opportunities and formidable challenges for organisations transitioning to the digital era.

Literature shows a growing interest in leveraging AI to transform business operations, underscoring its potential to enhance efficiency, productivity, and objectivity (Raisch & Krakowski, 2021). AI’s integration across various

business functions including marketing, customer service, and human resources facilitates digitalisation, enabling companies to modernise and streamline their processes (Xu et al., 2020; Khatri et al., 2020; Van den Broek et al., 2021; Feng et al., 2022).

1.3. Data Management and Methodology

The dissertation corresponds to different quantitative analyses including bibliometric analysis within the systematic review, econometric modelling (logistic regression) and GANs.

In Chapter 2, the data is obtained from the Scopus database, and bibliometric analysis was conducted on 125 documents, more precisely, 85 from Italy and 40 from Spain. This method reveals the primary developments, key research themes, and the prevailing collaboration trends at individual, university and country levels in the field of digitalisation in SMEs.

The data for Chapters 3,4 and 5 was derived, as previously said, from a survey carried out in the context of a specific project: "Entrepreneurial factors, digital ecosystems, and digital transformation of SMEs" -DIGIPYME- (PID2020-113384GB-I00), funded by the Ministry of Science and Innovation of Spain. It was carried out in the second quarter of 2022 among Spanish SMEs with a workforce ranging from one to 200 employees. The survey included a random selection of small and medium-sized enterprises from the Iberian Balance Sheet Analysis System (SABI) database. The sample accurately reflects the SME population in Spain with a margin of error of ±5.0% at a confidence level of 95% by means of using simple random sampling and assuming a binomial population (p=q=0.5, most unfavourable scenario). The survey employed the computer-assisted telephone interviewing (CATI) technique. The final dataset comprises 802 valid observations for the analysis in Chapters 3 and 4 and 836 for Chapter 5. Moreover, in Chapter 5, it incorporates the novel AI technique of GANs due to the imbalance in the database, where only 85 SMEs have embraced artificial intelligence techniques and 751 do not, constituting approximately 10% of the total number of observations. GANs are thus used in this chapter to generate synthetic data to balance the data set.

1.4. Structure of the dissertation

Right after the introductory section, the thesis follows Chapter 2 which investigates a comparative analysis of the literature that conducts a performance analysis using bibliometric technique through the data extracted from the Scopus database.

In Chapter 3, the research explores vital factors that drive the digital transformation process of SMEs. In particular, this chapter examines digital transformation as an innovation process through the enterprise that results in the introduction of new or substantially innovative goods and processes using digital technology. Moreover, this chapter also provides an additional analysis of the differences in the determinants of digital innovation between microenterprises and other SMEs.

In Chapter 4, the investigation is followed by a quantitative analysis which examines the internal and external factors influencing the barriers to the adoption of e-commerce technologies within SMEs. This chapter analyses the factors through three different dimensions: Technological, Organisational and Environmental.

In the final phase of the thesis, Chapter 5 demonstrates another quantitative analysis that explores the factors influencing the adoption of AI in SMEs, with a particular focus on the role of competencies and skills.

In Chapter 6, the dissertation concludes with a thorough encapsulation of the primary discoveries from this scholarly investigation. It presents a comprehensive view of digitalisation and its application in SMEs, reflecting on the implications of these findings, their relationship to existing literature, and their potential impact on policy and practice.

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Chapter 2

Bibliographic Analysis of Digitalisation in SMEs: A Comparative Study from Italy and Spain.

Abstract

The paper carries out a comparative analysis of the literature pertaining to digitalisation in SMEs in Italy and Spain. These countries exhibit similarities in their business frameworks, corporate cultures, and academia as well as the research industry. Notably, there exists a discernible gap in literature review papers that incorporate bibliometric analysis, with existing works tending to provide a broad overview of the given topic. The paper aims to explore the following questions: a) What are the variances in the developments and trends in Italian and Spanish works on digitalisation within SMEs between 2018 and 2023? b) How do key topics that have been the focus of research change in the given period? and c) What are the differences concerning the prevailing trends in collaborative networks among authors, universities, and countries in Italian and Spanish studies on digitalisation in the given period? The study employs bibliometric techniques to analyse a dataset consisting of 125 publications from top-tier journals sourced from the Scopus database. A performance analysis was carried out on 85 documents from Italy and 40 from Spain utilising the Bibliometrix package and the Biblioshiny tool. The outcomes demonstrate a surge in research attention towards digitalisation in SMEs in both countries. Italy demonstrates a remarkable presence in academic publications and citations, alongside longer author timelines. Nevertheless, both countries exhibit limited diversity in the scope of research themes. Moreover, the findings underscore Italy's extensive collaborative networks, whereas Spanish universities prioritise frequent and international collaboration.

Keywords: Digitalisation, SMEs, Bibliometric Analysis, Digital Technologies

2.1 Introduction

SMEs represent an important form of business organisation, constituting approximately 95% to 99% of all companies. This underscores the fundamental role of SMEs as the basis of the economy (Jadhav et al., 2023). Concurrently, the rapid progress of innovation and digital technology is primarily reforming the business industry, modifying consumer behaviour, and revolutionising business models (Bleicher & Stanley, 2016). In this context, digitalisation is now a crucial catalyst for entrepreneurship, playing a significant role in driving business survival and development (OECD, 2020; Reuschke et al., 2021; Gartner et al., 2022; Zahra et al., 2023; Zhiyong et al., 2023). By implementing digital technologies, businesses can revolutionise the way they monitor, control, and automate internal operations, primarily to heightened efficiency and significant cost savings (Liu et al., 2023). With regard to this matter, in order to facilitate effective integration, it is imperative for enterprises to possess a thorough comprehension of the significance and supplementary value of digital innovations (Bleicher & Stanley, 2016) where such digitalisation holds pivotal importance for SMEs. Conversely, SMEs are lagging behind large enterprises in the realm of digitalisation (OECD, 2020; Reuschke et al., 2021) due to hindrances stemming from their inherent characteristics, such as limited scale, a lack of professional management, constraints in obtaining financial and technological resources, and deficiencies in human resources (Li et al., 2018; Meier et al., 2022).

Recent publications from both Italy and Spain have delved into the digitalisation of SMEs (Quinton et al., 2018; North et al., 2020; Denicolai et al., 2021; Matarazzo et al., 2021; Martin-Martin et al., 2022). Despite this, there is a lack of literature review papers with bibliometric analysis, and the papers approach the topic from a broad perspective (Melo et al., 2023; Fauzi et al., 2023). Additionally, few papers particularly address Italy and Spain (Sharma et al., 2023; Mele et al., 2023).

This paper concentrates on the literature pertaining to digitalisation within SMEs in Italy and Spain, contributing with a comparative bibliographic analysis that has not been previously undertaken. This unique approach will shed light on the academic interest in both countries, where very few bibliometric studies have been conducted on this topic (Fauzi et al., 2023; Mele et al., 2023; Melo et al., 2023; Sharma et al., 2023) and none have presented comparative outcomes. Furthermore, the selection of Italy and Spain for this analysis is grounded in their shared cultural richness and regional diversity. Both countries stand out as prominent and substantial economies in the EU, making them ideal subjects for a comparative study. An in-depth examination of their business structures is essential to illuminate the

critical role played by the SME sector, which serves as a foundation of their economic frameworks. Equally important is the exploration of their shared production characteristics and international productive specialisation. These similarities provide valuable insights into the interplay between regional economies and global markets. To further enhance this analysis, the European Commission's DESI (Digital Economy and Society Index) serves as a robust tool for assessing the level of digitalisation in both countries, offering key metrics to evaluate their digital readiness and integration. Moreover, given the substantial economic importance of SMEs in Italy and Spain, it is vital to delve into the progressive digitalisation initiatives undertaken within the sector. Such initiatives not only reflect the evolving landscape of small and medium-sized enterprises, but also highlight their adaptive capacity in leveraging digital technologies to drive innovation, competitiveness, and growth in increasingly digital economies.

Data collection continues until September/October 2023, focusing on the 2018-2023 period due to the scarcity of prior literature from Italy and Spain on this topic before 2018. Moreover, the use of performance analysis, which is one of the bibliometric techniques, facilitates a comprehensive exploration of this research domain. This method will cover primary developments, key research themes, and the prevailing collaboration trends in the field of digitalisation in SMEs.

Despite the given particular regional area, this study aims to provide insights into the recent trends by addressing the following questions: What are the disparities in the progress and trends in Italian and Spanish studies on digitalisation in SMEs from 2018 to 2023? b) How do primary research themes differ on digitalisation in SMEs in the given period? and c) What are the comparisons concerning the prevailing trends in collaborative networks among authors, universities, and countries in Italian and Spanish studies on digitalisation during the given period?

In pursuit of this objective, we examined 125 scientific publications including 85 from Italy and 40 from Spain, covering the period from 2018 to 2023. These publications are derived from the Scopus database and are intended to address the abovementioned questions.

The findings reveal that the research on digitalisation in SMEs has seen significant progress in Italy and Spain. Italy has taken the lead in both publication volume and author interest, with a greater number of highly cited papers compared to Spain. Italian researchers are included in 14 author clusters and have extensive collaborative networks. In contrast, Spanish universities prioritise frequent international collaborations. Furthermore, both countries engage

in frequent collaboration, and the United Kingdom is a common collaborator. Moreover, the results also highlight the need for empirical evidence to further enrich the existing body of research.

2.2 Literature Review

Within this literature review section, our initial focus centres on the critical role of digitalisation of SMEs. Subsequently, we elucidate the most distinguished research papers pertaining to digitalisation of SMEs, originating from Italy and Spain. Finally, a comprehensive overview is provided, highlighting the most relevant bibliometric analysis papers within this particular domain.

The emergence of digital technologies has dramatically reshaped the business landscape, leading to significant changes in traditional industries (Gao et al., 2013). The process of digitalisation demands effective integration of digital technologies and SMEs can use these technologies in terms of gaining a competitive advantage, through cost leadership and strategic differentiation in the marketplace (Zahra et al., 2023; Zhiyong et al., 2023). In this context, this competitive advantage can be attained by adopting Industry 4.0 technologies including cloud computing, artificial intelligence, big data, automation, and blockchain, which can drive cost reduction and efficiency gain.

In today's business landscape, digitalisation represents a crucial opportunity for SMEs to thrive and expand (Scuotto et al., 2016; Bresciani et al., 2018; Zahra et al., 2023; Zhiyong et al., 2023). This technological change has acquired significant attention from researchers, leading to many studies in this domain. Notably, scholars affiliated with Italian and Spanish universities have actively contributed to this body of work, resulting in numerous recent publications from both countries on this subject (Quinton et al., 2018; Bouwman et al. 2018; Garzoni et al., 2020; Denicolai et al., 2021; Matarazzo et al., 2021; Martin-Martin et al., 2022;).

When it comes to the papers on digitalisation in SMEs that employ bibliometric analysis, there are few studies in the literature. Thus, a notable deficit appears in the literature, particularly concerning its representation on a national scale. In this regard, the papers in this domain are postulated below.

Amid the corpus of available publications, a specific paper titled “Sustainable Digital Transformation in SMEs: A Review on Performance” provides clarification on the pivotal role of digitalisation in SMEs. This study not only

highlights the importance of digitalisation but also elucidates its considerable effect on the triple bottom line, which encompasses economic, social, and environmental dimensions (Melo et al., 2023).

Another important contribution to this focus is the paper titled “Investigating the Emerging and Future Trends of Knowledge Management in Small and Medium Enterprises: A Science Mapping Approach.” This paper argues that current market trends require SMEs to embrace digital technology. Additionally, it differentiates itself as an innovative work in providing a science mapping analysis on knowledge management in SMEs (Fauzi et al., 2023).

Diving deep into the hurdles encountered by SMEs, “Navigating the Storm: The SME Approach to Tackling the Pandemic Crisis” sheds light on the strategic responses of SMEs amidst the pandemic. The findings underscore the pivotal role of government policies aimed at strengthening SMEs and fostering their resilience after the crisis (Sharma et al., 2023).

Moreover, an influential paper entitled “Revisiting the Idea of Knowledge-Based Dynamic Capabilities for Digital Transformation” carefully examines the current investigation of knowledge-based dynamic capabilities in the realm of digital transformation. The goal is to introduce a novel conceptualisation of digital dynamic capabilities, elucidating how organisations produce and distribute knowledge in the digital era (Mele et al., 2023).

In summary, this literature review has offered a comprehensive overview of esteemed scholarly contributions concerning digitalisation in SMEs from Italy and Spain, as well as recent bibliometric analyses focused on digitalisation within the SME sector. By carefully analysing the evolution of digitalisation in SMEs, prioritising research areas, and understanding the global viewpoints, and the path to further research is identified. The focus is on conducting in-depth country-level analysis for Italy and Spain. Despite substantial advancements in understanding digitalisation in SMEs, notable gaps in the existing literature require attention and additional exploration. To address this, the current study employs an innovative comparative bibliographic analysis for Italy and Spain that has not been previously undertaken.

2.3 Methodology and Data Collection

In this research, a comprehensive bibliometric analysis was performed, incorporating a performance analysis within the contexts of Italy and Spain. Broadly, this approach encompasses the use of quantitative methodologies applied to bibliographic data to assess the impact and progression of scientific publications (Donthu et al., 2021). The analysis was implemented utilising the Bibliometrix package (Aria & Cuccurullo, 2017) which is considered for the RStudio. Furthermore, the selection of the Biblioshiny tool was underpinned by its sophisticated capabilities, which exceed those of alternative tools such as SciMAT and VOSviewer (Moral-Munoz et al., 2020).

In the pursuit of insights, exclusively a performance analysis is conducted. This decision is underpinned by the objective of upholding the brevity and directness of the paper. Moreover, the chosen methodology involves a comprehensive investigation aimed at quantifying the volume of publications and citations related to the research framework (Donthu et al., 2021). The results are articulated in a comparative way for both Italy and Spain.

With regard to the database selection, the decision favoured a singular source, with a focus on Scopus. This choice was underpinned by the benefits it confers in mitigating potential homogenisation issues associated with data extraction from different databases (Waltman, 2016). Furthermore, Scopus serves as a supplementary database to the Web of Science (WOS), offering an approximate 20% increase in research material (Marino-Romero et al., 2024).

In order to obtain data from Scopus, a thorough examination of literature pertinent to the subject matter was undertaken to discern pertinent keywords. Concurrently, the document type was set as "Article," the source type as "Journal," and the language as "English." It is important to note that the data collection extends until 2023 (Sep/Oct), prompting the focus on the 2018-2023 period due to limited literature from Italy and Spain on this subject before 2018. Employing Scopus syntax, the initial search string was structured to facilitate exploration of the title, abstract, and keyword fields of publications, as is postulated below:

TITLE-ABS-KEY (("Digital transformation" OR digitalisation OR digitalization) AND ("Small and Medium Enterprises" OR sme*)) AND PUBYEAR > 2017 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))

The results indicate a total of 708 publications. Going forward, we have limited the region/territory separately for Italy and Spain.

(LIMIT-TO (AFFILCOUNTRY , "Italy")) / (LIMIT-TO (AFFILCOUNTRY , "Spain"))

Following careful data processing and cleaning, a comprehensive analysis was conducted on 85 documents from Italy and 40 from Spain, all of which were published in the period of 2018-2023. The results are presented in a comparative method.

2.4 Results

This section presents the findings of the bibliometric analysis, with a specific focus on the performance analysis conducted for Italy and Spain. These results directly address the prior postulated research questions. The examination explores various dimensions, encompassing summary data, authors, publications, universities, countries, and a three-field plot. The results are presented in a comparative manner, providing valuable insights into the bibliometric analysis for Italian and Spanish studies.

Performance Analysis

Performance analysis plays a crucial role in evaluating the contributions of research components within a specific field (Cobo et al., 2011). It assesses productivity by considering the volume of publications and measures impact

through citation numbers (Wang & Barabási, 2021). This descriptive nature distinguishes performance analysis (Donthu et al., 2020) as an essential tool in research evaluation.

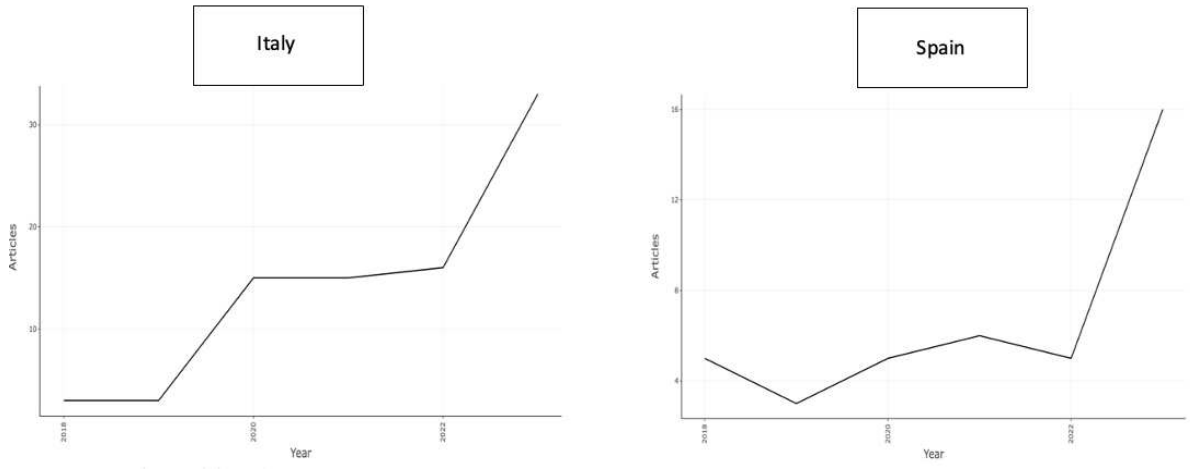
Figure 2.1. Summary of docs and measurement

Source: Authors' elaboration

The findings reveal an impressive annual growth rate of 61.54% for Italy and 26.19% for Spain from 2018 to 2023 (Figure 2.1). The detailed analysis for Italy involved 85 papers published in 52 journals by 280 authors, yielding a total of 7,008 cited references. Meanwhile, the analysis for Spain included 40 papers published in 38 journals by 143 authors, with a total of 2,929 cited references. Notably, both countries showed an increase in the number of articles over time (Figure 2.2). It is important to note the fluctuations in Spain's paper production, demonstrating periodic drops between 2019 and 2022. In 2023, both Italy and Spain reached record-breaking paper production levels, with Italy producing 33 units and Spain producing 16 units. Italy's production increased from 3 units in 2018 to 16 units in 2022, while Spain's production fluctuated between 5 and 6 units from 2018 to 2022 (Italy: 2018-3, 2019-3, 2020-15, 2021-15, 2022-16; Spain: 2018-5, 2019-3, 2020-5, 2021-6, 2022-5). Interestingly, in 2023, both countries had an

average citation per year (ACP) of 2.3. Upon closer examination, the ACP for Italy began to decline from 17.9 in 2021, following a significant increase from 5.7 in 2019. Conversely, Spain's ACP decreased to 2.7 in 2019 from 9.6 in 2018, rose to 8.2 in 2020, and then dropped to 1.9 in 2022.

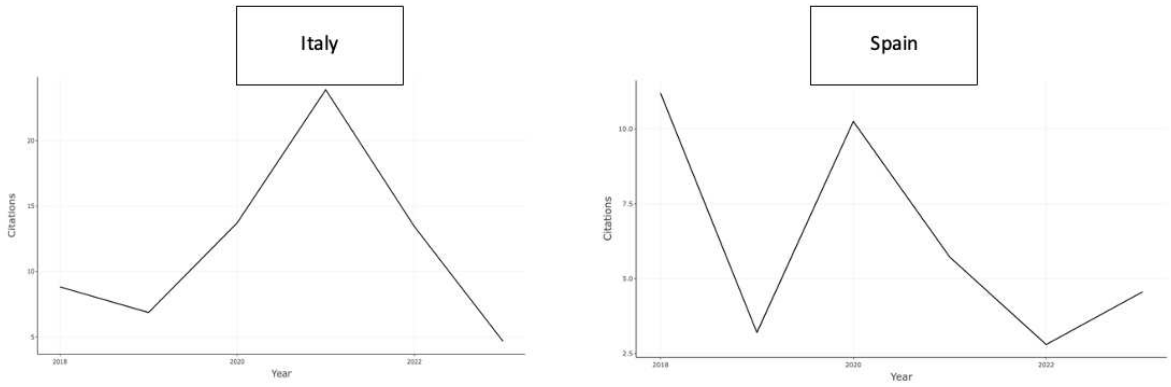
Figure 2.2. Annual Scientific Production



Source: Authors' elaboration

The observed trend over the specified period emphasises the enduring significance and ongoing evolution of research in the "digitalisation and SMEs" sphere. It is imperative to underscore the necessity for continuous research and examination, particularly in light of the perpetual evolution and rise of new digital technologies.

Figure 2.3. Average Citations Per Year



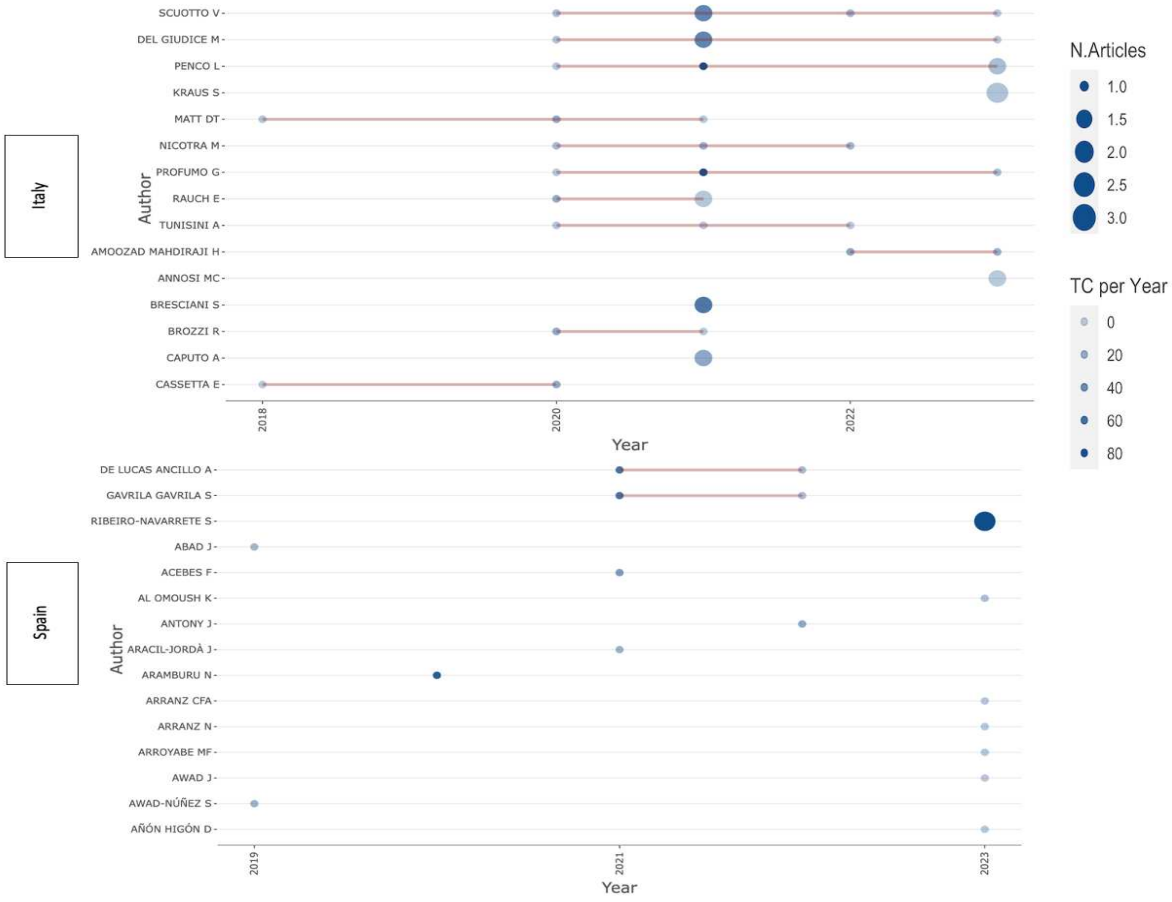
Source: Authors' elaboration

Regarding the summary of Figures 2.1, 2.2, and 2.3 over the specified period, Italy produced nearly twice as many papers as Spain. Additionally, the number of authors involved in the field of digitalisation and SMEs in Italy was almost double that of Spain. Notably, the interest of authors from both countries in this topic has been on the rise since 2022. Moreover, the ACP for both countries is lower than in previous years; however, Spain has experienced a slight increase since 2022.

2.4.1 Authors

This section offers a comprehensive overview of the authors' performance. Figure 2.4 illustrates the top 15 authors from both countries, showcasing their high productivity over time.

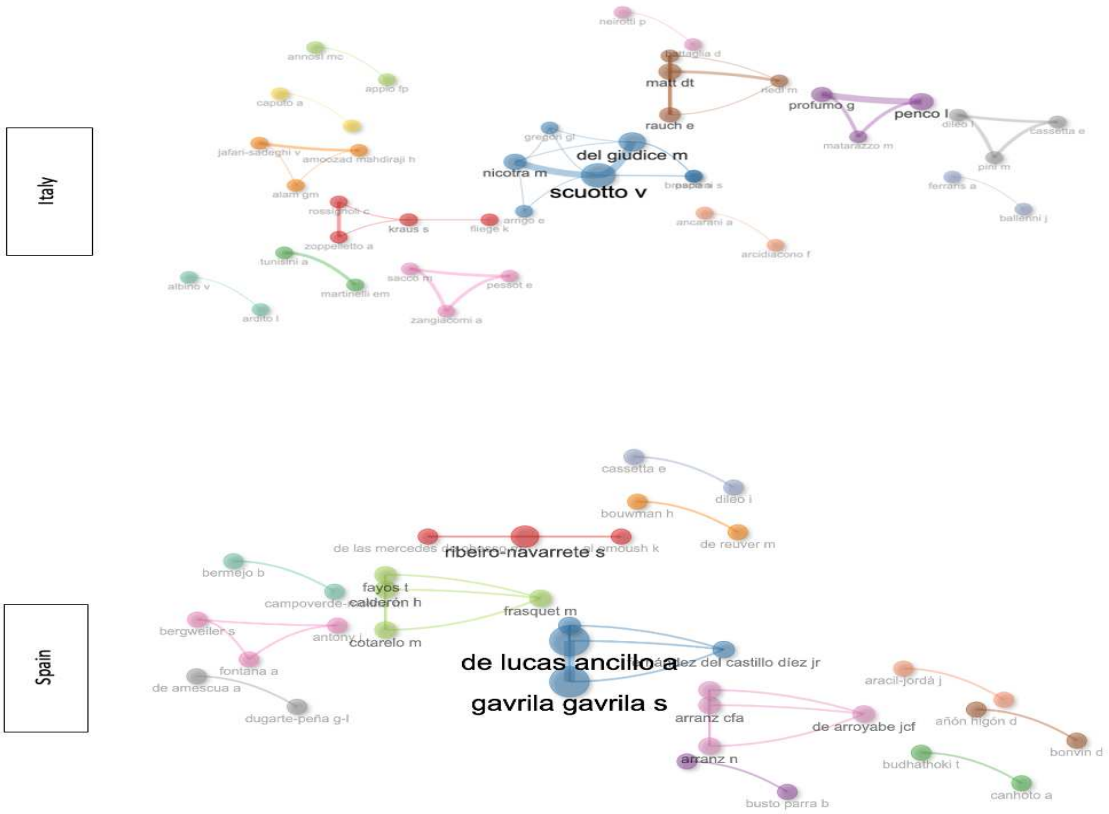
Figure 2.4. Authors' Production over time



Source: Authors' elaboration

Within the graph, the timeline of authors is represented by a line, while the size of the dots links to the number of publications. Additionally, the colour intensity signifies the annual citation frequency, providing valuable insights into the authors' impact and influence. In Figure 2.4, it's clear that in Italy, V. Scutto and L Penco are the most productive authors, each with 4 articles. Following closely are M. Del Guidice, S. Kraus, D. Matt, M. Nicotra, and G. Profumo, all contributing 3 articles. In Spain, A. De Lucas Ancillo, S. Gavrila Gavrila, and S. Riberio-Navarrete are leading authors, with 2 articles each, while the rest of the authors each contributed 1 article. Moreover, in Italy, L Penco and G. Profumo have achieved a commendable total of 326 citations, positioning them as the leading authors in the annual citation frequency. Following closely, S. Bresciani has garnered 217 citations. Additionally, M. Del Guidice and V. Scutto have both received 179 citations each. Shifting focus to Spain, N. Aramburu has emerged as the top author with a total of 77 citations, trailed by A. De Lucas Ancillo and S. Gavrila Gavrila, each with a total of 49 citations.

Figure 2.5. Author Collaboration Network



Source: Authors' elaboration

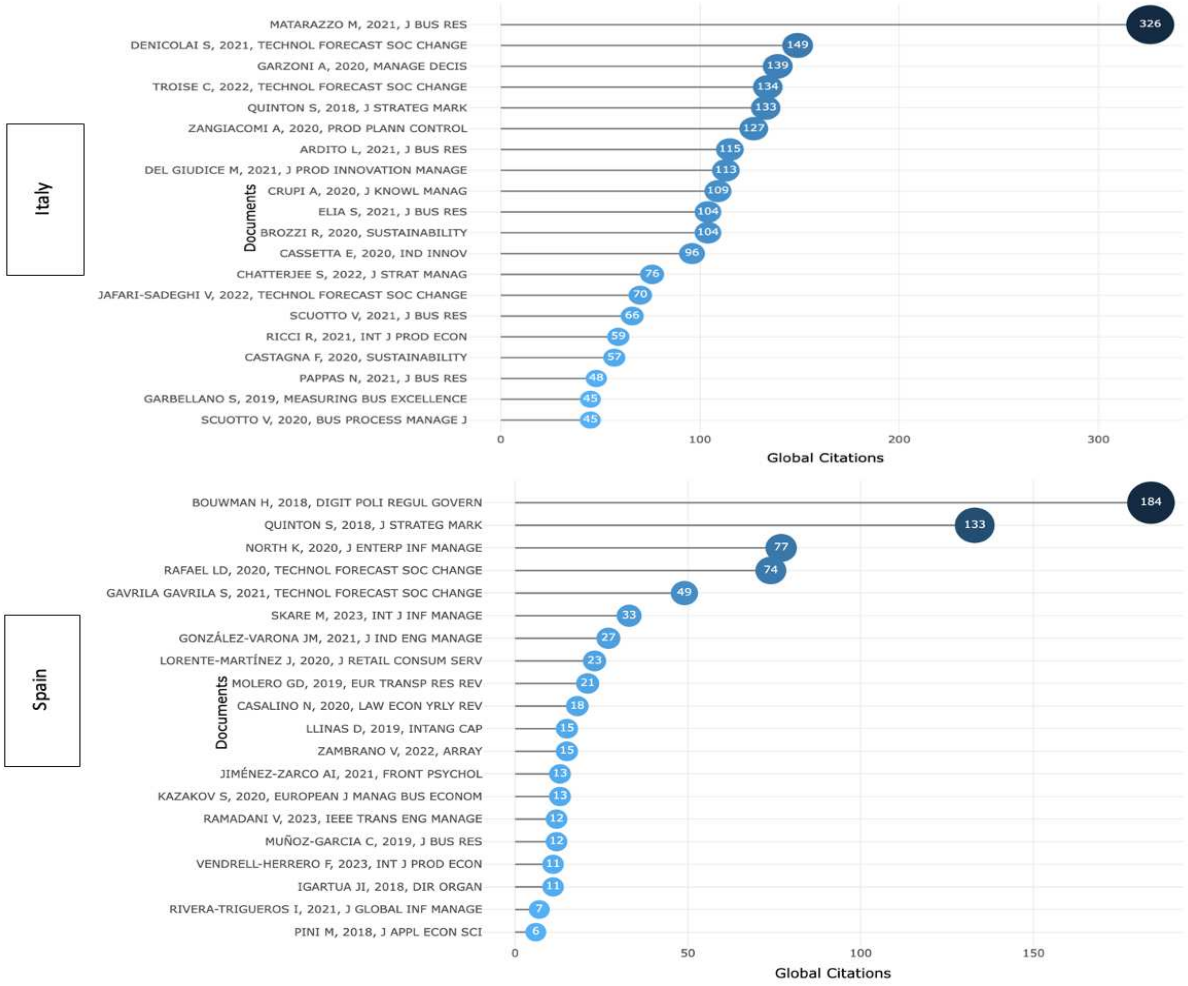
In Figure 2.5, we can observe the collaboration network among authors for both Italy and Spain. The colours in the graph represent the number of clusters, whilst the thickness of lines between authors represents how often they collaborate. This analysis reveals 14 clusters in Italy and 13 in Spain, within this context, V. Scuotto, M. Del Guidice, and M. Nicotra are frequent collaborators in Italy, while in Spain, authors S. Gavrila Gavrila and De A. Lucas Ancillo frequently collaborate. Additionally, G. Profumo and L. Penco, as well as D. Matt and E. Rauch are also identified as frequent collaborators in Italy.

2.4.2 Publications

In a comprehensive analysis presented in Figure 2.6, a ranking of the top 20 articles from both countries is depicted based on their highest citation numbers. Notably, in Italy, the scholarly work entitled “Digital Transformation and Customer Value Creation in Made in Italy SMEs: A Dynamic Capabilities Perspective” by Matarazzo et al. (2021) stands out with 326 citations, signifying its substantial impact. Following closely is the article “Internationalization, digitalization, and Sustainability: Are SMEs Ready? A Survey on Synergies and Substituting Effects among Growth Paths” by Denicolai et al. (2021), which has gathered 144 citations. Furthermore, “Fostering digital transformation of SMEs: a four-levels approach” holds the third position with 139 citations by Garzoni et al. (2020).

In the context of Spain, the paper with the title “The Impact of Digitalization on Business Models” by H. Bouwman et al. (2018) stands out as the most cited, having gathered 184 citations. Following closely is “Conceptualising a Digital Orientation: Antecedents of Supporting SME Performance in the Digital Economy” by Quinton et al. (2018) which has attained the second position with 133 citations. The third most cited paper, “Promoting Digitally Enabled Growth in SMEs: A Framework Proposal” (North et al., 2020), has received 77 citations, demonstrating its significance in this area of research. Concerning the disparity in citation numbers, there could be several factors that make an impact. In this regard, foremost, innovative and field-specific trend research is more likely to be cited. Italian research might generally be of higher quality or more innovative, leading to more citations.

Figure 2.6 Most Global Cited Documents



Source: Authors' elaboration

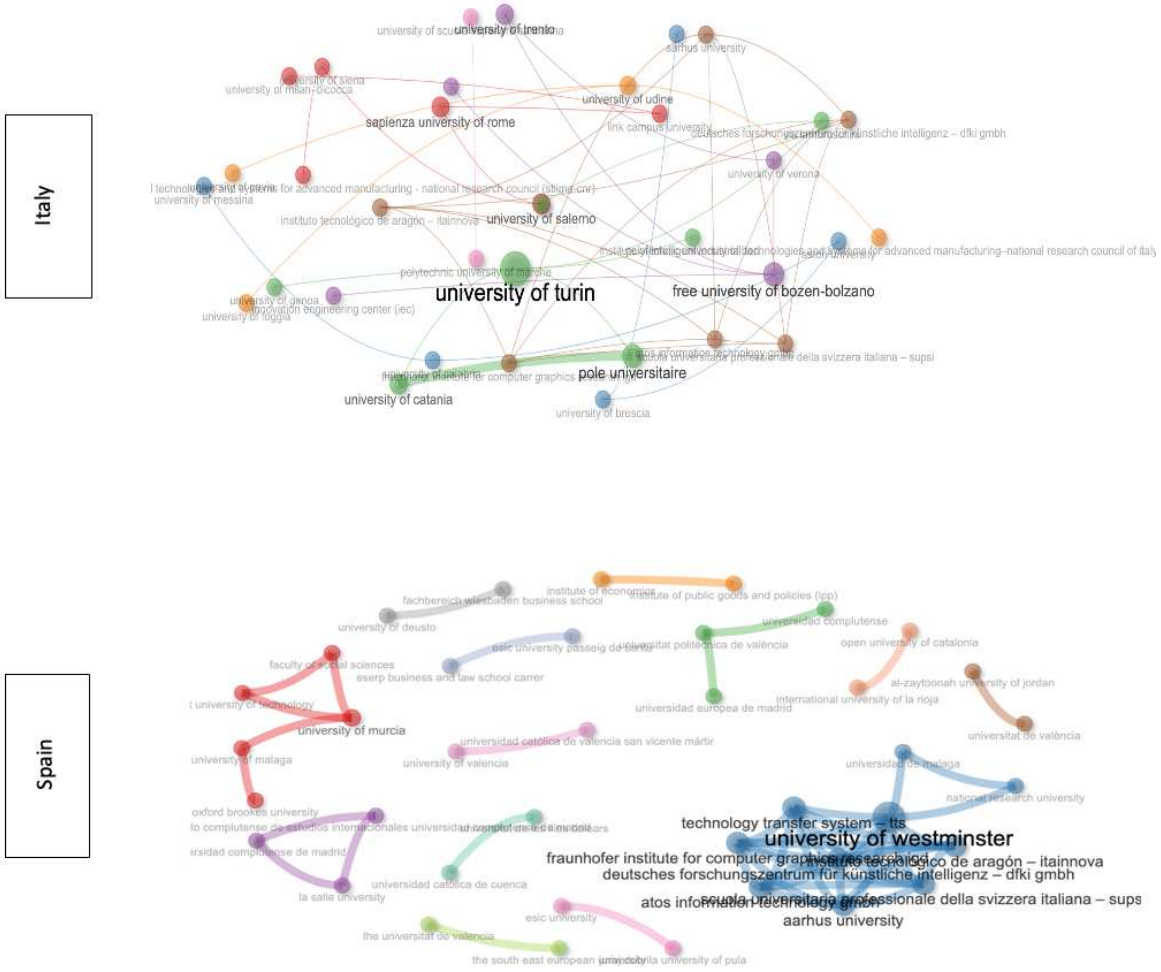
Moreover, collaboration within high-performing local networks can also boost citation counts. Italian researchers may benefit from strong local academic networks that enhance research quality and visibility. Furthermore, open access could be a significant factor where publications that are freely accessible tend to receive more citations.

2.4.3 Universities

The following section examines the collaboration network between universities in both countries. As described in Figure 2.7, colours are used to denote collaboration clusters, while the thickness of the lines represents the frequency

of collaboration within these clusters. The first observation reveals that Spanish universities are involved in more frequent collaboration within their clusters.

Figure 2.7 University Collaboration Network



Source: Authors' elaboration

Moreover, the results also indicate that Spanish universities demonstrate a greater degree of international collaboration. In contrast, Italian universities appear to exhibit a preference for local collaboration. In this regard, there could be several factors such as fund availability, institutional and national research policies. In Spain, there might be more funding opportunities or incentives for international collaborations. This could include grants from the European Union or other international bodies that encourage cross-border research. When it comes to Italy, there may be more robust funding for domestic projects, leading universities to prioritise local collaborations. In terms of institutional

policies, In Spain, universities might have policies that actively promote and facilitate international partnerships and support for joint publications. Regarding Italy, policies might be more focused on strengthening local networks and building national research capacity, thus emphasising local collaborations. With regard to national research policies, In Spain, national research agendas might prioritise global challenges that require international cooperation, including the area of technology development. Conversely, in Italy, the focus might be more on regional or national issues that are best addressed through local collaborations.

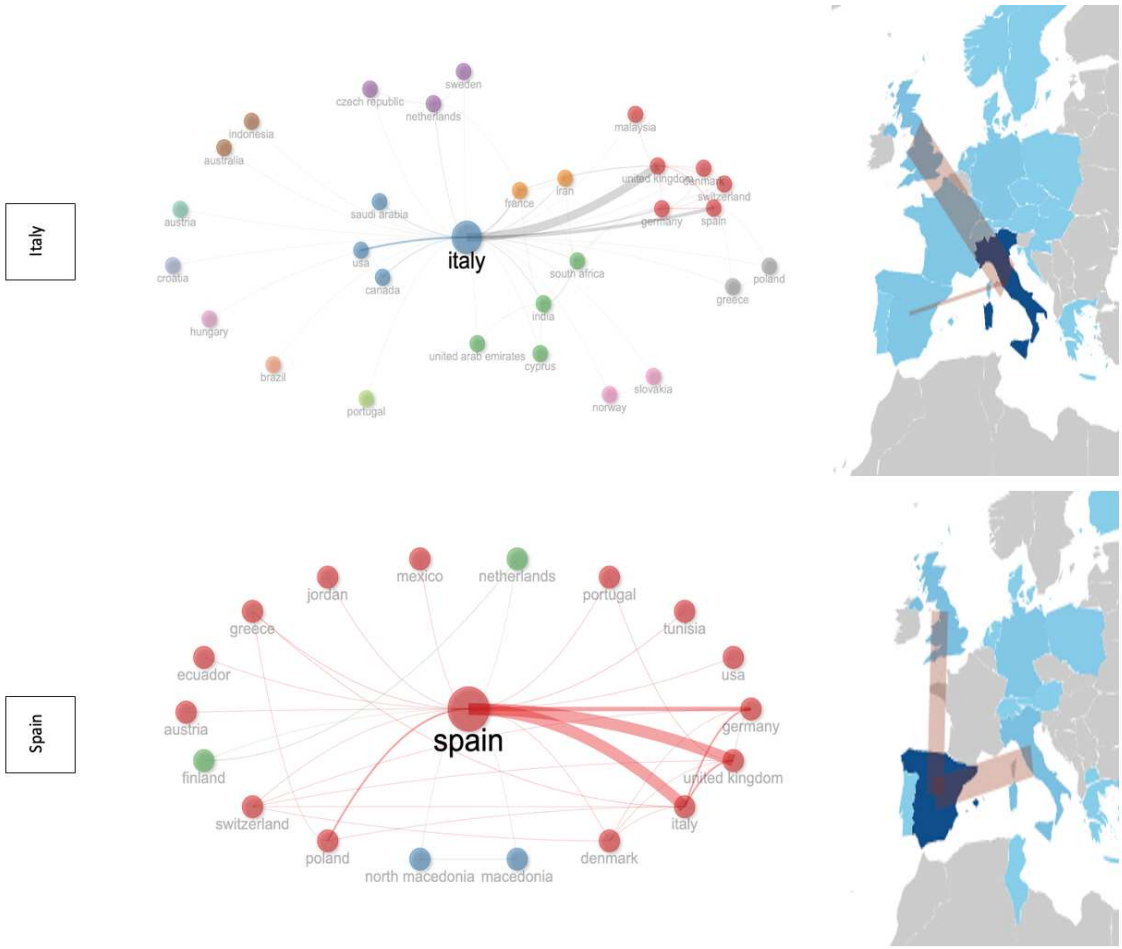
In Italy, the vibrant green cluster stands large, uniting the prestigious universities of Turin, Catania, Pole, and Genoa. Interestingly, the University of Salerno stays in two clusters, showcasing remarkable collaboration. Meanwhile, in Spain, the dynamic blue cluster incorporates the Universities of Malaga and Ramon Llull, specialising in tech transfer and joined by esteemed international partners such as Westminster and Aarhus. Additionally, the red cluster emerges as the second largest, encompassing the influential universities of Valencia, Malaga, and Murcia.

The distinctive patterns of university collaboration and their impact on scientific and technological progress can be attributed to various factors such as funding availability and institutional and national research policies. In Spain, there are abundant funding opportunities and incentives for international collaborations, including grants from the European Union or other international bodies promoting cross-border research. Conversely, Italy boasts robust funding for domestic projects, leading universities to prioritize local collaborations. In terms of institutional policies, Spanish universities actively promote and facilitate international partnerships and support joint publications, while Italian policies focus on strengthening local networks and building national research capacity. Spain's national research agendas prioritize global challenges requiring international cooperation, particularly in technology development, while Italy's research policies concentrate on regional or national issues best addressed through local collaborations.

2.4.4 Country Collaboration

In this section, the collaboration networks of Italy and Spain are presented. In Figure 2.8, colours define clusters in these networks, with the line thickness indicating the frequency of collaboration. A preliminary observation reveals that internal collaboration is more prevalent in Spain, as evidenced by the sizes of the respective bubbles.

Figure 2.8 Country Collaboration Network



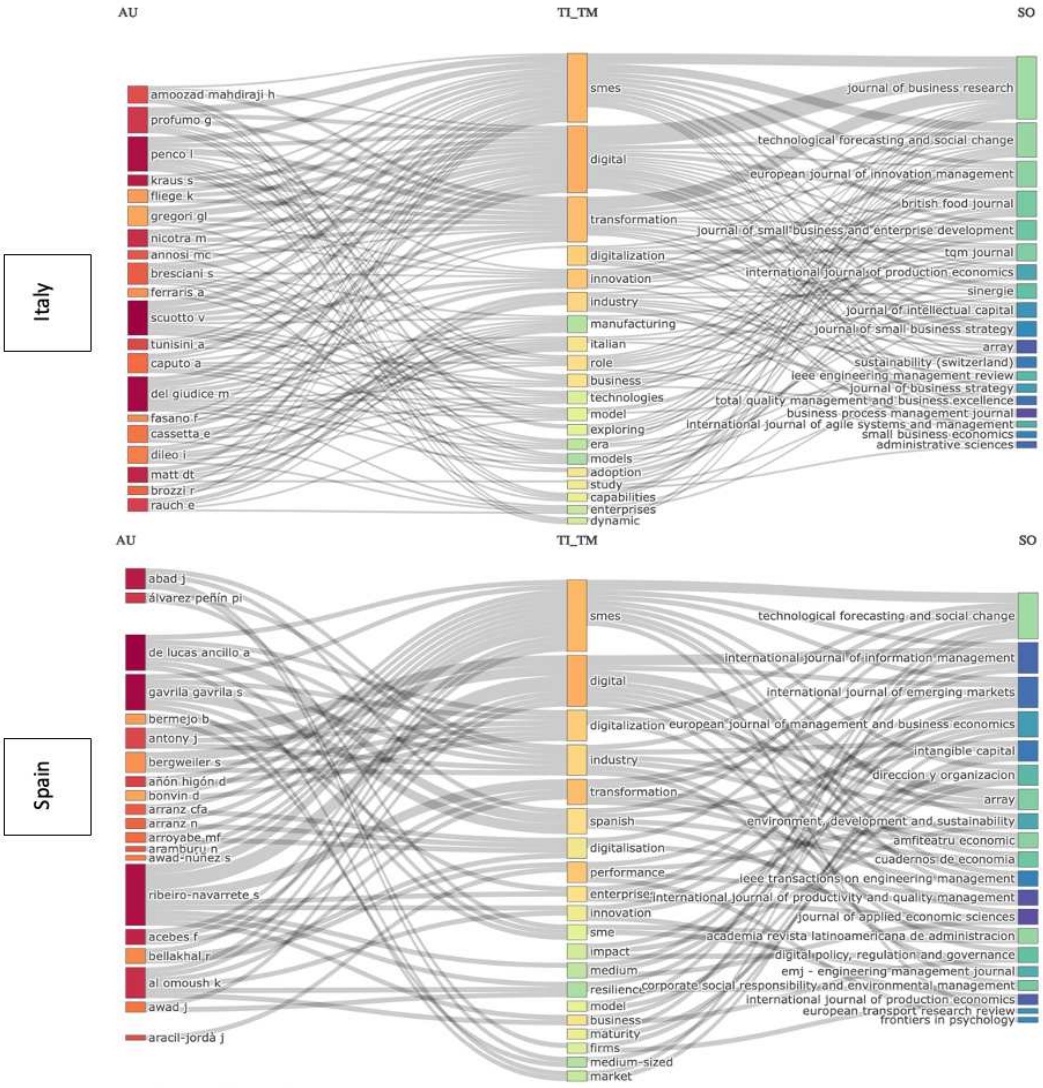
Source: Authors' elaboration

A closer examination of the line thicknesses demonstrates that Italy primarily engages in collaboration with Spain and the United Kingdom, while Spain collaborates with Italy, the United Kingdom, and Germany. Moreover, the map on the right side depicts frequent collaborations between Italy and Spain, along with the United Kingdom.

2.4.5 Three Fields Plot (Sankey Diagram)

The diagram presented visualises the fundamental components within three domains (namely authors, titles, and journals) and illustrates their interconnections. In Figure 2.9, the size of each box corresponds to the proportion or frequency of usage. From left to right, AU denotes authors, TI_TM refers to titles, and SO represents journals.

Figure 2.9 Three Fields Plot (Author-Title-Journal)



Source: Authors' elaboration

In the context of Italian authors, the analysis reveals that Del Giudice has employed a diverse range of words in his titles, encompassing "digital", "transformation", "SMEs", "innovation", "manufacturing", and more, amounting to 12 keywords. Notably, with respect to the frequency of his publication output, he predominantly features SMEs and digital transformation. Subsequently, Scutto and Penco are notable for each utilising 10 keywords. Conversely, in Spain, Riberio-Navarrete distinguishes himself with a total of 8 keywords, frequently incorporating SMEs, digital transformation, and innovation within his titles. Trailing close behind are De Lucas Ancillo and Gavrila Gavrila with 6 keywords each. Their focus is predominantly on SMEs, "digitalisation", "Spanish", "industry", and "market".

In the context of academic publishing preferences, Italian authors demonstrate a propensity to submit their research to the Journal of Business Research, Technological Forecasting and Social Change, and the European Journal of Innovation Management. Conversely, authors based in Spain exhibit a preference for Technological Forecasting and Social Change, the International Journal of Innovation Management, and the International Journal of Emerging Markets as their top three choices for dissemination of their scholarly work.

2.5 Conclusion

An examination was undertaken on a total of 125 publications sourced from esteemed journals (Top-Tier), encompassing 85 documents from Italy and 40 from Spain. The analysis facilitated through the utilisation of the Bibliometrix package and the Biblioshiny tool, yielded comprehensive results. Notably, the publications were released within the timeframe spanning 2018 to 2023.

The literature pertaining to digitalisation in SMEs has undergone notable developments in both Italy and Spain. There has been a recent increase in interest in this area within both countries, with expectations of boosting ACP which currently lags behind. Italy stands ahead of Spain in terms of both publication volume and author interest, likely due to sustained enthusiasm and available funding for research in this field. Furthermore, Italy has a higher number of papers with over 100 global citations in the last 5 years, in contrast to Spain. The prevalence of theoretical papers signifies the need for more empirical evidence to further enrich the existing body of research.

The anticipated themes in the published research are expected to encompass the most frequently referred terms, namely “Digitalisation” or “Digital Transformation”, and “SMEs” in both countries. Predominantly, the prevalent themes in Italy comprise “Innovation”, “Industry”, and “Manufacturing”, while in Spain, they encompass “Industry”, “Performance”, and “Innovation”. This suggests a certain lack of diversity in the identified themes. Notably, upon examining the three most frequently cited papers from each country in terms of themes, it is apparent that in addition to the common keywords “Digitalisation” and “SMEs”, Italian papers address “Customer”, “Value Creation” and “Dynamic Capabilities,” as well as “Internationalization” and “Sustainability.” Meanwhile, Spanish papers feature keywords such as “Business models”, “Digital Economy” and “Digital Growth”.

In the context of network collaborations, there are 14 clusters in Italy and 13 in Spain. Italy exhibits a comparatively larger scale of collaborative networks. Moreover, universities in Spain demonstrate a higher frequency of collaboration within their respective clusters with a heightened degree of international collaboration, while Italian universities primarily engage in local collaboration. When it comes to country collaboration analysis, the size of bubbles suggests a greater prevalence of internal collaboration in Spain. Italy's primary collaborative partners are Spain and the United Kingdom, whereas Spain engages in collaboration with Italy, the United Kingdom, and Germany. The United Kingdom is a key partner for both Italy and Spain, actively participating in joint initiatives with both countries.

Summing up the outcomes, it is evident that there has been an increase in interest regarding digitalisation within SMEs in both Italy and Spain. Italy demonstrates notable strength in terms of publications and citations, characterised by longer author timelines. However, the research themes in both countries exhibit a lack of diversity. While the research themes in Italy and Spain are centred on “Digitalisation” and “SMEs”, Italy places particular emphasis on “Innovation”, “Industry”, and “Manufacturing”, whereas Spain highlights “Industry”, “Performance”, and “Innovation”. Moreover, Italy showcases 14 author clusters and possesses larger collaborative networks, while Spanish universities prioritise frequent and international collaborations. Moreover, Spain's internal collaboration is remarkable, and both countries frequently collaborate with the United Kingdom. Additionally, the existing literature reflects a predominant focus on theoretical papers, underscoring the need for empirical evidence.

The findings presented in this paper offer principal insights for academics, universities, and government bodies. They underscore the critical importance of digitalisation in SMEs as a prime area for research in both Italy and Spain. Academic institutions must prioritise this field and allocate resources for further studies. Encouraging interdisciplinary and cross-border collaborations is vital for enhancing research quality and impact. The identification of multiple author clusters in Italy suggests the potential for developing specialised research groups, with universities playing a key role in supporting their formation to drive focused research efforts and increase productivity. On the policy front, governments should bolster funding for research in SME digitalisation, recognising its potential to spur economic growth and competitiveness. Furthermore, policies that facilitate international research collaborations can harness global expertise and resources, particularly aligning with Spain's emphasis on international partnerships. Policymakers should also integrate SME digitalisation into national research agendas, aligning it with broader economic and technological objectives.

This research is constrained by several limitations. Initially, the database utilised was exclusively obtained from Scopus. Additionally, the analysis conducted was confined to performance analysis, a decision made to prioritise the brevity and directness of the paper.

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Chapter 3

Digital Transformation of Small and Medium-Sized Enterprises as a Process of Innovation: A Holistic Study of its Determinants

Abstract

This paper delves into the crucial factors that drive the digital transformation process of SMEs. In this context, digital transformation refers to the conceptual approach of implementing innovative modifications to a company's products and processes. The proposed comprehensive theoretical model encompasses three dimensions in the digital transformation process in SMEs: 1) the technology dimension, 2) the human capital dimension, and 3) the organisational/relational dimension. These dimensions are considered from a holistic approach. Moreover, these aspects are evident at three levels of examination: a) the entrepreneur or manager; b) the firm; and c) the external environment of the company. The empirical analysis detailed in this article is predicated on a representative survey of Spanish SMEs. The study underscores the pivotal role played by internal expertise and external knowledge sources in driving digital innovation within SMEs. The utilisation of information and communication technology (ICT) through consultants, suppliers, universities, and technological centres emerges as a critical determinant of success in this domain. Furthermore, the analysis emphasises the imperative of a well-defined strategy for digital transformation within the company and the delegation of digitalisation responsibilities beyond the purview of the entrepreneur/manager's leadership. Similarly, it suggests that entrepreneurs/managers who effectively utilise the Internet are more likely to drive digital product innovation, while those harbouring aspirations for growth serve as catalysts for digital process innovation. The results also reveal that the significance of the identified determinants differs to some extent between microenterprises and larger SMEs.

Keywords: digitalisation; digital transformation; digital innovation; digital capabilities; digital ecosystem; SMEs.

3.1 Introduction

In the next few decades, the challenge of adopting and utilising information and telecommunication technologies (ICT) will be an urgent issue for many businesses. Digital technologies are exerting a significant influence on almost every economic sector through the establishment of new markets for new goods and transforming production and distributing processes. The process of digitalisation has emerged as a catalyst for entrepreneurship and the enhancement of productivity. Consequently, it plays a vital role in ensuring the survival and expansion of businesses (OECD, 2020; Reuschke et al., 2021; Gartner et al., 2022; Zahra et al., 2023; Zhiyong et al., 2023). Furthermore, the COVID-19 period has expedited the process of digital transformation for many enterprises, particularly SMEs (Mandviwalla & Flanagan, 2021).

According to Vial (2019:118), digital transformation can be defined as a process in which the use of digital technologies causes disruptions that prompt businesses to make strategic changes in order to modify how they create value. This process also involves dealing with the structural changes and organisational obstacles that can impact the positive and negative results of the transformation. Therefore, digitalisation entails a process of transformation for organisations that may impact various aspects of their operations, including products, production processes, marketing strategies, and business structure. Consequently, completely new or substantially modified products and processes might arise (Berman, 2012; Nambisan et al., 2017; Kohli & Melville, 2019). Hence, in essence, digital transformation signifies an organisational innovation process.

Due to the importance of this process for the future of firms, it is essential to have a deeper comprehension of the factors that facilitate and hinder digital innovation. Prior research (Vial, 2019; Hanelt et al., 2021; Rêgo et al., 2021) has examined this issue, but it has primarily focused on specific factors and technologies such as big data (Ciampi et al., 2021), artificial intelligence (Anica-Popa et al., 2021), blockchain (Morkunas et al., 2019), and the Internet of Things (IoT) (Ben-Daya et al., 2017). However, it lacks a comprehensive understanding of the overall nature and factors of the digitalisation of enterprises. Moreover, the existing empirical literature is lacking, predominantly qualitative, and focuses on large enterprises (Rêgo et al., 2021; Reuschke et al., 2021; Ghosh et al., 2022). Nevertheless, SMEs often encounter a notable lag in their progress toward digitalisation (OECD, 2020; Reuschke et al., 2021) owing to the barriers they encounter in digitally transforming their businesses. The access of these companies to financial, technological, and human resources may be restricted due to their particular characteristics,

including their small size and inadequately professionalised management (Li et al., 2018; Meier et al., 2022). Consequently, it is practical to delve into the particular factors that influence digitalisation in such enterprises.

This article aims to address the gap in existing literature by examining the factors that contribute to and hinder the process of digital transformation in SMEs. To that end, this study examines digital transformation as an innovation process through the enterprise that results in the adoption of new or substantially innovative goods and processes using digital technology. Hence, the paper examines the phenomenon of digital transformation by using the idea of "new to firm" innovation (OECD/Eurostat, 2018).

This research makes a theoretical contribution to the field by presenting a comprehensive approach to examining the determinants of digital transformation in SMEs. This approach incorporates previously studied factors and introduces novel elements that further complicate the ongoing topic. The analytical framework distinguishes between three dimensions (technological, human capital, and organisational/relational) and three levels of analysis (the individual entrepreneur/manager, the firm, and the business environment) in order to examine the factors that influence the process of digital transformation in SMEs. The prior research indicates a lack in the integration of various dimensions/levels of analysis, which might impact the reliability of the findings obtained in studies with a particular emphasis. The technique employed in this study allows us to tackle the problems related to omitted variables that appear in previous investigations that concentrate on certain factors influencing digitalisation. The analysis presented in this paper contributes to the existing body of literature by demonstrating that the digitalisation of products and processes is driven by different factors and that the determinants of digital transformation show some variation between microenterprises and other SMEs.

The empirical investigation outlined in this article is predicated on an extensive dataset comprising 802 SMEs procured from a representative survey of the SME sector in Spain. A stratified sampling approach was used, separating the data into two subgroups: microenterprises (fewer than 10 employees) and larger SMEs (10 or more employees). This robust dataset enables a consistent evaluation of the study's hypotheses. This database lets us reliably evaluate the hypotheses indicated in this paper. The paper employs logistic regression modelling as the econometric methodology.

The findings indicate that human capital and organisational/relational aspects pose significant obstacles to digitalisation in SMEs, extending beyond basic technology components. Therefore, possessing both internal ICT skills and external expertise from ICT consultants, suppliers, universities, and technology centres is crucial for achieving digital transformation in this particular sort of firm. Hence, the findings of the present study underscore the importance of collaboration and cooperation in the development of digital ecosystems. The study also highlights the need to have a clear and defined digital transformation plan within the organisation. It emphasises the necessity of distributing digitalisation tasks beyond the entrepreneur/manager's leadership. It is noted that the profile of entrepreneurs/managers as Internet users and their desire for advancement also impact digital product and process innovations, respectively. The paper also emphasizes the varying significance of key determinants of digital innovation between microenterprises and other SMEs.

3.2 Theoretical foundations for the analysis of the digital transformation of SMEs

This section begins by assessing the existing literature on the digital transformation of SMEs, it then introduces the analytical framework that will be employed in this study (Section 3.2.1.). Furthermore, the paper provides the hypotheses that will be examined in the empirical part of the study (Section 3.2.2.).

3.2.1 Literature review and analytical framework

Despite the increasing amount of research on digital transformation (Vial, 2019; Hanelt et al., 2021; Rêgo et al., 2021), it is still limited and has not yet provided clear explanations for the key aspects involved in this process (Kohli and Melville, 2019; Ritala et al., 2021). In addition, the current body of research primarily concentrates on large enterprises (Giustiziero et al., 2021; Ghosh et al., 2022) and specific technologies (Morkunas et al., 2019; Ben-Daya et al., 2017; Anica-Popa et al., 2021; Ciampi et al., 2021), thus lacking a holistic framework that allows for examining the challenges SMEs encounter when undergoing digital transformation.

Organisational transformations brought about by integrating and adopting digital technologies entail a process of innovation. Previous studies have examined the concept of innovation in the context of the digital transformation

process through the use of various frameworks (Kohli and Melville, 2019; Bogers et al., 2022). Therefore, in reference to the implementation of ICT within an organisation, the phrases "information technology innovation" (Jeyaraj, Rottman, and Lacity, 2006) and "information system innovation" (Swanson, 1994) have been employed to describe the introduction of new processes, products, and services. Moreover, the concept of "digital innovation" (Lee and Berente, 2012) has been applied to adopt a "product-centric perspective" by indicating novel combinations of physical and digital products in order to create innovative products (Kohli & Melville, 2019).

In general, implementing, integrating, and assimilating ICT within enterprises can result in advancements in operational systems, marketing strategies, products, and organisational structures and practices. The factors that influence product and process innovations driven by ICT will be examined in this paper.

The phenomenon of SME digitalisation is intricate and multifaceted. A theoretical framework that distinguishes between a collection of functional dimensions and levels of analysis is a valuable tool for adopting a holistic approach. This chapter establishes three dimensions comprising the digital transformation procedure: the technological, the human capital, and the organisational/relational dimensions. Each of these dimensions manifests itself at three distinct levels of analysis: the individual entrepreneurs/managers, the firm, and its external environment (see Table 3.1).

When considering different levels of analysis, the impact of entrepreneurs/managers on the establishment, organisation, and performance of SMEs is especially significant, as opposed to their effect on larger enterprises (Guzmán & Santos, 2001; Romero and Martínez-Román, 2012; Hadjielias et al., 2022). Thus, on an individual level (i), the personality characteristics and mentality of the entrepreneur/manager might influence the digital transformation process in SMEs (Li et al., 2018; Ghosh et al., 2022). Moreover, the process of digitalisation within SMEs is inherently influenced by the firm's particular characteristics, including its resources, organisational structure, and managerial practices. The firm level of analysis (ii) is determined by these characteristics in the study of the digital transformation of SMEs. Finally, firms perform within a certain environment and engage with several agents, including clients, suppliers, competitors, public administration, universities, research centres, and business groups (Kohli and Melville, 2019). A third level of analysis of the digitalisation process thus consists of gathering the external environment's characteristics (iii).

Moreover, in the following section, the three distinct functional dimensions of the digitalisation of the business are described below.

A. Technological dimension.

This digital transformation process is linked to advancements in ICT that facilitate the generation, collection, storage, processing, analysis, and sharing of information that has been converted to a binary code. This category comprises electronic equipment, such as personal digital agendas, robots, drones, video cameras, computers, and mobile phones; as well as software, including video streaming, voice interfaces or chatbots, blockchain, artificial intelligence, cloud computing, the Internet of Things (IoT), and Ben-Daya et al., 2017; Anica-Popa et al., 2021). The implementation of these digital applications is made feasible by the Internet, an essential facilitator in the advancement of the digital economy. Concerning this perspective, the degree of Internet connectivity and usage within an enterprise is a fundamental technological determinant of digital transformation in business.

B. Human capital dimension.

Enterprises function as knowledge-generating entities that engage in internal and external learning processes, subsequently employing the acquired knowledge to foster innovation (Alavi & Leidner, 2001). Consequently, the acquisition of knowledge and skills, as well as the corresponding learning process, constitute a second critical component in the digital transformation process of businesses. Therefore, as stated by Kohli and Melville (2019: 205), the concept of digital innovation is intricately linked to knowledge and learning. From an internal standpoint, the level of education and prior professional training of entrepreneurs/managers and the remaining personnel may deliver the learning capacities that enable entry into the knowledge and competencies essential for addressing the company's digital transformation. Nevertheless, it stands to reason that the skills and knowledge that are fundamental to the digitalisation process are those that pertain to digital technologies and their practical implementations. Moreover, firms can indirectly benefit from the human capital and expertise of other firms and entities by engaging in training activities, contracting consultant services, and collaborating in numerous other capacities.

C. Organisational/relational dimension.

The digitalisation process in SMEs is impacted by the integration of digital technology, digital capabilities, and other resources. This integration leads to innovation as a result of managing internal organisational processes and partnerships with external agents. On this matter, Ghosh et al. (2022:2) have introduced the notion of digital transformation capability, which they define as the company's systematic capacity to recognise and cultivate fundamental capabilities required for digital transformation. Similar to this, Li et al. (2018) argue that insufficient managerial capabilities are a significant obstacle to digital transformation in SMEs. According to Ghosh et al. (2022), the organisational structure of an enterprise can either facilitate or impede digital transformation. Therefore, for the process to develop successfully, businesses must configure internal operational structures that assign appropriate roles and responsibilities. Likewise, the implementation of ICTs within an organisation introduces novel challenges that necessitate the endorsement of the entrepreneur, the management team, and the remaining personnel. Consequently, for digital transformation initiatives to be efficient, they must conform to the prevalent organisational culture (Jeyaraj et al., 2006; Ghosh et al., 2022). Therefore, the degree of achievement in the implementation of the digital transformation process within SMEs may depend on the manner in which the process is promoted, considered, and administered within the firm.

Similarly, regarding the external perspective, how SMEs engage with other agents influences their digital transformation process. Accessibility to the intangible and tangible resources required to accelerate digital transformation can be facilitated through community collaboration and the exchange of knowledge (Wang and Ramiller, 2009; Kohli & Melville, 2019). Focusing on this, Ghosh et al. (2022) emphasises the significance of strategic partnerships as a means to obtain digital transformation capabilities. However, they also acknowledge the challenge of effectively managing these partnerships due to the potential for conflicting interests among the participants. The concept of "digital ecosystems" (Dyba et al., 2022; Li et al., 2012; Senyo et al., 2019) has emerged from this connected perspective regarding how collaboration with a firm's stakeholders (including clients, suppliers, other firms, public administrations, universities and research centres, business associations, and others) can influence digital transformation. Value co-creation processes linked to digital transformation and the expansion of the digital economy are propelled by digital ecosystems. In addition, the notion of a "digital entrepreneurial ecosystem" was introduced by Sussan and Acs (2017), emphasising the significance of Schumpeterian entrepreneurs in the formation of digital enterprises and the development of new products and services. Digital ecosystems frequently arise within

the framework of the digital platform economy, facilitating engagements among various stakeholders including platform-reliant businesses, end consumers, and governmental entities (Aminullah et al., 2022; Lafuente et al., 2022).

Table 3.1

Analytical framework. A typology of determinants of digital transformation in SMEs

	Technological dimension	Human capital dimension	Organisational and relational dimension
Entrepreneur/manager level	User profile (H1)	Educational background (H4)	Entrepreneurial orientation (H8)
Firm level	Technology availability (H2)	Education and training of employees (H5)	Digital strategy (H9) Distribution of digital responsibilities (H10) Attitudes of employees towards digitalisation (H11)
Business environment level	Infrastructure availability (H3)	Consulting services (H6) Public policies for promoting digital capabilities (H7)	Cooperation with external actors (universities and R&D centres, suppliers, clients, public administration, etc.) (H12)

3.2.2 Research hypotheses

This section presents the research hypotheses that will be examined in the empirical part of this article. The hypotheses are categorised according to the analytical framework described in Section 3.2.2 (see Table 3.1).

A. Technological dimension

While addressing the wide range of digital technologies that have diverse applications, this paper employs Internet use and accessibility as a proxy factor to express the technological dimension of the digitalisation process. The reason for this is that the Internet facilitate the operation of digital technologies and digital business applications.

At the individual level, the awareness of the entrepreneur/manager plays a crucial role in the digital transformation of SMEs (Li et al., 2018; Hanelt et al., 2021). The use of the Internet by entrepreneurs and managers enables them to see the potential linked to the digital revolution of their businesses (Orrensalo et al., 2022). Therefore, it establishes the extent to which entrepreneurs/managers can take on the responsibility of leading and driving the innovation initiatives aimed at the digital transformation of their firms (Martín-Martín et al., 2022).

At the firm level, the ability of an organisation to innovate and digitally transform its products and processes is inherently dependent on its ICT infrastructure and the degree to which its employees have access to Internet-connected electronic devices (Armstrong and Sambamurthy, 1999). This aspect serves as a critical enabler for any digital technology-driven innovation process within the organisation.

When it comes to the features of the business environment, several studies have emphasised the benefits of having reliable Internet connectivity (Belloc et al., 2012; Falch & Henten, 2018). According to Haller and Lyons (2015), using broadband may enhance the efficiency of SMEs and promote their digital transformation. Hence, the issue of Internet accessibility has been recognised as an essential factor that might result in a spatial disparity in digital connectivity between urban and rural regions (Labrianidis & Kalogeressis, 2006; Prieger, 2013).

With respect to this, the subsequent hypotheses concerning the technological dimension of the digital transformation process are postulated.

H1: Entrepreneurs and managers who engage in extensive utilisation of the Internet are more inclined to introduce innovations that drive the digital transformation of their SMEs.

H2: SMEs with a higher proportion of staff utilising electronic equipment (including computers, tablets, and mobile phones) with Internet connectivity, demonstrate a greater tendency to adopt digital innovations that drive the digital transformation of their SMEs.

H3: SMEs encountering challenges in establishing a reliable Internet connection (one that is stable, with sufficient capacity and offered at a reasonable cost) are less likely to present innovations to drive their digital transformation.

B. Human capital dimension.

The level of education of the entrepreneur/manager has been found to have a significant impact on SMEs (Romero and Martínez-Román, 2012, 2015). Additionally, top management support has been recognised as a key driver of digital transformation (Jeyaraj et al., 2006; Gono et al., 2016; Ghosh et al., 2022). In this regard, the entrepreneur/manager's education and skills can constitute significant factors in the effective implementation of ICT (Ramayah et al., 2016).

Moreover, research has shown a connection between an organisation's innovative mindset to the quality and education of its employees (Cooper and Zmud, 1990). Skilled workers in organisations may gain a significant competitive edge through employee-driven innovation, allowing them to stand out from their competition. Effective management of these knowledge assets is crucial for enhancing the innovative capacities of firms (Kesting & Ulhøi, 2010). In this regard, the acquisition of ICT skills becomes particularly significant (Ghobakhloo & Ching, 2019). Staff motivation to enhance their skills and innovation by the use of technical knowledge which might result in innovation, while reinforcing digital capabilities within firms can facilitate the implementation and assimilation of ICT.

However, enterprises have the option to initiate their digital transformation through inter-organisational (open innovation) channels, intra-organisational (internal capabilities and in-house R&D), or a combination of both (Scuotto et al., 2017). Consequently, they are able to take advantage of the human capital that is accessible to them in the external environment. Engagement of ICT consulting services is a direct method of obtaining external knowledge and skills. This might enhance the capacity of SMEs to promote their digital transformation. Moreover, SMEs receive varying degrees of public support across different nations (Meramveliotakis & Manioudis, 2021). Nevertheless, SMEs can derive advantages from such support in diverse areas (Chan et al., 2022; Wang et al., 2023). Consequently, public institutions can play a pivotal role in enhancing awareness regarding the significance of digitalisation and the

concomitant opportunities and risks for SMEs. Furthermore, public initiatives can facilitate the acquisition of digital capabilities that SMEs frequently lack. Regarding this, the following hypotheses are postulated in this paper:

H4: Entrepreneurs/managers holding a university degree or possessing advanced professional training demonstrate a higher propensity to implement innovations to drive their digital transformation.

H5: SMEs that employ staff with ICT expertise or digital skills demonstrate a greater tendency to adopt digital innovations to drive their digital transformation.

H6: SMEs that contract external ICT consulting services demonstrate a higher propensity to implement innovations to drive their digital transformation.

H7: SMEs participating in public activities to raise digital awareness and training demonstrate a greater tendency to adopt digital innovations to drive their digital transformation.

C. Organisational/relational dimension.

At the individual level, it has been established that the entrepreneurial orientation and motivation of managers/entrepreneurs is a crucial factor in the growth and progress of SMEs (Hermans et al., 2015; Forcadell & Öbeda, 2022). Entrepreneurs/managers who are particularly ambitious have an increased likelihood of successfully establishing businesses (Guzmán & Santos, 2001; Shane, 2009). Their determination for development can be a source of motivation to promote the digitalisation of their businesses.

At the firm level, the process of digitalisation has a significant impact on the strategic management and internal organisation of businesses. A clear and particular vision is crucial in guiding the effective growth of the digitalisation of businesses (Matt et al., 2015; Hess, 2016). Many firms rely on a digital strategy, which is defined as an organisational strategy developed and implemented by utilising digital resources to create a unique advantage (Bharadwaj et al., 2013:472). Nevertheless, the process of digitalisation in SMEs is not frequently the outcome of a deliberate and obvious strategy. Instead, it often relies on "ad hoc approaches" and individual initiatives undertaken by the entrepreneur, members of the management team, and certain workers (Kohli & Melville, 2019). Moreover, the duties and tasks resulting from the digital transformation in businesses can be allocated in various manners within the

organisation: they might be directly directed by the entrepreneur/manager themselves, or they can be assigned to a special ad hoc unit under the leadership of a Chief Digital Officer (CDO). Alternatively, they can be allocated between many units, departments, or individuals. In certain situations, these tasks/responsibilities are not officially designated, and the process is guided by scattered efforts from different individuals in a spontaneous form. The existing literature does not provide a definitive answer to the issue of whether organisational form is more efficient (Matt et al., 2015; Ghosh et al., 2022). However, the entrepreneur/manager being alone responsible for the digitalisation duties and tasks might be a drawback. The entrepreneur/manager at SMEs may possess insufficient digital knowledge and abilities, as well as a limited understanding of the potential of digitalisation. Additionally, they may have time constraints that prevent them from adequately reflecting on and effectively implementing the digitalisation process. Regardless, digital transformation is a comprehensive process that has the capacity to alter the whole business. It is crucial to have the acceptance of workers and active participation in this process. If employees observe the digitalisation process as a potential danger to their job security or as a source of disruption and disadvantages, they may oppose change, thus hindering the advancement of digital transformation.

Moreover, SMEs may enhance their digital transformation by engaging in collaborative efforts with other agents in their business environment (Sussan & Acs, 2017)[1]. Suppliers may play a role in fostering innovation and promoting the digitalisation of SMEs by responding to their requirements, requests, and expertise (Fernández-Serrano et al., 2019). Specifically, digital technologies like blockchain and IoT have a significant impact on supply chain management (Ko et al., 2005; Ben-Daya et al., 2017). Furthermore, the rapid advancement of technology has necessitated a requirement for coordinated R&D activities (Chesbrough, 2023). According to this, SMEs may engage in partnerships with research centres and academic institutions to finance their R&D costs and gain access to additional resources, therefore expediting their digitalisation initiatives (Chan et al., 2022).

Based on the arguments presented above, the following hypotheses are proposed:

H8: Entrepreneurs/managers with growth ambition demonstrate a higher propensity to implement innovations to drive the digital transformation of SMEs.

[1] The potential impacts of collaborating with other agents, such as customers and competitors, on advancements toward digital transformation were rejected in additional assessments that are not included in this paper.

H9: SMEs with an explicit and ongoing digital strategy demonstrate a higher propensity to implement innovations to drive their digital transformation.

H10: SMEs in which the entrepreneur/manager directly assumes the responsibilities regarding digitalisation demonstrate a greater tendency to adopt digital innovations to drive their digital transformation.

H11: SMEs whose employees have a positive attitude toward digitalisation demonstrate a greater tendency to adopt digital innovations to drive their digital transformation.

H12: SMEs that cooperate with other actors in their ecosystems training demonstrate a greater tendency to adopt digital innovations to drive their digital transformation.

3.3 Data and methodology

This section presents the data used in this study (Section 3.3.1) and the employed methodology (Section 3.3.2).

3.3.1 Data and variables

This research is based on a survey conducted during the second quarter of 2022, targeting Spanish SMEs with a workforce ranging from 1 to 200 employees. Using the System of Iberian Balance Analyses (SABI) database, a stratified random sample was selected, dividing the population into two strata: microenterprises (fewer than 10 employees) and other SMEs (10 or more employees). Sampling allocations ensured representativeness within each stratum, with a margin of error of ±5.0% at a 95% confidence level. The methodology employed for the survey was computer-assisted telephone interviewing (CATI). A response rate of 21.5% was obtained from the fieldwork. No bias was detected between respondents and non-respondents, and the final dataset used for this analysis comprises 802 valid observations, compromising 379 microenterprises and 423 SMEs with 10 employees or more.

A. Dependent variables

In this study, the dependent variables encompass two distinct forms of innovation that are linked to the digital transformation of SMEs:

- Product innovation (prod_inn). The value of this binary variable is determined by the responses to the subsequent question: “During the 2019-2021 period, did your company introduce innovations in new or significantly improved products/services that involve a digitalisation process?”.
- Process innovation (proc_inn). This binary variable corresponds to the following question: “During the 2019-2021 period, did your company introduce innovations in its production, logistics, or distribution processes, either for new processes or significant improvements in existing ones, that imply a digitalisation process?”.

Both variables are assigned a value of 1 if the company has implemented an innovation (product or process) with a digitalisation dimension, and 0 if there has been no such implementation.

B. Explanatory variables

The research encompasses the following explanatory variables:

i) Technological dimension

- Intensity in the use of the Internet by the entrepreneur/manager (Entrep_Internet): The entrepreneurs/managers interviewed were asked “How often and for what purpose do you use the Internet?” Subsequently, their responses were coded as an ordinal variable, utilising a scale ranging from 1 to 5, where 1 denotes a sporadic and simple use of the Internet and 5 indicates a frequent and complex use (Emp_Internet).
- Percentage of the personnel utilising company-provided computers, tablets, and/or mobile phones with access to the Internet (Emp_Internet).
- Broadband quality (Internet_connec): The managers were surveyed about their “experience difficulty in attaining a proper Internet connection”. Subsequently, their responses were converted into an ordinal variable, ranging from 0 to 3, wherein 0 denoted minimal and 3 significant.

ii) Human capital dimension

- Entrepreneurs/managers with university degrees or higher professional studies (Entrep_edu): This binary variable denotes the value of 1 for those SMEs with entrepreneurs/managers who had a university degree or higher professional training and 0 for the rest.
- Percentage of employees with higher education (Emplo_edu).

- Medium-level staff with ICT expertise (Techn_TIC): This binary variable denotes the value 1 for those companies that have ICT experts in medium-level positions (0 otherwise).
- ICT training initiatives in the company (ICT_train): This binary variable takes the value of 1 if the firm established training activities to enhance the staff's ICT skills in the three years before the survey (0 otherwise).
- External ICT consultancy (ICT_consu): This binary variable denotes the value of 1 in the firm if the presence of outsourced ICT functions with external suppliers and consultants within the 2019-21 timeframe (0 otherwise).
- Public training activities (Publ_train): This binary variable takes value 1 if, during the 2019-2021 period, The firm involved in any initiative conducted by public administrations at the local, regional, national, or EU levels, pertaining to the promotion, dissemination, or training activities related to business digital transformation (0 otherwise).

iii) Organisational/relational dimension

- Ambition for firm growth (Growth_amb): this variable captures the relevance of the entrepreneur's/manager's attitude towards the growth of the company in the future. Subsequently, their responses were coded as an ordinal variable, utilising a scale ranging from 1 to 5, where 1 denotes minimal: "manageable by myself or with few employees" and 5 means that they are willing the enterprise to become "as big as possible"
- Digital strategies (Dig_strategy): This binary variable denotes the value of 1 if the company was applying an explicitly digital transformation strategy (0 otherwise).
- Responsibilities of digital transformation assumed by the entrepreneur/manager (Entr_dig_head): This binary variable takes the value of 1 if the decisions concerning the digital transformation of the enterprise were run straight by the entrepreneur/manager.
- Workers' attitudes towards digitalisation (Staff_dig_mot): this variable is based on the following question: "Are your employees generally motivated about the company's digital transformation?". The responses were classified according to an ordinal variable using a Likert scale ranging from 1 to 4. A rating of 4 denotes a high level of motivation, while a rating of 1 signifies complete resistance.

- Cooperation with suppliers (Coop_suppl). This variable measures the level of collaboration with suppliers in the local region, other regions of Spain, and internationally, specifically in the context of digitalisation. Responses for each spatial area were discretely coded as ordinal variables within the range of 0 to 3, wherein 3 indicates a high level of collaboration, and 0 indicates a low level of collaboration. The variable is derived from the summation of these ordinal variables.
- Cooperation with Universities and R&D centres (Coop_univ). This variable measures the degree of collaboration with universities and research centres in their local area, across other regions of Spain, and internationally, specifically concerning digitalisation. The variable was developed using a methodology like that used for assessing cooperation with suppliers.

C. Control variables

To accurately assess the impact of the primary explanatory variables, the estimated models incorporate a set of control variables.

- Firm size (Employees). The analysis encompasses the company's size, gauged by the number of employees. Jeyaraj et al. (2006) highlighted that firm size stands out as one of the top three predictive factors for ICT innovation adoption, based on a comprehensive meta-analysis of prior literature.
- Sectoral dummies: In this study, the SMEs were categorised into four sectors: industry, construction, trade, and services. To account for this categorisation, dummy variables were incorporated into the estimated models for the first three sectors, with the service sector being designated as the base category.

Table 3.2 presents the primary descriptive statistics for the dependent, explanatory, and control variables. On average, the entities within the sample represented small-scale enterprises with an average of 19 employees, predominantly operational within the service sector. The majority of these enterprises did not implement any digitalisation-associated innovations during the 2019-2021 timeframe. Consequently, it is plausible to infer that the average SME subject to the survey exhibited a relatively low degree of digital transformation.

Based on the technological perspective, average enterprises in the dataset encountered no significant issues in accessing a reliable Internet connection. Approximately 75% of their employees operated electronic equipment that

was connected to the Internet, and the entrepreneur/manager demonstrated frequent and diverse utilisation of online resources.

From the human capital viewpoint, it is noteworthy that the typical entrepreneur or manager possesses a university degree or higher professional training, signifying a strong educational foundation. Conversely, less than half of the staff within the average company hold such esteemed qualifications, highlighting a potential area for development. Additionally, it is noteworthy that no information and communication technology (ICT) experts are present among the medium-level staff of these companies.

When it comes to an organisational perspective, it is notable that the average company proclaims the active implementation of a digital transformation strategy, a process led by the entrepreneur or manager. Moreover, the typical entrepreneur or manager indicates a moderate level of ambition for company growth and reports an observable, reasonable level of employee motivation towards the digital transformation efforts within the company.

Table 3.2 also highlights distinct differences in digitalisation practices between microenterprises and other SMEs. Microenterprises have a higher proportion of staff using Internet-connected devices such as computers, tablets, and mobile phones. However, they face limitations, including lower availability of in-house ICT experts, less engagement in ICT training initiatives, and less reliance on external ICT consultancy. They also demonstrate lower growth ambition, are less likely to adopt a formal and ongoing digital strategy and tend to centralize digitalisation responsibilities with the entrepreneur or manager. Additionally, microenterprises engage less frequently in collaborations with suppliers, universities, and research centres on digitalisation issues and introduce fewer digital innovations compared to SMEs.

Table 3.2

Descriptive statistics

	All SMEs				Microenterprises		Small and medium-sized companies	
Variable	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Mean	Std. Dev.
Dependent variables								
Product innovation	0.428	0.495	0	1	0.390	0.330	0.460	0.499
Process innovation	0.370	0.483	0	1	0.488	0.469	0.410	0.492
Explanatory variables								
Technological dimension								
Intensity of the use of the Internet by the entrepreneur/manager	4.467	0.866	1	5	4.420	0.881	4.510	0.850
Staff using electronic equipment with Internet connection	74.063	34.340	0	100	78.988	33.211	69.784	34.779
Broadband access and quality	0.417	0.787	0	3	0.430	0.818	0.410	0.760
Human capital dimension								
Entrepreneur's/manager's education level	0.712	0.453	0	1	0.714	0.453	0.712	0.454
Employees with higher education (%)	41.609	35.556	0	100	47.081	38.857	36.646	31.566
Medium-level staff with ICT expertise	0.308	0.462	0	1	0.200	0.403	0.400	0.490
ICT training initiatives of the company	0.395	0.489	0	1	0.350	0.479	0.430	0.495
ICT consultancy	0.641	0.480	0	1	0.550	0.498	0.720	0.448
Public activities to raise digital awareness and training	0.092	0.289	0	1	0.070	0.247	0.110	0.319
Organizational/relational dimension								
Ambition for firm growth	2.778	1.429	1	5	2.320	1.421	3.170	1.319
Digital strategies	0.617	0.486	0	1	0.542	0.499	0.681	0.467
Digital responsibilities of the entrepreneur/manager	0.445	0.497	0	1	0.589	0.493	0.324	0.468
Workers' attitudes towards digitalisation	3.132	0.998	1	4	3.050	1.064	3.200	0.932
Cooperation with suppliers	0.918	1.807	0	9	0.755	1.597	1.057	1.962
Cooperation with universities and R&D centers	0.357	1.194	0	9	0.250	0.945	0.449	1.368
Control variables								
Firm size	19.310	27.269	1	200	3.973	2.200	32.282	31.650
Industry	0.138	0.345	0	1	0.081	0.273	0.187	0.391
Construction	0.131	0.338	0	1	0.130	0.337	0.132	0.339
Trade	0.209	0.407	0	1	0.250	0.434	0.176	0.381
Services	0.522	0.500	0	1	0.539	0.499	0.504	0.500

Total number of valid observations = 802 (379 microenterprises and 423 SMEs with 10 employees or more).

3.3.2 Econometric methodology

This research employs logistic regression to evaluate the impact of independent variables on dichotomous innovation variables. This econometric model can be presented as follows:

$$\ln\left(\frac{p}{1-p}\right) = z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k \quad (1)$$

In (1), p stands for the probability that $y = 1$, where y alternatively represents the innovation dummies (prod_inn and proc_inn), x_j are the independent variables (explanatory and control variables), and β_j denote the regression coefficients $(j = 1...k)$.

The probability that a company innovates in its products and processes as a result of the application of digital technologies, for a given value of x_j, is given by the following expression:

$$p = \frac{\exp\left(\beta_0 + \sum_j \beta_j x_j\right)}{1 + \exp\left(\beta_0 + \sum_j \beta_j x_j\right)} \quad (2)$$

This logistic regression model is estimated using the maximum likelihood method.

3.4 Results

Separate models for product and process innovation were estimated, and collinearity did not present a problem in these assessments. The outcomes pertaining to digital product innovations can be found in Table 3.3. Concerning control variables, it is observed a negative and marginally significant impact of the number of employees on innovation, which suggests that smaller companies may exhibit greater flexibility in introducing digital product innovations.

Concerning the technological dimension, entrepreneurs/managers who employ the Internet in a complex manner are significantly more successful in introducing product innovations. Regarding this matter, it appears that the awareness and experience that entrepreneurs/managers possess regarding digital technology significantly influence the successful digital transformation of SMEs, as highlighted by Li et al. (2018) and Hanelt et al. (2021). On

the contrary, the usage of electronic equipment by staff members and the provision of a reliable Internet connection within the organisation do not yield any significant results.

Regarding the human capital dimension, it has been observed that the presence of technical personnel with ICT expertise, the implementation of digitalisation-focused training programs, and the use of external ICT consulting services have a substantial positive impact on digital product innovation. This indicates that the digital transformation process of SMEs can be accelerated by both internal and external digital competencies. Nevertheless, the impact of the staff's and entrepreneurs'/managers' formal educational backgrounds on digital product innovation is negligible.

Finally, with respect to the organisational/relational dimension, it is noted that the presence of a well-defined digitalisation strategy has a significantly positive impact on digital product innovation. This is consistent with Matt et al. (2015) and Hess (2016) among others. Additionally, it appears that staff motivation for digital transformation has a substantial positive impact on digital innovation in SMEs. Similarly, cooperation activities with suppliers and more importantly technological centres and universities have substantial beneficial effects on product digital innovation. This finding suggests that the digital transformation of SMEs can be accelerated through their engagement with other agents in entrepreneurial digital ecosystems, as suggested by Sussan and Acs (2017).

Table 3.3

Logistic regression. Digital product innovation

	β	S.E.	p-value	Exp(β)
Technological dimension				
Entrep_Internet	0.545 (***)	0.143	0.000	1.725
Emp_Internet	0.004	0.003	0.164	1.004
Internet_connec	0.080	0.110	0.466	1.084
Human capital dimension				
Entrep_edu	0.029	0.221	0.895	1.029
Emplo_edu	0.000	0.003	0.934	1.000
Techn_TIC	0.762 (***)	0.199	0.000	2.142
ICT_train	0.388 (**)	0.190	0.041	1.474
ICT_consu	0.677 (***)	0.196	0.001	1.967
Publ_train	0.441	0.304	0.147	1.554
Organizational/relational dimension				
Growth_amb	0.089	0.064	0.163	1.093
Dig_strategy	0.862 (***)	0.210	0.000	2.369
Entr_dig_head	0.065	0.182	0.721	1.067
Staff_dig_mot	0.173 (*)	0.102	0.088	1.189
Coop_suppl	0.149 (*)	0.058	0.010	1.161
Coop_univ	0.374 (***)	0.126	0.003	1.454
Control variables				
Employees	-0.007 (*)	0.004	0.093	0.993
Industry	0.030	0.273	0.912	1.031
Construction	-0.323	0.286	0.258	0.724
Trade	0.035	0.225	0.877	1.035
Constant	-5.519 (***)	0.764	0.000	0.004
Goodness of fit				
-2 Log likelihood		819.237		
Chi-square		276.879 (***)		
Nagelkerke R Square		0.392		
% correct predictions		73.8		

Number of valid observations = 802. S.E. = Standard Error. (*) Statistically-significant at the 0.10 level. (**) Statistically-significant at the 0.05 level. (***) Statistically-significant at the 0.01 level. Cut-off point = 0.40.

The results regarding process innovation are presented in Table 3.4. In this case, there are no variables within the technological dimension that have a statistically significant effect on digital process innovation. With respect to the human capital dimension, only the presence of technical staff with ICT expertise and the use of external ICT consultancy displays positive statistically significant effects on process innovation. Nevertheless, it seems that organisational/relational factors have a significant impact on digital process innovation. The present occurrence demonstrates that the growth ambition of the organisation yields a significant positive effect (that was not present in the results for digital product innovation). Moreover, similar to what was observed with digital product innovations, the presence of a digital strategy has a significant positive impact on digital process innovations. It is important to

note that SMEs where the responsibility for digital transformation lies solely with the entrepreneur/management are less likely to implement digital process innovations. This phenomenon may be attributed to the need, particularly in the context of process innovations, for a systematic and deliberate implementation that is linked to a more natural approach to digitalisation, rather than relying only on the personal drive of the entrepreneur/manager. Finally, collaboration with suppliers has a significant positive impact on process innovation, similar to product innovation. However, in the context of process innovation, cooperating with universities and R&D centres does not have a significant impact.

The combined analysis of the findings for digital product and process innovations strongly confirms hypotheses H5, H6, H9, and H12. The findings provide support for hypotheses H1 and H11 specifically concerning digital product innovations, and hypotheses H8 and H10 specifically in relation to digital process innovation. However, the findings provided permit us to reject hypotheses H2, H3, H4, and H7.

Overall, the study reveals that the technology dimension is not the primary impediment to attempting the digital transformation of SMEs in Spain. This aligns with the findings of Tabrizi et al. (2019) that emphasise the notion that digital transformation does not just revolve around technology. While the majority of SMEs have the required basic digital technology, they could encounter challenges in terms of human capital and organisational/relational limitations when it comes to effectively integrating digital technologies into their businesses. Concerning human capital, the findings indicate that the formal educational backgrounds of the entrepreneur/manager and the staff members are not as significant as their digital skills. External sources of knowledge from suppliers, universities, and research centres are considered crucial factors since they have the ability to compensate for, complement, and multiply internal digital competencies. Finally, SMEs that adopt a formal and well-defined approach to digital transformation, including a clear digital strategy and explicit distribution of digitalisation responsibilities, are observed to make more significant progress in their journey towards digital transformation. Based on this finding, independent and spontaneous initiatives toward digital transformation are considered a limited and ineffective approach that often leads to unsatisfactory outcomes within many SMEs. Additionally, it is important to mention that public activities aimed at promoting digital awareness and providing digital training appear not to have any impact on digital innovation in SMEs. According to Meier et al. (2022), this suggests that these initiatives require to be customised to the specific conditions of the company in order to achieve desired results.

Table 3.4

Logistic regression. Digital process innovation

	β	S.E.	p-value	Exp(β)
Technological dimension				
Entrep_Internet	0.119	0.119	0.318	1.126
Emp_Internet	0.004	0.003	0.196	1.004
Internet_connec	-0.138	0.112	0.217	0.871
Human capital dimension				
Entrep_edu	-0.188	0.214	0.381	0.829
Emplo_edu	0.004	0.003	0.172	1.004
Techn_TIC	0.443 (**)	0.190	0.019	1.558
ICT_train	0.295	0.185	0.111	1.343
ICT_consu	0.640 (***)	0.192	0.001	1.897
Publ_train	0.398	0.278	0.152	1.489
Organizational/relational dimension				
Growth_amb	0.165 (***)	0.061	0.007	1.179
Dig_strategy	0.628 (***)	0.208	0.003	1.873
Entr_dig_head	-0.412 (**)	0.174	0.018	0.662
Staff_dig_mot	-0.055	0.098	0.571	0.946
Coop_suppl	0.161 (***)	0.054	0.003	1.175
Coop_univ	0.108	0.087	0.214	1.114
Control variables				
Employees	-0.004	0.004	0.261	0.996
Industry	0.249	0.256	0.331	1.283
Construction	-0.026	0.274	0.924	0.974
Trade	0.158	0.217	0.464	1.172
Constant	-2.809 (***)	0.611	0.000	0.060
Goodness of fit				
-2 Log likelihood		883.481		
Chi-square		173.760		
Nagelkerke R Square		0.266		
% correct predictions		71.3		

Number of valid observations = 802. S.E. = Standard Error. (*) Statistically-significant at the 0.10 level. (**) Statistically- significant at the 0.05 level. (***) Statistically-significant at the 0.01 level. Cut-off point = 0.40.

It is valuable to separately examine the factors influencing digital innovation in microenterprises versus larger SMEs with 10 or more employees. Table 3.5 highlights key differences in digital product innovation between these groups. For microenterprises, training initiatives and staff motivation related to digitalisation do not significantly influence digital product innovation, unlike in larger SMEs. Similarly, the influence of ICT expertise and consultancy is weaker in microenterprises. In contrast, growth ambition strongly drives digital product innovation in SMEs with at least 10 employees, while the effect of digital strategy diminishes. Notably, partnerships with universities and research institutions play a more significant role in fostering digital product innovation in microenterprises than in their larger counterparts.

Table 3.5

Logistic regression. Digital product innovation by size groups within SMEs

	Microenterprises				Small and medium-sized enterprises (with 10 employees or more)			
	β	S.E.	p-value	Exp(β)	β	S.E.	p-value	Exp(β)
Technological dimension								
Entrep_Internet	0.513(**)	0.216	0.017	1.671	0.573(***)	0.201	0.004	1.774
Emp_Internet	0.003	0.005	0.534	1.003	0.004	0.004	0.321	1.004
Internet_connec	-0.016	0.152	0.915	0.984	0.161	0.169	0.341	1.174
Human capital dimension								
Entrep_edu	0.203	0.338	0.548	1.225	-0.141	0.311	0.649	0.868
Emplo_edu	-0.003	0.004	0.427	0.997	0.002	0.005	0.638	1.002
Techn_TIC	0.604(*)	0.349	0.083	1.830	0.991(***)	0.262	0.001	2.695
ICT_train	-0.060	0.300	0.841	0.941	0.726(***)	0.265	0.006	2.066
ICT_consu	0.494(*)	0.269	0.066	1.639	1.058(***)	0.319	0.001	2.880
Publ_train	0.670	0.552	0.225	1.955	0.414	0.388	0.285	1.513
Organizational/relational dimension								
Growth_amb	-0.080	0.094	0.394	0.923	0.293(***)	0.099	0.003	1.340
Dig_strategy	1.556(***)	0.305	0.001	4.738	0.169	0.328	0.607	1.184
Entr_dig_head	0.158	0.269	0.557	1.171	-0.150	0.269	0.576	0.860
Staff_dig_mot	0.135	0.139	0.332	1.145	0.307(*)	0.164	0.062	1.359
Coop_suppl	0.165(*)	0.092	0.074	1.179	0.167(**)	0.079	0.034	1.182
Coop_univ	0.774(***)	0.289	0.007	2.168	0.242(*)	0.142	0.090	1.273
Control variables								
Employees	-0.008	0.062	0.904	0.993	-0.007	0.005	0.131	0.993
Industry	0.639	0.486	0.188	1.895	-0.228	0.353	0.518	0.796
Construction	-0.320	0.441	0.468	0.726	-0.306	0.405	0.450	0.736
Trade	0.347	0.311	0.264	1.415	-0.407	0.360	0.259	0.666
Constant	-5.037(***)	1.170	0.001	0.006	-6.585(***)	1.138	0.001	0.001
Goodness of fit								
-2 Log likelihood	375.956				409.733			
Chi-square	131.125 (***)				174.679 (***)			
Nagelkerke R Square	0.397				0.452			
% correct predictions	73.1				75.4			
Nº valid observations	379				423			

S.E. = Standard Error. (*) Statistically-significant at the 0.10 level. (**) Statistically-significant at the 0.05 level. (***) Statistically-significant at the 0.01 level. Cut-off point = 0.40.

Table 3.6 highlights differences in the factors driving digital process innovation in microenterprises versus larger SMEs. For microenterprises, the digital habits and educational backgrounds of entrepreneurs or managers are crucial. Entrepreneurs who frequently use the Internet and lack formal higher education are more likely to drive digital process innovation. This may stem from their focus on practical, immediate solutions tailored to business needs, leveraging the accessibility and simplicity of digital tools. Alternative learning methods, such as online courses or hands-on training, often equip them with practical digital skills aligned with their business objectives.

Microenterprises also benefit from a higher percentage of educated staff and participation in public initiatives supporting digitalisation. Cooperation with suppliers significantly boosts process digital innovation, but access to ICT experts and consultants does not play a major role, unlike in larger SMEs.

Table 3.6

Logistic regression. Digital process innovation by size groups within SMEs

	Microenterprises				Small and medium-sized enterprises (with 10 employees or more)			
	β	S.E.	p-value	Exp(β)	β	S.E.	p-value	Exp(β)
Technological dimension								
Entrep_Internet	0.633(***)	0.222	0.004	1.184	-0.227	0.157	0.149	0.797
Emp_Internet	0.002	0.005	0.760	1.002	0.007	0.004	0.105	1.007
Internet_connec	-0.157	0.170	0.356	0.854	-0.074	0.154	0.631	0.929
Human capital dimension								
Entrep_edu	-0.780(**)	0.346	0.024	0.458	0.246	0.294	0.403	1.279
Emplo_edu	0.007(*)	0.004	0.096	1.007	0.001	0.004	0.792	1.001
Techn_TIC	0.517	0.341	0.129	1.677	0.429(*)	0.246	0.080	1.536
ICT_train	0.182	0.301	0.547	1.199	0.245	0.252	0.331	1.277
ICT_consu	0.407	0.274	0.138	1.502	0.984(***)	0.300	0.001	2.675
Publ_train	1.263(**)	0.527	0.017	3.534	-0.095	0.341	0.781	0.910
Organizational/relational dimension								
Growth_amb	0.036	0.094	0.699	1.037	0.296(***)	0.092	0.001	1.344
Dig_strategy	0.455	0.309	0.141	1.576	0.834(***)	0.310	0.007	2.303
Entr_dig_head	-0.255	0.268	0.343	0.775	-0.600(**)	0.255	0.019	0.549
Staff_dig_mot	0.184	0.147	0.210	1.202	-0.265(*)	0.149	0.076	0.767
Coop_suppl	0.239(***)	0.092	0.009	1.270	0.117(*)	0.070	0.094	1.124
Coop_univ	0.281	0.201	0.163	1.324	0.071	0.100	0.476	1.074
Control variables								
Employees	0.088	0.064	0.172	1.091	-0.005	0.004	0.272	0.995
Industry	-0.385	0.554	0.487	0.680	0.305	0.312	0.329	1.356
Construction	0.230	0.423	0.587	1.259	-0.056	0.383	0.884	0.946
Trade	0.356	0.316	0.259	1.428	-0.032	0.328	0.923	0.969
Constant	-5.488(***)	1.196	0.001	0.004	-1.625(**)	0.827	0.049	0.197
Goodness of fit								
-2 Log likelihood	367.589				474.962			
Chi-square	110.135 (***)				98.072 (***)			
Nagelkerke R Square	0.352				0.279			
% correct predictions	75.5				69.3			
Nº valid observations	379				423			

S.E. = Standard Error. (*) Statistically-significant at the 0.10 level. (**) Statistically-significant at the 0.05 level. (***) Statistically-significant at the 0.01 level. Cut-off point = 0.40.

For SMEs with at least ten employees, the leadership style of entrepreneurs/managers negatively impacts digital process innovation. This reflects the need for decentralized, structured approaches to digitalisation in more

complex organizations. Growth ambition and a formal digital strategy are significant drivers in these larger SMEs, while staff motivation toward digitalisation can have a marginally negative effect, indicating potential resistance or dissatisfaction that must be managed.

Overall, microenterprises benefit from simpler approaches to digital innovation, relying on external collaborations with suppliers, universities, and research centres to offset resource constraints. Larger SMEs, in contrast, pursue more sophisticated digital innovation strategies, utilizing ICT expertise, consultancy services, and structured internal training. These firms also require robust management practices to navigate the complexities of digital transformation effectively.

3.5 Discussion and Conclusion

This study delves into the realm of digital transformation within SMEs, considering it as an innovative process. The primary objective is to address a significant research gap by comprehensively examining the drivers and barriers to digitalisation in SMEs from a holistic perspective. Moreover, the study aims to integrate factors that have received substantial attention in the literature with those that have been largely overlooked. In order to address this, a proposed theoretical framework delineates three dimensions of enablers - technological, human capital, and organisational/relational - across three levels of analysis: the individual entrepreneur/manager, the company, and the business environment. This particular framework is purposely designed to accommodate the distinctive characteristics of SMEs while acknowledging the specific impediments and constraints that impact their digital transformation processes. Consequently, the conducted research yields a comprehensive understanding of the fundamental nature and determinants propelling digitalisation in SMEs, thus contributing a valuable complement to prevailing research predominantly centred on digitalisation in larger firms. Moreover, this study makes a significant contribution to the existing body of literature that individually investigates digital innovations in both products and processes, in addition, it demonstrates their determinants differ to some extent for microenterprises and the rest of SMEs.

The analysis offers compelling empirical evidence on a relatively unexplored subject utilising a representative sample of Spanish SMEs. The proposed holistic approach sets it apart from other research that concentrates on specific determinants of digitalisation, which may yield deceptive results due to bias linked with omitted variables. Concerning the technological dimension, the findings demonstrate that the level of complexity in entrepreneurs'/managers' use of

the Internet has a considerable positive impact on the implementation of digital product innovations. In the domain of the human capital dimension, the presence of technical personnel with extensive ICT experience, external technical evaluation by ICT consultants, and the implementation of training programs oriented towards digitalisation within the company are noted to exert a substantial influence on digital innovation. In the context of SMEs' digital transformation, a blend of internal and external competencies emerges as pivotal. Within the organisational/relational domain, the explicit formulation of a digitalisation strategy stands out as a fundamental determinant contributing to the favourable outcome of digital innovation initiatives. Furthermore, it is imperative to note that the direct implementation of this strategy should not be within the purview of the entrepreneur/manager. Rather, it should be delegated to a specific department or individual, or alternatively, maybe a shared responsibility across multiple departments or personnel. Collaboration with suppliers, as well as universities and technological centres, represents indispensable facilitators for digital innovations within SMEs. Lastly, an entrepreneurial orientation, coupled with a strong drive for growth, has been evidenced to exert a positive influence on the advancement of innovation in the organisation's production processes through the adoption of digitalisation.

The analysis reveals notable differences in how various factors influence digital innovation in microenterprises compared to larger SMEs. Microenterprises tend to adopt a more straightforward approach, heavily influenced by the personal traits of their entrepreneurs or managers while relying less on intricate knowledge resources. When specialized expertise is necessary, they turn to external partnerships with suppliers, universities, and research institutions to fill the gap. Conversely, other SMEs deal with greater complexity in their digital innovation efforts. These organizations require more specialized knowledge, deeper staff engagement, and a more structured, professional approach to managing digital transformation.

These findings emphasise that the obstacle hindering SMEs in their digitalisation initiatives is not primarily technological. The essential technological resources necessary for digitalising such businesses are already within reach. Thus, it is the human capital and organisational/relational aspects that predominantly shape the approach of SMEs to their digital transformation. On the one hand, the company's ability to integrate digital technologies into its products and processes in an innovative manner is directly contingent upon the availability of digital skills within the organisation. These skills dictate the company's capacity to assimilate novel digital knowledge and transform it into innovative digital products and processes. On the other hand, organisational/relational factors are essential for driving

digital innovation within SMEs. In the context of an internal perspective, the findings of this study underscore that a spontaneous and unplanned approach to digitalisation, solely driven by the personal initiative of the entrepreneur/manager, is not the optimal strategy for SMEs. Oppositely, in order to effectively interpret their efforts into product and process innovations, SMEs must institute a formalised, strategically designed, and planned approach to their digital transformation. It is imperative that SMEs cultivate an open innovation approach to digital transformation by adeptly managing their associations with various entities such as ICT consultants, suppliers, universities, and research centres. This will enable them to surmount the constraints imposed by their scale. Additionally, the findings outlined in this paper propose that SMEs must modify their organisational capabilities in tandem with their growth trajectory to accommodate the enhanced complexity of the digital innovation process. The results of this paper indicate that SMEs must evolve their organisational capabilities as they grow to effectively manage the increasing complexity of the digital innovation process.

The outcomes of this study carry significant implications for management and public policy. Our results underscore the critical role of investing in human capital and training as a vital component of any strategy to tackle the digital transformation challenge faced by SMEs. Public administration could advance this goal by incentivising training initiatives sought by SMEs and by facilitating their access to ICT consulting services, rather than conducting training programs directly. The findings presented in this study underscore the significance of interaction and collaboration within digital ecosystems. SMEs should actively contribute to the establishment of these networks and integrate themselves within existing structures. Public administration, in a similar vein, can serve as a catalyst for the construction and advancement of digital ecosystems that facilitate the successful participation of SMEs. Furthermore, focusing on the limitation of the paper, due to the period of data as it refers to the Covid phase, which undermines the possibility of generalising results to the non-Covid periods. Regarding future study suggestions, it could be interesting to employ Encuesta sobre Estrategias Empresariales (ESEE) and Technological Innovation Panel (PITEC) databases for the same type of analysis.

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Chapter 4

Addressing Challenges and Catalysts for E-Commerce Adoption in SMEs

Abstract

The study discusses and examines the internal and external factors influencing the adoption of e-commerce technologies within SMEs. The study employs the theoretical Technological, Organisational and Environmental (TOE) model, which comprehensively integrates the technological, organisational, and environmental dimensions affecting e-commerce integration within SMEs. The study employs the binary logistic regression model to examine the postulated hypotheses. The findings indicate that, within the technological dimension, the constraint of funds/financing exerts a noteworthy negative impact on e-commerce implementation. Additionally, investments in ICT, software, consulting, R&D, and innovation are observed to be notably influential, and constraints in these areas could significantly impede e-commerce adoption. Moreover, deficiencies in digital competencies, sales forecasting, and entrepreneurial motivation relating to personal and professional development are identified as adverse factors affecting SMEs' adoption of e-commerce. Within the environmental dimension, any decline in the status of leading rivalry, collaboration with clients, and competitors is shown to act as an obstacle to e-commerce adoption. The practical and social implications of this study underscore a wide array of managerial considerations. It emphasises the vital role of investing in human capital and education, particularly in training, as a crucial component in addressing impediments to SMEs' e-commerce adoption. The study further articulates the significance of financing, including accessing and availability of funds within the ecosystem. This highlights the need for interaction and collaboration with other stakeholders, advocating for the fostering of these networks and their integration into existing organisational structures of SMEs.

Keywords: SMEs, E-commerce, Challenges, Obstacles, Enablers

4.1. Introduction

The contemporary surge of e-commerce has precipitated a fundamental shift in global market dynamics. This progressive framework, underpinned by technological innovations, has heralded a new paradigm in commerce, prompting companies to exploit online marketplaces for sustained competitiveness. E-commerce, denoting the process of acquiring and trading goods or services via the Internet (Turban et al., 2000), represents a transformative platform fostering international competitive dynamics and facilitating business development (Ha, 2020; Susanty et al., 2020). Notably, technological innovations and the proliferation of user-friendly e-commerce platforms have facilitated the establishment of a digital presence for SMEs. E-commerce offers SMEs unparalleled access to a global market while minimising operational expenses. However, SMEs have not kept pace with larger enterprises in adopting e-commerce (Alam et al., 2011; Govindaraju et al., 2015) primarily due to resource constraints and the substantial costs associated with digital technology adoption (Scupola, 2009). Data from 2020 demonstrates significant disparities in e-commerce engagement among companies in Spain based on size, with only 10.10% of microenterprises, 25.16% of small companies (10-50 employees), and 33.91% of medium-sized companies (50-249 employees) involved in e-commerce, compared to 44.89% of large enterprises (250 and more employees) (Instituto Nacional de Estadística, 2021). This underlines the influential role of company size in determining e-commerce adoption. Further research is imperative to identify specific obstacles impeding SMEs from embracing e-commerce, which will inform tailored policy initiatives designed to enable their participation in this essential distribution channel.

This paper intends to examine the factors impacting the implementation of e-commerce in SMEs, but in the literature, there are diverse theoretical frameworks such as the Technological Acceptance Model (TAM) (Rauniar et al., 2014), the Theory of Planned Behavior (TPB) (Cheng, 2019), and the Theory of Reasoned Action (TRA) (Vallerand et al., 1992). Previous literature underscores three principal concerns influencing SMEs' obstacles in adopting and utilising e-commerce: limited achievements, inadequate e-commerce awareness, and its business impact (Salwani et al., 2009; Akram et al., 2019; Saridakis et al., 2019). Addressing these concerns is pivotal to encouraging broader e-commerce adoption among SMEs.

Opposite to prior works, the approach to this matter is based on the Technological, Organisational, and Environmental (TOE) model, with specific weight on the environmental dimension. This work recognises the critical need for engagement with other ecosystem stakeholders. Rather than predominately emphasising technological determinants,

this research highlights the importance of the environmental dimension. The paper emphasises the vital significance of interaction and collaboration with other stakeholders within this framework.

Moreover, prior literature has been mainly qualitative, lacking sufficient quantitative evidence. This study has relied on a comprehensive dataset of 802 SMEs, drawn from a representative survey of the SME sector in Spain. Using a stratified sampling method, the data is divided into two groups: microenterprises (fewer than 10 employees) and larger SMEs (10 or more employees). This robust dataset provides a solid foundation for testing the study's hypotheses. Logistic regression modelling is employed as the primary econometric method for analysis.

The outcomes of this paper hold significant implications for business management in SMEs by emphasising the importance of digital skills, business cooperation, and strategic actions for e-commerce adoption by SMEs. It is imperative for SMEs to actively cultivate connections with business partners and push themselves within professional networks. Furthermore, our findings indicate that assuming a leading role in competitive activities and fostering entrepreneurial stimulus for personal and professional growth positively impacts e-commerce implementation. Similarly, the findings underscore the necessity of expanding financial resources as an essential element of any strategy aimed at addressing the challenges of e-commerce adoption. Additionally, it is crucial for SMEs to partake in research and development initiatives and innovation, which correlates directly with investments in ICT, software, and consultancy, thus facilitating e-commerce adoption. This connection is also pertinent to the financial aspect. Moreover, the paper demonstrates the differences in the importance of the determinants of e-commerce adoption for microenterprises and other SMEs.

The paper is structured as follows: Section 4.2 presents the theoretical foundation, literature review and research hypotheses, Section 4.3 details data collection and techniques, and Section 4.4 presents and discusses the results. Finally, the chapter concludes with a section that reviews the principal outcomes and presents various management and policy implications.

4.2. Literature review

4.2.1 Theoretical Background

Based on prior research, there has been a thorough investigation into the emergence and adoption of e-commerce (Nogoev et al., 2011; Akram et al., 2019). It is widely recognised that e-commerce technology presents several tangible prospects and benefits by facilitating closer connections between firms and their customers, moreover, saving time, lowering costs, and boosting revenue (Al-Qirim, 2007; Saridakis et al., 2019). The prevailing literature has identified key benefits, encompassing enhanced cost-effectiveness, intensified sales, improved performance, advanced processing, larger market occurrence, and elevated customer satisfaction (Turban, 2010). In summary, technological advancements have a substantial and direct influence on the operational, commercial, and organisational effectiveness of SMEs, with e-commerce serving as a crucial determinant for SMEs to attain a competitive advantage (Ledwaba et al., 2019).

The shift from traditional trade to digital platforms presents a considerable challenge to SMEs (Wang et al., 2011) owing to the intensified competition in the digital sphere. Concerning this circumstance, there is more difficulty and pressure than traditional trade (Zhu, 2004). Remarkably, large enterprises have taken the lead in e-commerce advancement, while SMEs have been slow to embrace this technology (Van Akkeren et al., 2003; Alam et al., 2011; Govindaraju et al., 2015) due to resource constraints and the substantial costs associated with the adoption of digital technologies (Scupola, 2009). Thus, the availability of resources is crucial in the implementation of digital technologies (Abebe, 2014).

Furthermore, beyond the significance of e-commerce adoption, several factors have been identified as potential obstacles. The literature has underscored the responsibility of government (Raed et al., 2021), the tech understanding of entrepreneurs/managers (Zheng et al., 2004), their management proficiency and knowledge (Chuang et al., 2007), confidence in e-commerce channels (Inna and Murat, 2023), inadequate financial resources (Scupola, 2009), and the level of technological readiness (Alam et al., 2011; Abou-Shouk et al., 2016).

E-commerce holds increasing significance for firms, with online channels providing avenues for new opportunities, cost efficiencies, and heightened competitive positioning within the market (Lefebvre, 2005; Al-Qirim, 2007; Saridakis et al., 2019). At the organisational level, extant literature underscores the pivotal role of technological

readiness in small firms, significantly impacting their adoption of e-commerce (Abou-Shouk et al., 2016). Furthermore, the literature emphasises the adverse impact of constrained financial resources on this adoption process (Scupola, 2009; Saridakis et al., 2019). On an individual basis, scholarly research highlights the influential role of managerial expertise (Chuang et al., 2007) and technological knowledge (Zheng et al., 2004) in driving the implementation of e-commerce technologies.

Amid the Covid pandemic, global e-commerce surged by 19%, marking a transformative shift in the commercial landscape (Statista, 2022a). This essential change has underscored the imperative for SMEs to embrace novel technologies to maintain their competitive edge (Winarsih et al., 2020). Thus, it is evident that the pandemic has engendered innovative prospects in e-commerce, which SMEs should duly recognise.

Predominantly, existing literature has concentrated on the technological factors of e-commerce in SMEs, particularly focusing on the firm's resources in this realm (Scupola, 2009; Abebe, 2014; Saridakis et al., 2019). Nevertheless, alongside the technological dimension, the study assesses the organisational and environmental dimensions. In contrast to prior studies, our analysis accords significance to the environmental dimension, accentuating the importance of fostering interaction and collaboration with other actors.

4.2.2 Research Framework

Concerning the prior literature on e-commerce, various models have been precisely examined and applied including the Theory of Planned Behavior (TPB) (Cheng, 2019), the Theory of Reasoned Action (TRA) (Vallerand et al., 1992), Technological Acceptance (TAM) (Rauniar et al., 2014), and the Technological, Organisational, and Environmental Framework (TOE). We have picked the TOE model (see Fig. 1 below) as the theoretical basis for our study, primarily due to its comprehensive examination of technical, organisational, and environmental factors. This framework with multiple characteristics is widely acknowledged for its heightened analytical efficacy compared to frameworks with a single aspect (Molla and Licker, 2005) and is esteemed for its dynamic perspective, which postulates that changes within an enterprise are directed not only by individuals of the company but also by the company's characteristics (Hameed et al., 2012). Previously, the TOE framework contributed to investigating the moderating influence of entrepreneurial orientation (EO) on the relationship between technological, organisational, and environmental

variables and e-commerce implementation in micro-enterprises (Li et al., 2022). Apart from its positive attributes, the TOE model has been critiqued for its oversight of the individual characteristics of entrepreneurs, managers, and employees (Ghobakhloo & Tang, 2013).

4.2.3 Research hypotheses

This section presents the hypotheses that will undergo testing in the empirical part of this study delineated and categorised in accordance with the research framework proposed in Section 2.2 (Figure 1). Specifically, these hypotheses are grouped into three principal dimensions: technological, organisational, and environmental.

A. Technological Dimension

The technological dimension encompasses an assembly of technologies, resources, expenses and compatibility that exert a profound impact on the implementation of e-commerce. The role of financing and the scarcity of funds in this process is highly substantial, as any limitations in financial resources may prompt SMEs to exercise warning in their investment and capital use. Financial limitations are identified as a main obstacle (Scupola, 2009; Saridakis et al., 2019).

Furthermore, the firm’s innovation is characterised by a practical approach to research and development (R&D) and innovation which performs a pivotal position in driving e-commerce implementation among SMEs (Sitong et al., 2010; Ciampi et al., 2021). Enterprises with greater attention to innovativeness are more predisposed to generate new or improved products and demonstrate a heightened motivation to promote them internationally on online platforms.

Contrariwise, SMEs may recognise the essential of investing in ICT, software solutions, and consulting services to enable the advancement of their e-commerce processes (Matlay et al., 2003; Yadiati et al., 2019). In this regard, it highlights the critical importance of technological resources in effectively employing online selling procedures.

Moreover, previous studies have emphasised the vital benefits of reliable Internet connectivity (Belloc et al., 2012; Falch and Henten, 2018). Broadband internet usage has the potential to develop SMEs' efficiency and transform their implementation of e-commerce strategies (Haller and Lyons, 2015). Thus, problems pertaining to Internet connectivity

have been recognised as a momentous issue in the success of e-commerce initiatives (Prieger, 2013). In light of these considerations, the following hypotheses are proposed concerning the technological dimension of e-commerce adoption:

H1: A lack of funds impedes the adoption of e-commerce by SMEs.

H2: Challenges in accessing a proper Internet connection (stable, with sufficient capacity and reasonable cost) impede the adoption of e-commerce by SMEs.

H3: Limited innovativeness delays the adoption of e-commerce by SMEs.

H4: Inadequate investment in ICT, software, and consultancy obstructs the adoption of e-commerce by SMEs.

B. Organisational Dimension

The organisational aspect encompasses the firm's attributes that can impact the implementation of e-commerce technologies, including digital competencies, sales and purchase projections, and the aspirations for personal and professional advancement of managers and entrepreneurs. Multiple studies examining e-commerce adoption by SMEs have established a strong correlation between an organisation's digital competencies and its success in adopting and utilising e-commerce platforms (Hong & Zhu, 2006; Saffu et al., 2008). Prior research suggests that successful e-commerce adoption by SMEs hinges not only on digital competencies but also on effective sales forecasting practices (Liu et al., 2019). This is associated with the notion of "knowledge barriers" (Attewell, 1992; Ciampi et al., 2021), where staff knowledge development can significantly encourage new technology implementation. The absence of adequate understanding presents SMEs with substantial risks and challenges in the realm of digitalisation. Enhanced knowledge among managers and entrepreneurs is pivotal in mitigating the inherent obscurity linked with the adoption of new technology, thereby diminishing the risk involved (Caldeira & Ward, 2003; Cioppi et al., 2003; Veglio et al., 2020). In this context, the managerial proficiency and entrepreneurial expertise in management (Chuang et al., 2007) and their technological understanding (Zheng et al., 2004) are pivotal in driving the implementation of this technology.

In this context, the following hypotheses are advanced with respect to the organisational dimension of e-commerce acceptance:

H5: Limited digital competencies significantly hinder the adoption of e-commerce by SMEs.

H6: The lack of sales and purchase forecasts adversely affects the adoption of e-commerce by SMEs.

H7: Low motivations of managers/entrepreneurs for personal and professional development adversely affect the implementation of e-commerce by SMEs.

C. Environmental Dimension

The achievement of e-commerce implementation is heavily influenced by the external environment. Factors such as cooperation with customers and competitors, as well as the pressure from competitors, play a crucial role. The intensity of competition within an industry, often referred to as competitor pressure, significantly influences e-commerce adoption. Firms operating in highly competitive environments are more likely to embrace e-commerce as it expands their marketing reach and creates an additional channel for promoting their products (Zhu and Kraemer, 2005). Moreover, collaboration within a business ecosystem, including suppliers, clients, and competitors, can significantly boost the implementation of new technologies for SMEs (Romero and Martínez-Román, 2015; Sussan et al., 2017).

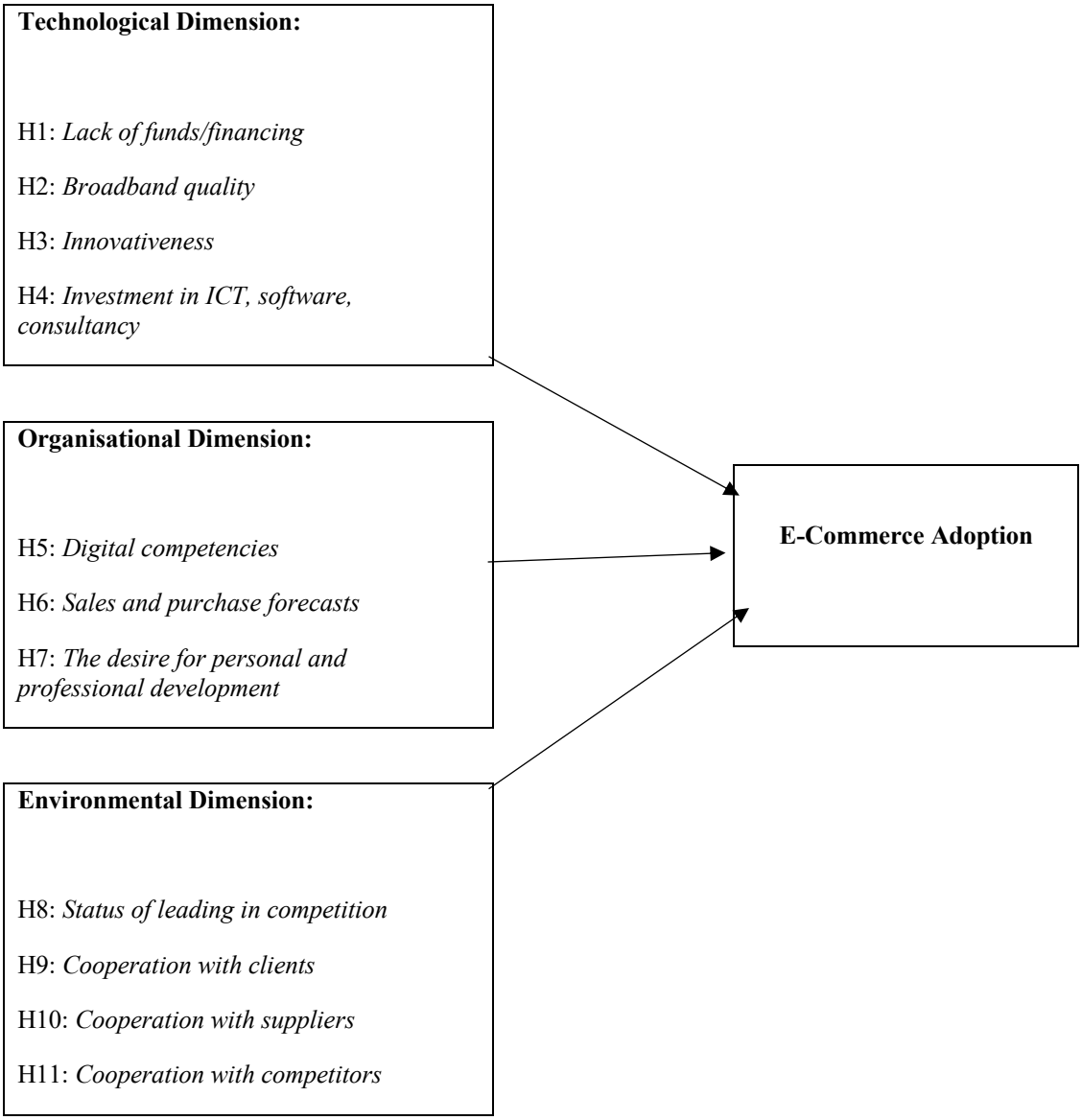
H8: A decreased level in the status of leading in competition adversely affects the adoption of e-commerce by SMEs.

H9: A lack of collaboration with clients obstructs e-commerce implementation in SMEs.

H10: A lack of collaboration with suppliers obstructs e-commerce implementation in SMEs

H11: A lack of collaboration with competitors obstructs e-commerce implementation in SMEs.

Figure 4.1. Research Framework



Source: authors' contribution

4.3. Data and Methodology

4.3.1 Data and variables

The data for this research was obtained from the survey detailed in the previous chapter, conducted during the second quarter of 2022 among Spanish SMEs with employee counts ranging from 1 to 200. The final dataset used in this analysis includes 802 valid observations, comprising 379 microenterprises and 423 SMEs with 10 or more employees.

A. Dependent Variable

The dependent variable under consideration in this paper is the following:

- E-commerce adoption. This variable serves as a binary indicator that assesses whether the company engages in the sale of goods or services through web or mobile applications, or not.

B. Explanatory Variables

The explanatory variables under consideration in this paper are the following:

i) Technological dimension

- Lack of funds/financing. Entrepreneurs and managers were asked to assess the significance of financial limitations as a barrier to the digitalisation of their enterprises. Their responses were categorised as an ordinal variable ranging from 0 to 3, where 0 denotes no impact and 3 corresponds to considerable impact.
- Broadband quality. The managers were surveyed about their "experience difficulty in attaining a proper Internet connection". Subsequently, their responses were converted into an ordinal variable, ranging from 0 to 3, wherein 0 denoted minimal and 3 significant.
- Innovativeness. The entrepreneurs and managers who were the subjects of the interviews were questioned about the extent to which their respective firms prioritise research and development (R&D) and innovation. Subsequently, their responses were coded as an ordinal variable, utilising a scale ranging from 1 to 5, where 1 denotes minimal and 5 indicates a high level.
- Investment in ICT, software, and consultancy. The entrepreneurs/managers questioned were tasked with estimating the percentage of total expenditure on information and communication technologies (more

precisely, computers and PC equipment, electronic components, other ICT goods and components), software and services, as well as ICT consulting, regarding the entire budget during the given period, 2019-21.

ii) Organisational Dimension

- Digital Competencies. This variable constitutes a vital tool for assessing digital skills within a business framework. It includes ten pivotal competencies, incorporating those pertinent to email utilisation, operation of printing and scanning devices, expertise in fundamental office software, management of digital certificates, adeptness in social media application, cloud system navigation, familiarity with financial institution platforms, electronic billing expertise, knowledge in marketing analytics tools, and comprehensive presidency of business procedures across computerised ERP systems. The scale ranges from 0 to 10, effectively reflecting the level of digital competence.
- Sales and purchases forecasts. During the interviews, entrepreneurs and managers were asked about their company's practice of periodically forecasting sales, collections, purchases, and payments. This binary variable denotes a value of 1 if the company engages in forecasting and 0 if not.
- The desire for personal and professional development. This variable serves to demonstrate the extent to which the individuals who were interviewed embarked on entrepreneurial endeavours driven by personal or professional advancement. Responses were recorded as an ordinal variable on a Likert scale ranging from 1 to 5, allowing for a comprehensive evaluation where 5 reflects complete agreement and 1 indicates complete disagreement.
- Escape unemployment, insecurity, and job insecurity. This variable assesses the extent to which the individuals interviewed decided to become entrepreneurs out of necessity. The responses were coded on a Likert scale ranging from 1 to 5 as an ordinal variable, with 5 denoting complete agreement and 1 representing complete disagreement.
- Risk-taking propensity. The entrepreneurs and managers who were interviewed were questioned about their business's willingness to undertake high-risk missions that could potentially yield significant returns. Their responses were coded using a Likert scale as an ordinal variable, on a scale from 1 to 5, where 5 represented full agreement and 1 represented complete disagreement.

iii) Environmental Dimension

- Status of leading in competition. The entrepreneurs and managers who were interviewed were tasked with expressing their level of concurrence with the following statement about their enterprise: "In contrast to competitors, it is typically my enterprise that assumes the initiative in implementing actions and takes the lead to which competitors subsequently respond." The responses were categorised as an ordinal variable, ranging from 1 to 5, with 5 representing complete agreement and 1 indicating complete disagreement.
- Cooperation with clients. This variable represents the degree of collaboration with clients in areas pertaining to digitalisation. It is a binary variable, denoted by a value of 1 for companies engaged in client collaboration and 0 for those that are not.
- Cooperation with suppliers. This variable captures the existence of collaboration with suppliers in areas pertaining to digitalisation. It is a binary variable, denoted by a value of 1 for companies engaged in collaboration with suppliers and 0 for those that are not.
- Cooperation with competitors. This variable captures the existence of collaboration with competitors in areas pertaining to digitalisation. It is a binary variable, denoted by a value of 1 for companies engaged in collaboration with competitors and 0 for those that are not.
- Difficulties in finding cooperation partners, advisors, or suppliers. The entrepreneurs and managers who participated in the interviews were questioned regarding the significance of "challenges in finding cooperation partners, advisors, or suppliers" in impeding the digitalisation of their enterprises. Their responses were categorised as an ordinal variable, ranging from 0 to 3, with 0 denoting no and 3 indicating a high level.
- Lack of customer demand/interest. The interviewed managers were questioned about the significance of the "lack of demand/interest from customers" as a barrier to the digitalisation of their respective firms. Their responses were categorised as an ordinal variable, ranging from 0 to 3, with 0 denoting none and 3 signifying high.

C. Control Variables

The estimated models encompass a set of control variables that accurately pinpoint the impact of the main explanatory variables.

- Firm size (employees). The analysis incorporates the size of the firm, measured by the number of workers.

- Sectorial dummies: SMEs within the sample were classified into 4 sectors: industry (manufacturing, water, and energy), construction, trade, and services (recognised as the fundamental category in the model).

A number of the variables mentioned above were derived from questions included in our survey, originating from the questionnaire utilised by the National Institute of Statistics of Spain in their Survey of Information and Communication Technology and Electronic Commerce Usage in Companies (Instituto Nacional de Estadística, 2021).

In relation to the innovativeness, risk-taking, and proactivity variables, the questions employed have been modified from the instrument developed by Covin and Slevin (1989) for evaluating a company's entrepreneurial orientation. Furthermore, several other variables have been implemented in line with prior research (Martínez-Román and Romero, 2017; Fernández-Serrano et al., 2019; Martín-Martín et al., 2022). Table 4.1 illustrates descriptive indicators of our dataset.

Table 4.1 illustrates descriptive statistics but also separately for microenterprises and other SMEs. As can be observed microenterprises have a higher proportion of investment in ICT, software and consultancy. However, they experience fewer digital skills within their business, moreover, they are less risk taker than the other SMEs. Furthermore, microenterprises are less active in terms of collaboration with other actors such as clients, suppliers and competitors.

Table 4.1

Descriptive statistics

	All SMEs				Microenterprises		Small and medium-sized companies	
Variable	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Mean	Std. Dev.
Technological dimension								
Luck of fund and financing	1.026	1.141	0	3	1.080	1.203	0.980	1.082
Broadband quality	0.417	0.787	0	3	0.430	0.818	0.410	0.760
Innovativeness	3.488	1.288	1	5	3.430	1.321	3.530	1.260
Investment in ICT, software, consultancy	11.333	16.626	0	100	11.772	17.752	10.923	15.513
Organisational dimension								
Digital competencies	7.830	1.940	1	10	7.344	2.010	8.247	1.768
Sales and purchase forecasts	2.879	1.146	1	4	2.550	1.153	3.160	1.062
Risk-taking propensity	2.209	1.219	1	5	2.090	1.237	2.320	1.198
The desire for personal and professional development	3.831	1.380	1	5	3.900	1.404	3.780	1.355
Escape unemployment. insecurity and job insecurity	2.338	1.449	1	5	2.420	1.556	2.260	1.341
Environmental dimension								
Status of leading in competition	3.001	1.250	1	5	2.840	1.295	3.140	1.191
Cooperation with clients	0.247	0.432	0	1	0.211	0.408	0.277	0.448
Cooperation with suppliers	0.283	0.451	0	1	0.255	0.437	0.306	0.461
Cooperation with competitors	0.111	0.314	0	1	0.101	0.302	0.119	0.324
Difficulties in finding cooperation partners, advisors, or suppliers.	0.639	0.918	0	3	0.570	0.917	0.690	0.912
Lack of customer demand/interest	0.891	1.048	0	3	0.910	1.073	0.880	1.028
Control variables								
Firm size	19.310	27.269	1	200	3.973	2.200	32.282	31.650
Industry	0.138	0.345	0	1	0.081	0.273	0.187	0.391
Construction	0.131	0.338	0	1	0.130	0.337	0.132	0.339
Trade	0.209	0.407	0	1	0.250	0.434	0.176	0.381
Services	0.522	0.500	0	1	0.539	0.499	0.504	0.500

Total number of valid observations = 802 (379 microenterprises and 423 SMEs with 10 employees or more).

4.3.2. Econometric methodology

In the present research, the logistic regression approach has been employed to analyse the impact of independent variables on the e-commerce adoption variable. This econometric model is presented as follows:

$$\ln\left(\frac{p}{1-p}\right) = z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k \quad (1)$$

In equation (1), p denotes the probability that $y = 1$, where the e-commerce adoption is represented by y and it alternatively represents the innovation dummies (prod_inn and proc_inn), x_j variables serve as independent (explanatory variables), and β_j denote the regression coefficients $(j = 1...k)$.

The TOE model application yields the probability of a company adopting e-commerce for a specific value of x_j, which is expressed as:

$$p = \frac{\exp\left(\beta_0 + \sum_j \beta_j x_j\right)}{1 + \exp\left(\beta_0 + \sum_j \beta_j x_j\right)} \quad (2)$$

The logistic regression model has been estimated through the utilisation of the maximum likelihood method.

4.4. Results

The findings pertaining to e-commerce adoption are described in Table 4.2. Regarding the technological aspect, inadequate funds and financing have a markedly positive impact on the adoption of e-commerce by SMEs (H1). Similarly, both research and development (R&D) activities and innovation (H3), as well as investments in ICT, software, and consultancy (H4), demonstrate significant and positive effects on e-commerce adoption. Opposite to H1, H3, and H4, the firm's access to a suitable internet connection, as indicated in H2, does not exhibit a significant effect.

Table 4.2. Logistic regression: E-commerce adoption

	β	S.E.	p-value	Exp(β)
Technological dimension				
Lack of funds and financing	0.245 (***)	0.088	0.005	1.277
Broadband quality	0.028	0.119	0.817	1.028
Innovativeness	0.185 (**)	0.081	0.022	1.204
Investment in ICT, software, consultancy	0.012 (**)	0.006	0.039	1.012
Organisational dimension				
Digital competencies	0.174 (***)	0.056	0.002	1.190
Sales and purchases forecasts	0.201 (**)	0.087	0.021	1.223
Risk-taking propensity	-0.064	0.083	0.443	0.938
The desire for personal and professional development	0.147 (**)	0.072	0.041	1.159
Escape unemployment, insecurity and job insecurity	-0.030	0.063	0.633	0.970
Environmental dimension				
Status of leading in competition	0.168 (**)	0.084	0.046	1.183
Cooperation with clients	0.750 (**)	0.295	0.011	2.117
Cooperation with suppliers	-0.402	0.284	0.157	0.669
Cooperation with competitors	0.590 (*)	0.317	0.063	1.803
Difficulties in finding cooperation partners, advisors, or suppliers.	0.315 (***)	0.118	0.008	1.370
Lack of customer demand/interest	-0.092	0.103	0.374	0.912
Control Variables				
Employees	-0.009 (**)	0.004	0.036	0.991
Industry	-0.255	0.280	0.363	0.775
Construction	-0.545 (*)	0.299	0.068	0.580
Trade	0.529 (**)	0.230	0.021	1.697
Constant	-4.612 (***)	0.607	0.000	0.010
Goodness of fit				
-2 Log likelihood		728.186		
Chi-square		144.462		
Nagelkerke R Square		0.268		
% correct predictions		74		

Number of valid observations = 802. S.E. = Standard Error. (*) Statistically-significant at the 0.10 level. (**). Statistically-significant at the 0.05 level. (***) Statistically-significant at the 0.01 level. Cut-off point = 0.50.

In the context of the organisational dimension, the results presented in Table 4.2 provide support for all hypotheses H5, H6, and H7 that were posited. This suggests that any identified constraints related to digital competencies, sales and purchases forecasting, and a deficiency in entrepreneurial motivation correlated with personal and professional development would exert a negative impact on the adoption of e-commerce by SMEs.

Furthermore, concerning the environmental dimension, the statistical significance of leading in competition (H8) underscores the potential impediment to e-commerce adoption in case of a reduction in this factor. Additionally, collaboration with clients (H9) and competitors (H11) is observed to have a positive bearing on the adoption of e-commerce. Conversely, collaboration with suppliers (H10) does not yield a statistically significant effect on e-commerce adoption by SMEs. Furthermore, the lack of customer demand or interest is not determined to be a substantial obstacle to e-commerce adoption.

In addition, it is interesting to observe the factors affecting e-commerce adoption separately for microenterprises and SMEs with 10 employees or more. Table 4.3 provides a comparison of the results for these two size groups. As can be observed, lack of funds and financing significantly impacts e-commerce adoption in other SMEs, while this factor has no significant effect on microenterprises. Similarly, innovativeness and investment in ICT, software, and consultancy are significant drivers of adoption in other SMEs but are not statistically significant for microenterprises.

Digital competencies, however, play an important role in both groups, with a slightly higher impact observed in other SMEs. In contrast, sales and purchases forecasting has a significant effect on adoption in microenterprises, whereas it does not influence other SMEs. Interestingly, the desire for personal and professional development significantly affects adoption in other SMEs but has no notable impact on microenterprises.

When considering environmental factors, cooperation with suppliers, clients and competitors has a substantial and statistically significant influence on e-commerce adoption in other SMEs, particularly cooperation with clients and competitors, which shows the strongest effect. For microenterprises, cooperation difficulties with partners, suppliers, or advisors have a significant impact, while these challenges do not seem to influence other SMEs. Moreover, in the case of microenterprises, the status of leading in competition demonstrates a significant impact.

Finally, control variables reveal sector-specific differences. For microenterprises, firms in the construction sector are less likely to adopt e-commerce, whereas other SMEs in the trade sector exhibit a strong positive association with

adoption. These findings emphasize the differing dynamics of e-commerce adoption based on firm size and resource availability.

Table 4.3. Logistic regression: E-commerce adoption by size of groups within SMEs

	Microenterprises				Small and medium-sized enterprises (with 10 employees or more)			
	β	S.E.	p-value	Exp(β)	β	S.E.	p-value	Exp(β)
Technological dimension								
Lack of funds and financing	0.144	0.122	0.239	1.155	0.380(***)	0.144	0.008	1.462
Broadband quality	0.116	0.165	0.481	1.123	-0.178	0.196	0.364	0.837
Innovativeness	0.156	0.110	0.156	1.169	0.286(**)	0.133	0.031	1.331
Investment in ICT, software, consultancy	0.000	0.008	0.964	1.000	0.031(***)	0.010	0.003	1.031
Organisational dimension								
Digital competencies	0.174(**)	0.075	0.021	1.190	0.238(**)	0.097	0.014	1.269
Sales and purchases forecasts	0.326(***)	0.117	0.005	1.385	0.005	0.147	0.972	1.005
Risk-taking propensity	-0.007	0.114	0.950	0.993	-0.191	0.133	0.152	0.826
The desire for personal and professional development	0.076	0.101	0.452	1.079	0.243(**)	0.112	0.030	1.276
Escape unemployment. insecurity and job insecurity	-0.113	0.088	0.201	0.893	0.074	0.100	0.457	1.077
Environmental dimension								
Status of leading in competition	0.209(*)	0.118	0.077	1.232	0.184	0.137	0.180	1.201
Cooperation with clients	0.621	0.406	0.126	1.861	0.957(**)	0.464	0.039	2.604
Cooperation with suppliers	-0.074	0.399	0.854	0.929	0.761(*)	0.447	0.089	0.467
Cooperation with competitors	0.000	0.486	1.000	1.000	1.243(***)	0.466	0.008	3.464
Difficulties in finding cooperation partners, advisors, or suppliers.	0.430(**)	0.175	0.014	1.537	0.238	0.174	0.173	1.269
Lack of customer demand/interest	0.114	0.145	0.431	0.892	0.007	0.158	0.962	1.007
Control Variables								
Employees	-0.012	0.061	0.837	0.998	-0.001	0.005	0.802	0.999
Industry	0.801	0.498	0.108	2.228	-0.565	0.389	0.146	0.568
Construction	-0.871(**)	0.441	0.048	0.419	-0.341	0.442	0.441	0.711
Trade	0.339	0.309	0.274	1.403	0.979(***)	0.378	0.010	2.661
Constant	-4.276(***)	0.842	0.001	0.014	-5.992(***)	1.047	0.001	0.002
Goodness of fit								
-2 Log likelihood	356.603				337.367			
Chi-square	68.770 (***)				108.540 (***)			
Nagelkerke R Square	0.263				0.374			
% correct predictions	72.1				76			
Nº valid observations	379				423			

Number of valid observations = 802. S.E. = Standard Error. (*) Statistically-significant at the 0.10 level. (**). Statistically significant at the 0.05 level. (***) Statistically-significant at the 0.01 level. Cut-off point = 0.50.

4.5. Discussion and Conclusion

This study investigates the possible obstacles and drivers that impact the integration of e-commerce in SMEs. It also outlines effective strategies for managing the costs associated with this technology. The research events to bridge an existing gap by conducting a comprehensive examination of the obstacles hindering e-commerce adoption in SMEs. This approach integrates well-explored factors in the current body of literature with those that have received less attention, thus presenting a more complete perspective. Unlike the predominant focus on technological influences in prior works (Scupola, 2009; Abebe, 2014; Saridakis et al., 2019), this study acknowledges the substantial impact of the environmental aspect. Therefore, it is crucial to underscore the significance of interaction and cooperation with other actors in the ecosystem as pivotal elements in this perspective. Applying the TOE theoretical framework (Molla and Licker, 2005) allows us to comprehend the effect of three aspects of enablers - technological (lack of funds/financing, broadband quality, R&D activities and innovation, investment in ICT, software, consultancy), organisational (digital competencies, sales and purchase forecasts, entrepreneurial motivation), and environmental (status of leading in competition and cooperation with clients, suppliers, and competitors).

The present study employs the TOE theoretical framework as a robust model for examining the implementation of e-commerce in SMEs. Notably, this framework comprehensively incorporates a diverse array of factors, including not only technological considerations but also organisational and environmental perspectives, thereby providing a holistic view (Hameed et al., 2012).

The study presents quantitative empirical findings and provides crucial insights into an underexplored area, by utilising a representative sample of the Spanish SME sector. The results indicate that, with regard to the technological dimension, the lack of funds and financing significantly hinders the adoption of e-commerce. The study affirms financial constraints as a major barrier, a sentiment also confirmed by Scupola (2009) and Saridakis (2019). Likewise, the effectiveness of investment in ICT, software, consulting, R&D, and innovation is highlighted, with any restrictions in these areas potentially impacting e-commerce adoption negatively. Regarding the organisational dimension, limitations in digital competencies, sales and purchases forecasting, and entrepreneurial inspiration, particularly in relation to personal and professional growth, are found to have adverse effects on SMEs' embrace of e-commerce. These findings support the perspectives emphasised by Hong and Zhu (2006) concerning the importance of digital,

Liu et al. (2019) for sales forecasting, and Martín-Martín et al. (2022) for entrepreneurial motivation in the digitalisation of SMEs.

In the context of the environmental dimension, any reduction in leading in competitive intensity would present a significant impediment to the implementation of e-commerce. Likewise, the positive influence of engaging with clients and competitors on e-commerce adoption is noteworthy, and any limitations on such engagement would adversely affect e-commerce acceptance among SMEs. Furthermore, the challenges related to identifying suitable collaborative associates, advisors, or suppliers are currently exerting a simultaneous effect on the implementation of e-commerce.

When it comes to the comparison between microenterprises and other SMEs, lack of funds, innovativeness, and ICT investment significantly influence SMEs but are not impactful for microenterprises. Both groups benefit from digital competencies, though sales forecasting is significant only for microenterprises, while personal development aspirations matter more for SMEs. Environmental factors also differ SMEs benefit from cooperation with clients and competitors, while microenterprises are more affected by difficulties in partnerships. Finally, sector-specific differences are evident, with construction firms less likely to adopt e-commerce among microenterprises and trade firms showing higher adoption rates among SMEs. These findings highlight the distinct drivers of e-commerce adoption across firm sizes.

The findings of this study carry significant implications for managerial consideration. This research demonstrates that investment in human capital, particularly the enhancement of digital awareness and skills, positions as a vital aspect of any comprehensive strategy aimed at addressing the challenges obstructing e-commerce acceptance in SMEs. Moreover, the presented results indicate the supreme significance of financial aspects, including accessibility to funds and a larger ecosystem. The findings also highlight the critical nature of encouragement in interaction and cooperation with other actors and industry players, aligning with previous works (Govindaraju et al., 2012; Pagano et al., 2021). In this regard, SMEs must dynamically maintain and push the advancement of these networks and integrate them into such an existing organisational structure to maximise their prospective advantages, in line with previous work (Hussain et al., 2020).

Multiple factors should be considered in light of the limitations of this research in the scope of the COVID-19 pandemic and its influence on e-commerce. Firstly, the results of the research may be impacted by the unusual conditions and quick shifts that occurred throughout the pandemic, possibly restraining the generalisability of the findings to other periods. Secondly, there may be a possibility of heterogeneity in the data because of the dynamic nature of the e-commerce setting within this period, which could have resulted in a wide range of individual strategies and practices employed by enterprises that may differ. Thirdly, the TEO framework incorporates wider groups, which can possibly generalise the difficulties of real-world consequences. When applying this concept practically, it is possible that further subcategorisation may be necessary.

Focusing on future research, two key themes are recommended, firstly, a comprehensive study of e-commerce acceptance by SMEs that could be interesting to explore, particularly examining both the period before COVID-19 and the period since. Secondly, it could be also motivating to see the investigation of cybersecurity challenges that SMEs face when adopting e-commerce or digital technologies.

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Chapter 5

Adoption of Artificial Intelligence in Small and Medium-Sized Enterprises: The Role of Competencies and Skills

Abstract

This paper examines the factors influencing the adoption of artificial intelligence (AI) in small and medium-sized enterprises (SMEs), particularly focusing on the role of competencies and skills. The study used data from a representative sample of Spanish SMEs and analysed it through logistic regression econometric methods. Furthermore, to achieve a balanced dataset, the research incorporated the novel AI technique of Generative Adversarial Networks (GANs). The results reveal that SMEs are more likely to adopt AI if their owners or managers have university degrees or advanced professional training, employ information technology (IT) experts, and offer IT-related training for their employees. Additionally, SMEs that possess management skills in Enterprise Resource Planning (ERP) systems and marketing analytics tools, as well as those that collaborate with universities and research centres, illustrate a higher likelihood of incorporating AI into their operations. These findings carry important implications for both business management and public policy. From a managerial standpoint, the findings highlight the critical need to invest in training programs and initiatives designed to enhance the skills of employees and managers, enabling them to effectively implement AI in business operations. From a policy perspective, the findings imply that public administrations should take an active role in boosting AI adoption among SMEs by launching projects to improve critical digital competencies.

Keywords: Artificial intelligence; SME; digital competence, digital skill, digitalisation, information technology, GAN

5.1 Introduction

The integration of Artificial Intelligence (AI) in business is poised to become a pivotal factor in the coming decades in terms of driving advancements in productivity and enhancing the competitiveness of companies across all sectors (Brynjolfsson et al., 2017; Damioli et al., 2021; Calvino & Fontanelli, 2023). In the process of implementing AI solutions in companies, it is vital to recognise that this transition necessitates the cultivation of new competencies and skills among the existing staff. This involves an intensive focus on acquiring knowledge related to AI technologies and understanding how to effectively integrate and manage these technologies within the existing operational framework. As a consequence of this shift, certain competencies and skills that were previously integral to the organizational structure may become less relevant or even obsolete. This is primarily due to the fact that numerous tasks which were traditionally carried out by human employees will now be seamlessly executed by automated systems (Acemoglu & Restrepo, 2019; Felten et al., 2021; Bodea et al., 2024).

In today's fast-paced business environment, it is essential for companies to have strong managerial teams and employees who can adeptly identify and capitalise on the potential of integrating AI into their operations for sustained growth and competitive advantage (Kietzmann and Pitt, 2020; Vrontis et al., 2021; Krakowski et al., 2022; Giraud et al., 2023). Professionals with specific expertise in information technology (IT) are anticipated to experience heightened demand, and it is imperative for all personnel to cultivate proficiency in digital competencies (Khatri et al., 2020; Alekseeva et al., 2021; Jaiswal et al., 2022). Nevertheless, there remains a lack of conclusive evidence regarding the vital skills necessary for successfully implementing AI within companies. As a result, this paper aims to tackle this research question.

The existing body of literature regarding the implementation of AI has primarily focused on large-scale enterprises that exhibit proactive tendencies in adopting this technology. Small and medium-sized enterprises (SMEs) encounter notable challenges in their digitalisation endeavours, primarily stemming from constraints in accessing financial, technological, and human resources due to their scale (OECD, 2021; Calvino & Fontanelli, 2023). Consequently, there exists a discernible research gap pertaining to the vital competencies and skills pivotal for the integration of AI within SMEs.

The primary objective of this paper is to examine the determinants of AI adoption in SMEs in Spain, with a specific focus on the influence of competencies and skills. Data from a representative sample of Spanish SMEs, gathered

through a 2022 survey, was employed for analysis. The study utilised a logistic regression model as an econometric technique. Acknowledging the low adoption rate of AI solutions among Spanish SMEs, this paper addresses the associated dataset imbalance by implementing Generative Adversarial Networks (GANs), a cutting-edge AI technique.

From a theoretical perspective, this study contributes to the existing literature by providing novel insights into the pivotal role of competencies and skills in the adoption of AI within the business domain. It elucidates the intricate interplay between Enterprise Resource Planning (ERP) systems, marketing analytics tools, and AI. From a methodological perspective, the research demonstrates the application of GANs to rectify issues related to dataset imbalances in economics and business research. From a pragmatic standpoint, this article extrapolates relevant implications for management and public policy, proposing actionable measures to promote the adoption of AI within SMEs.

The structure of the article is as follows: Section 5.2 provides a review of existing literature on the utilisation of AI in SMEs and the significance of competencies and skills, from which the research hypotheses for this study are derived. Section 5.3 presents the dataset used and the methodology applied in the analysis. Section 5.4 illustrates and examines the findings of the research. The article is then summarised with definitive conclusions and implications for practitioners.

5.2. Review of the scientific literature

The present state of research indicates a rapidly increasing interest in leveraging AI for business, underscoring its potential for profound transformation. Artificial Intelligence presents distinct advantages to businesses by strengthening efficiency and objectivity (Raisch & Krakowski, 2021). The incorporation of AI spans a wide array of functions and responsibilities within organisations, encompassing areas such as marketing (Feng et al., 2021), customer service (Nicolescu & Tudorache, 2022; Xu et al., 2020), and human resources, mainly in the context of decision-making processes related to recruitment (Khatri et al., 2020; Van den Broek et al., 2021). The correlation underscores a cooperative venture between AI and human input (Herrmann & Pfeiffer, 2022), accentuating the essentiality of human engagement in AI implementations (Berente et al., 2021).

The synergy between AI and its applications within the context of both managerial oversight and employee involvement holds significant importance. Managers assume a pivotal role in supervising AI implementation and ensuring its alignment with organisational objectives, whereas employees provide essential domain expertise and feedback for the refinement of AI systems. The interdependent relationship underscores the dynamic characteristic of AI integration in business settings, where human oversight and collaboration are essential in fully leveraging its potential. As the field continues to progress, an in-depth comprehension of the intricate interplay between AI and human stakeholders is increasingly imperative for the proficient utilisation of AI technologies within business contexts. The acknowledgement of the complementary roles of AI and human input lays the groundwork for more refined and impactful applications across diverse organisational functions.

On the one hand, it is evident from previous research that managers must develop and refine new AI skills in order to maintain the sustainability of their businesses (Krakowski et al., 2022). In this context, the integration of AI necessitates the acquisition of new qualifications, the undertaking of novel responsibilities, and the enhancement of essential skills (Griva et al., 2021; Vrontis et al., 2021). The existing literature posits the recommendation for managers to not only strengthen their technical proficiencies, encompassing comprehension of AI and its tools, data visualisation, and analytical acumen, but also to advance their non-technical competencies, including empathy, creativity, leadership, and critical thinking (Giraud et al., 2023). Proficiency in both technical and non-technical skills is imperative for the integration of AI in a business environment. Technical competencies are invaluable for comprehending and effectively utilising AI, while non-technical skills play a pivotal role in the successful deployment of AI systems (Giraud et al., 2023). The latest literature delves into the obstacles posed by AI in the realm of embryonic work methodologies (Goto, 2022). AI empowers managers by taking care of repetitive tasks, giving them the freedom to devote their attention to more complex and high-priority issues (Hagemann et al., 2019). Consequently, AI has the capacity to impact administrative competencies, potentially supplanting activities related to information retrieval and rudimentary decision-making. However, there exist managerial proficiencies and responsibilities that presently elude substitution or influence by AI and its associated tools. These aspects encompass imagination and leadership (Giraud et al., 2023), team motivation, stimulus, and sympathy (Plastino and Purdy, 2018), together with emotional intelligence and critical thinking (Mattingly & Kraiger, 2019).

On the contrary, concerning employees, the integration of AI and its associated applications leads to a reduction in employee responsibilities by managing routine tasks. Consequently, this facilitates heightened efficacy within the

organisation as employees are able to direct their attention toward more innovative duties and obligations (Acemoglu & Restrepo, 2018). Furthermore, AI empowers employees with lower skill levels to confidently manage intricate tasks that traditionally demanded specialised training (Mayer et al., 2020; Strich et al., 2021). Simultaneously, while AI expedites task management, it also assumes a pivotal role in assessing and overseeing employees' work performance (Harms & Han, 2019) as well as their daily activities (Malik et al., 2022). Additionally, AI possesses the capacity to provide staff with valuable direction and recommendations aimed at improving time management, objective set, and task selection (Malik et al., 2022). Furthermore, AI has the potential to support employees in enhancing their self-management skills by offering constructive feedback and acknowledging their successes (Tong et al., 2021).

However, prior research suggests that managers are key contributors to the successful deployment of AI and its associated tools (Sousa & Rocha, 2019; Giraud et al., 2023). In this regard, in today's era of the AI revolution, successful leadership demands not only traditional skills like organising, leading, and supervising, but also a deep understanding of AI and the dynamic collaboration between humans and AI (Basu et al., 2022; Herrmann & Pfeiffer, 2022). Hence, acquiring new and advanced knowledge and abilities will necessitate participation in training programs and/or obtaining relevant university education (Kietzmann & Pitt, 2020; Vrontis et al., 2021). In the context of SMEs, the personal profile of the business owner/manager is instrumental in shaping the organisation and fostering its growth (Romero & Martínez-Román, 2012; Martín-Martín et al., 2022). Enterprises led by owners and managers with a solid educational background are more likely to have the expertise needed to successfully integrate AI into their operations. Furthermore, the foremost business schools of the contemporary era, including Oxford Saïd, MIT Sloan, Cambridge Judge, London Business School, and Harvard Business School, offer executive education programs tailored for managers and entrepreneurs engaged in the sphere of AI and its related domains, accessible through both online and in-person modalities. This phenomenon serves to underscore the substantial demand for the cultivation of AI competencies. In light of these deliberations, this research posits the ensuing hypothesis:

H1: SMEs whose business owners or managers have a university degree or have completed an advanced level professional education and training program are more likely to implement AI in their businesses.

In the era of AI, possessing skills that integrate artificial intelligence can yield a substantial impact. Previous research has shown that digital skills are crucial during AI implementation (Oberländer et al., 2019; Carlisle et al., 2023). Moreover, mastering this process demands programming expertise, as underlined in prior research

(Subaveerapandiyan et al., 2024). Hence, engaging IT specialists within the organisation can markedly streamline the digitalisation process, particularly in implementing AI. IT specialists, as delineated within the scope of this study, refer to employees whose responsibilities directly pertain to IT, encompassing the development, operation, or maintenance of IT systems or their applications (Instituto Nacional de Estadística, 2019). This definition forms the basis for the following hypothesis in this research:

H2: SMEs with IT specialists on their staff are more likely to implement AI in their businesses.

Moreover, it is crucial to prioritise the advancement of employees' skills to keep pace with the evolving landscape of AI (Jaiswal et al., 2022). The literature has pinpointed several key skills that are highly relevant for employees in the realm of AI, including critical thinking capabilities (Delanoy and Kasztelnik, 2020), problem-solving skills (Seeber et al., 2020), digital skills (Allmann & Blank, 2021), soft skills (Hart et al., 2021), and continuous learning competences (Jaiswal et al., 2022). In light of this, firms must prioritise internal or external training to equip employees with the essential skills for integrating AI into their operations. Therefore, the following hypothesis is postulated:

H3: SMEs that conduct training activities related to IT for their staff are more likely to implement AI in their businesses.

Additionally, the successful incorporation of AI into operations requires companies to achieve a certain level of digital maturity (Lichtenthaler, 2020). SMEs that have already embraced advanced digital management tools like Enterprise Resource Planning (ERP) systems and marketing analytics tools are well-positioned to harness the potential of AI and drive innovation within their organisations. The existing research suggests a strong interrelationship between ERP systems and AI (Javad et al., 2024; Puthuruthy and Marath, 2024) as well as a significant connection between marketing analytics and AI (Hossain et al., 2022; Petrescu & Krishen, 2023). Considering this, the following hypothesis is put forward:

H4: SMEs with advanced skills in digital management, utilising ERP systems and marketing analytics tools, are more likely to implement AI in their businesses.

SMEs frequently encounter challenges in obtaining the requisite skills and knowledge essential for the implementation of AI in their business operations, primarily due to limitations in resources. This exacerbates the digitalisation disparity between SMEs and large companies (OECD, 2021). In this context, the partnership between universities and companies can be considered a pivotal driver of technological advancement and its subsequent integration (Sedlacek,

2013; Wirsich et al., 2016). SMEs stand to gain significant advantages by engaging in collaborations with universities, research centres, and public infrastructures. Such partnerships can play a pivotal role in promoting digital entrepreneurship and facilitating the digital transformation of established companies through the integration of AI (Chan et al., 2022). In this regard, we present the following hypothesis:

H5: SMEs that collaborate with universities and research centres in digitalisation-related issues are more likely to implement AI in their businesses.

5.3. Research methodology

In this section, we will first present the research data, followed by an explanation of other aspects of the methodology used.

5.3.1 Data description

The data for this research was derived from our survey on the digitalisation of SMEs in Spain, which has been described previously in this thesis.

The dependent variable in this study (AI) is a binary variable that denotes whether the company employed AI methodologies, encompassing machine learning, natural language processing, and voice recognition, as well as other techniques for processing and analysing large datasets, during the past three years (2019-2021).

Concerning the explanatory variables, we initially assessed the subsequent set of variables related to competencies within the firm:

- Entrepreneurs/managers with university degrees or higher professional studies (Ent_edu): This binary variable denotes those SMEs with entrepreneurs/managers who have acquired a university degree or higher professional training.
- Medium-level staff with IT expertise (IT_exp): This binary variable assigned the value 1 for those enterprises that have IT experts in medium-level positions (0 otherwise).

- IT training initiatives (IT_train): This binary variable illustrates whether the enterprises had carried out training activities to advance their employees' IT skills within the three years prior to the survey.
- ERP Systems (ERP): This binary variable demonstrates whether the enterprises have employed ERP systems.
- Marketing Analytics Tools (Mark_analy): This binary variable demonstrates whether the enterprises have employed digital marketing analytics tools.
- Cooperation with universities and R&D centres (Coop_univ). This binary variable captures whether SMEs collaborate with universities and research centres in various facets pertaining to digitalisation.

The analysis also takes into account firm size (Size), the age of the company (Age), and dummy variables for sectors (Trade or Services) as control variables.

5.3.2 Generative Adversarial Networks

In our database, only 85 SMEs have embraced artificial intelligence techniques, constituting approximately 10% of the total number of observations. This level of application is in accordance with other AI adoption studies conducted in SMEs in Spain (ONTSI, 2023). However, considering the significance of the data at hand: while 85 enterprises have adopted AI, a substantial 751 enterprises have yet to do so, resulting in a noticeable imbalance. This paper aims to address this disparity by employing GANs (Goodfellow et al., 2014; Goodfellow et al., 2020), an innovative technique for both semi-supervised and unsupervised learning (Radford et al., 2015; Donahue et al., 2018; Liu et al., 2018).

The use of GANs for data augmentation has proven to significantly enhance the performance of predictive models, as evidenced by studies (Douzas and Bação, 2018; Mottini et al., 2018; Ding, 2019). While still an emerging technique in the field of social sciences, there are numerous studies highlighting the satisfactory results and advancements achieved by GANs in comparison to alternative methods. Indeed, GANs have proven to be highly effective in various economic applications. These applications range from detecting banking fraud (Langevin et al., 2022) and identifying trading strategies (Koshiyama et al., 2020) to generating asset prices (Han et al., 2022), mobility networks (Mauro et al., 2022), and financial time series (Vuletic et al., 2024). They also play a crucial role in ensuring customer privacy (Anand & Lee, 2023) and economic scenario generators for market risk assessment (Wang et al., 2024).

The aforementioned studies substantiate the efficacy of GANs in economic research. GANs exhibit the capacity to effectively tackle a myriad of challenges, including data scarcity, imbalance, missing data, and inadequate survey responses, thereby yielding notably superior outcomes when compared with conventional methodologies. This underscored rationale substantiates the integration of GANs in this present article, wherein their application is employed to fabricate synthetic data, ensuring the equilibrium of the dataset.

Generative Adversarial Networks are powered by two essential components: the Generator and the Discriminator, working in harmony. Initially, the Generator takes in a random noise vector and creates synthetic data. This synthetic data is then combined with authentic data to train the Discriminator. The Discriminator's principal objective is to differentiate between genuine and synthetic data. The Generator endeavours to convincingly generate synthetic data, aiming to mislead the Discriminator, while the Discriminator strives not to be deceived. This dynamic adversarial process, expounded by Salimans et al. (2016), Heusel et al. (2017), Ge et al. (2018), and Bynagari (2019), propels the Generator towards enhancing its capability to generate synthetic data that closely approximates authentic data.

The key aim of this initiative is to accurately replicate and validate the original company data. This requires developing a model that can faithfully mimic real-world data. The comprehensive formula, delineated by Gonzalez-Abril et al. (2022), integrating both the Discriminator and Generator, is as follows:

$$\boldsymbol{V(\theta^D, \theta^G) = E_{x\sim P_x}[logD(x)] + E_{z\sim P_z}\left[\log\left(1 - D\left(G(z)\right)\right)\right]} \quad (1)$$

In this particular context, x denotes an authentic sample, while z represents a randomly generated noise vector. The output of the Discriminator when processing a genuine sample is denoted as D(x), and G(z) symbolises the output of the Generator derived from the noise vector z, thus generating synthetic data. D(G(z)) encapsulates the prediction from the Discriminator concerning the synthetic data. Px and Pz encapsulate the distributions of genuine and noise data, respectively, while Ex and Ez pertain to the anticipated log-likelihood originating from the disparate outputs of genuine and generated data. Finally, θ^D and θ^G represent the parameters or weights linked to the Discriminator and Generator models, respectively.

The value function is characterised by a min-max strategy designed to maximise the Discriminator loss while concurrently minimising the Generator loss, $\boldsymbol{min_{\theta^G} \max_{\theta^D} V(\theta^D, \theta^G)}$.

In order to implement GANs effectively, we carefully selected 85 observations from our database that demonstrate the specific characteristic we are interested in - namely, SMEs that have integrated AI solutions. The Generator, known as G(z), is designed with six dense layers. Functioning to transform a noise vector into an output vector of size 10, corresponding to the requisite features. Conversely, the Discriminator, labelled as D(z), is structured with three dense layers, each incorporating batch normalisation and leaky layers with an alpha value of 0.01.

The Generator and Discriminator both use the Adam optimiser with a consistent learning rate of 0.0001, ensuring efficient training. The Discriminator employs cross-entropy loss for its binary classification task, while the Generator's use of mean square error as its loss function is strategically chosen to enhance the match between real and synthetic data. This unique loss function has demonstrated its ability to significantly improve the fidelity of both real and synthetic distributions by adjusting the number of percentiles with precision.

The dataset is subject to validation procedures prior to its utilisation. Goodness-of-fit tests are implemented, setting the null hypothesis (H0) to ascertain whether the synthetic enterprises share the same distribution as the real enterprises, at a significance level of 5%. Categorical variables undergo Pearson's chi-squared tests, while quantitative variables are subjected to Kolmogorov-Smirnov tests (see Table No. 5.1).

Table 5.1. Features, number of different values, and p-value

Feature	values	p-value	Feature	values	p-value
Size	41	7.610086e-02	IT_exp	2	4.654900e-01
Age	39	5.172965e-02	IT_train	2	2.405108e-01
Trade	2	4.560974e-01	ERP	2	5.308537e-01
Services	2	4.228170e-01	Mark_analy	2	8.327084e-02
Ent_edu	2	2.916162e-01	Coop_uni	2	3.746260e-01

5.3.3. Logistic regression

The original database has been augmented by the addition of 669 items of synthetic data, resulting in a total of 1,508 observations for the logistic regression. Each observation corresponds to an individual enterprise, encompassing 10 variables within the database. Notably, 754 enterprises manifest the characteristic under investigation, while 754 do not.

In Table No. 5.2, the analysis of various variables' behaviour in the presence (AI=YES) and absence (AI=NO) of the study variable reveals important insights. Specifically, it is evident that 87% of enterprises implementing AI are led by entrepreneurs with higher education, in contrast to 70% of enterprises not utilising such technologies. Moreover, 66% of the enterprises incorporating AI have specialised IT technicians and mid-level professionals, in contrast to only 27% of enterprises not utilising AI. It's crucial to note that 72% of these AI-integrated enterprises conduct training activities to enhance IT knowledge, while only 36% of enterprises not using AI engage in such activities.

Table 5.2. Summary of descriptive statistics

	AI = YES					AI = NO				
	Mean[a]	Median	SD	Min	Max	Mean[a]	Median	SD	Min	Max
Size	32.120	24.670	26.769	1	170	17.360	10	22.975	1	160
Age	20.940	19.230	10.942	3	99	20.890	19	13.172	2	120
Trade	0.110	0	0.316	0	1	0.220	0	0.414	0	1
Services	0.720	1	0.450	0	1	0.500	1	0.500	0	1
Ent_edu	0.870	1	0.332	0	1	0.700	1	0.460	0	1
IT_exp	0.660	1	0.472	0	1	0.270	0	0.446	0	1
IT_train	0.720	1	0.449	0	1	0.360	0	0.481	0	1
ERP	0.750	1	0.431	0	1	0.470	0	0.500	0	1
Mark_analy	0.770	1	0.423	0	1	0.350	0	0.477	0	1
Coop_univ	0.270	0	0.446	0	1	0.100	0	0.299	0	1

(a) In the case of dichotomous variables, the mean represents the percentage of 1.
SD = Standard deviation. Min = Minimum. Max = Maximum.

Furthermore, companies harnessing AI demonstrate a 75% proficiency in ERP systems, a significant increase compared to the 47% showcased in companies without AI. Moreover, AI-adopting companies also exhibit a 77% competence in analytical marketing tools, far surpassing the 35% of non-AI-adopting companies. They also display an increased inclination towards collaboration with universities and research centres on digitalisation-related aspects. Notably, the service sector extensively utilises AI, and larger companies are more inclined to adopt AI. Interestingly, the age of the companies has minimal impact on AI usage where the two values are similar.

Logistic regression analysis is conducted, and parameter estimation is performed using the maximum likelihood method. The equation representing the model is articulated as follows:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 Size + \beta_2 Age + \beta_3 Trade + \beta_4 Services + \beta_5 Ent_{edu} + \beta_6 IT_{exp} + +\beta_7 IT_{train} + \beta_8 ERP + \beta_9 Mark_{analy} + \beta_{10} Coop_{univ} + u \quad (2)$$

where p = P(AI=1|X) denotes the probability of the AI variable assuming the value 1 when the explanatory variables X are present. This is computed as follows:

$$\boldsymbol{p = P(AI = 1|X) = \frac{\exp(\beta_0 + \sum_{i=1}^{10} \beta_i x_i)}{1 + \exp(\beta_0 + \sum_{i=1}^{10} \beta_i x_i)}} \quad (3)$$

where,

$\boldsymbol{\beta_0}$: the intercept term of the model

$\boldsymbol{\beta_i}$: coefficients of the explanatory variables

X: set of explanatory variables $\{\boldsymbol{x_1, x_2, \ldots, x_{10}}\}$

There are no collinearity issues among explanatory variables (see figure 5.1).

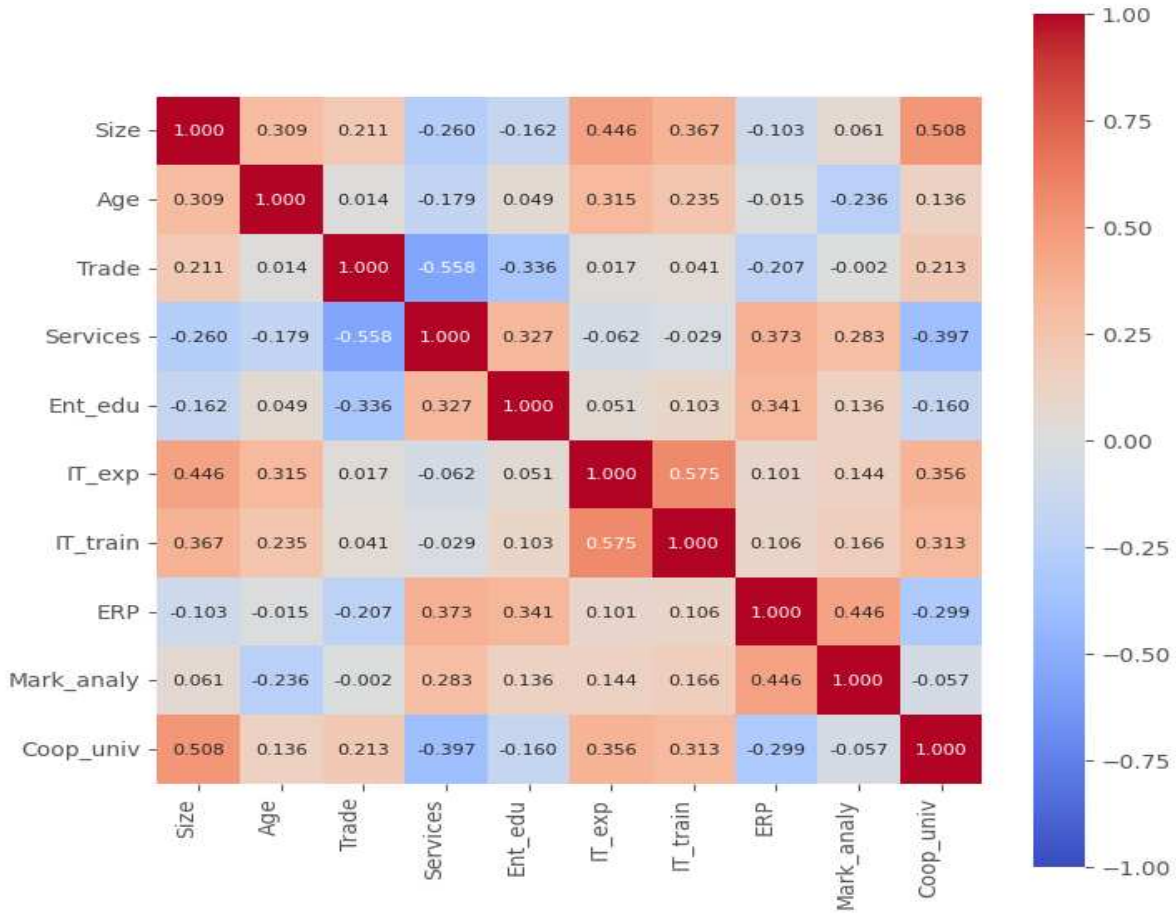

Figure 5.1. Matrix of correlations

5.4. Results and Discussions

The detailed results of the econometric analysis can be found in No. 5.3. The significant omnibus test (chi-squared) demonstrates that our model effectively explains the dependent variable, AI (p-value < 0.001). Moreover, the explanatory variables account for a substantial proportion of the variance in our dependent variable, ranging from 39.4% to 52.5%. In the classification table presented in Table No. 5.4, it is evident that our model exhibits a remarkable sensitivity of 94.3% and a specificity of 77.2%, resulting in an impressive overall classification accuracy of 85.7%.

Taking into account the control variables, it is evident that both age and size play a significant role. The negative sign for age suggests that younger firms are the ones most actively embracing AI. On the other side, the positive sign for

firm size indicates that larger firms are more inclined to integrate AI compared to smaller firms. This finding aligns with prior evidence (OECD, 2021; Calvino & Fontanelli, 2023) and can be attributed to the greater constraints smaller firms face when it comes to accessing technological, human, and financial resources. In the context of sectoral dummies, a statistically significant negative coefficient is marked for the trade variable. This finding proposes that SMEs in the trade sector face greater hurdles or impediments in adopting AI compared to the industrial sector, which acts as the reference category in our model. Conversely, the coefficient for the services variable, also statistically significant, demonstrates a positive association, indicating that AI implementation is more persistent among firms in the service sector relative to their industrial counterparts. This result is possibly correlated with the prevalence of advanced knowledge-intensive services.

Table 5.3. Logistic regression model

Variables	**B**	**S.E.**	**p-value**	**Exp(B)**
Const	-4.187	0.338	<0.001	0.015
Size	0.023	0.004	<0.001	1.023
Age	-0.022	0.007	0.001	0.978
Trade	-0.859	0.271	0.002	0.424
Services	1.110	0.209	<0.001	3.035
Ent_edu	1.066	0.224	<0.001	2.904
IT_exp	1.012	0.178	<0.001	2.750
IT_train	0.575	0.167	<0.001	1.778
ERP	0.842	0.184	<0.001	2.320
Mark_analy	1.565	0.168	<0.001	4.784
Coop_univ	1.826	0.242	<0.001	6.209
Goodness of fit				
Chi-squared	755.408	p-value	<0.001	
R^2 Cox and Snell	0.394	R^2 Nagelkerke	0.525	

n = 1,508 observations. S.E.= Standard Error.

Table 5.4. Classification

	Prognosed (AI)		**% correct**
Observed (AI)	**NO**	**YES**	
NO	582	172	77.2
YES	43	711	94.3
Global percentage			**85.7**

In reference to the explanatory variables, it is noted that they demonstrate statistical significance with a positive sign. These empirical findings offer robust support for all hypotheses postulated in Section 5.2.

First, our study findings reveal that SMEs whose business owners or managers possess a university degree or extensive professional training display a higher propensity to integrate AI technologies into their business operations, thus substantiating hypothesis H1. This underscores the significance of acquiring contemporary and innovative knowledge and skills for entrepreneurs/managers, which can be acquired through university education or specialised training programs. Entrepreneurs with a robust educational foundation are better positioned to comprehend the potential advantages associated with AI adoption and to proficiently execute the requisite transformations within their organisations. This prominence of the educational qualifications of business owners and managers aligns with prior research conducted by Romero and Martinez-Roman (2012) as well as Martín-Martín et al. (2022).

Likewise, the presence of technical staff possessing IT expertise and the implementation of IT training programs for staff are noted to have a considerable positive impact on AI adoption, substantiating our hypotheses H2 and H3. Enterprises with IT professionals among their workforce and those conducting IT-related training activities exhibit a notably favourable disposition toward AI adoption and possess the essential proficiencies to enable the successful integration of this technology. This observation underscores the imperative for SMEs to prioritise the recruitment of adept personnel and allocate resources toward continual training endeavours to effectively control advanced technologies such as AI. This result supports prior scholarly works highlighting the pivotal role of skills and competencies in fostering AI adoption (Alekseeva et al., 2021; Calvino & Fontanelli, 2023).

Our research findings strongly suggest that SMEs benefit from utilising marketing analytics tools and ERP systems, as they are more likely to adopt AI, confirming hypothesis H4. This underscores the importance of developing advanced digital skills and achieving higher digital maturity, as it enables firms to effectively comprehend and integrate AI technology into their operations. This strategic approach enhances their ability to adapt to and capitalise on the advantages offered by AI. It's essential to recognise digitalisation as a continuing learning process rather than a speedy climb, in order to maximise the potential for accomplishment. The use of advanced digital management tools in SMEs demonstrates their existing capabilities in adopting AI. Moreover, these tools play a crucial role in collecting and organising the vast amounts of data required for training AI models. This discovery aligns with previous research

highlighting the potential synergy between ERP systems, marketing analytics, and AI (Petrescu & Krishen, 2023; Jawad & Balázs, 2024).

Finally, our outcomes indicate that engagement with universities and research centres significantly influences the adoption of AI in SMEs, confirming hypothesis H5. Collaboration with universities and research centres streamlines the integration of AI in SMEs by delivering access to imperative technological and knowledge resources. This result aligns with Chan et al. (2022), where the beneficial implications of SMEs establishing collaborations with universities and research centres to drive their digital transformation. Furthermore, the observed impact related to this variable stands out as the most substantial, as demonstrated by the odds ratios (refer to Exp(B) in Table 5.3).

Overall, these findings emphasise the pivotal role of competencies and skills in shaping the integration of AI within SMEs in Spain. This clarification underscores the direct influence of digital human capital on the integration of AI tools in business.

5.5 Conclusions

This study examines the shifting landscape of competency requirements driven by the integration of AI within companies, with a specific focus on the context of SMEs in Spain. It underscores the pivotal significance of enhancing skill sets, fostering adaptability, and executing strategic workforce planning to leverage the potential of AI, thereby ensuring sustainable growth and competitiveness in the dynamic contemporary business environment.

The digitalisation approach of SMEs is shaped by the unique characteristics of these companies, which may present challenges in adopting AI. The paper emphasises the essential competencies and skills that support AI adoption in SMEs. This study is the first to examine the competence requirements for AI implementation with a focus on SMEs. Through empirical investigation of AI adoption in SMEs in Spain, our research fills a crucial gap in the current literature. Our results not only offer valuable visions into essential competencies for AI adoption but also deliver practical direction for SMEs expressing themselves in the realm of AI.

Our study utilises an innovative methodology known as Generative Adversarial Networks (GANs), which has traditionally been applied in fields such as medicine and engineering and has more recently been adopted within the realm of economics.

Our analysis demonstrates that SMEs whose business owners or managers possess a university degree or extensive professional training, employ IT experts, and provide IT-related training for their employees, exhibit a heightened willingness to integrate AI technologies. Furthermore, SMEs equipped with advanced digital management skills, including the use of ERP systems and marketing analytics tools, and engaged in partnerships with universities and research centres, display a greater propensity for the integration of AI into their operations.

These results have substantial implications for business management and public policy. From a managerial perspective, the results highlight the crucial necessity to boost digital skills within companies for the successful adoption of AI technologies. In this context, the pivotal importance of recruiting IT specialists is evident for SMEs seeking to incorporate AI. These specialists bring expertise in needs assessment, systems integration, data management, and cybersecurity, which are fundamental for the prosperous implementation of AI, driving innovation and operational efficiency in SMEs. Moreover, the results expressed in this study emphasise the significance of investing in training programs and initiatives targeting the enhancement of personnel and managerial proficiencies, thereby enabling the effective adoption of AI in their business operations.

Particularly, this study underscores the significant role of implementing ERP systems and marketing analytics in SMEs in driving the adoption of AI in business. ERP systems are essential in streamlining and integrating numerous business developments, offering a centralised platform for dealing with resources, finances, and operations. This integration yields structured data, which is essential for training AI models. Moreover, marketing analytics tools empower SMEs to collect, analyse, and interpret extensive customer data, thereby yielding deeper insights and facilitating informed decision-making. When combined, these technologies establish a robust data infrastructure, boosting the competence for AI implementation. In this regard, AI can automate and optimise duties, predict trends, personalise customer interactions and augment overall competence by leveraging the data from ERP systems and marketing analytics. Furthermore, SMEs are encouraged to cultivate partnerships with universities and research centres to strengthen their AI implementation events. Such synergistic partnerships can afford SMEs access to external knowledge, skills, and capabilities that may not be readily available internally.

Within the realm of policy, public administrations can exert considerable influence in advancing AI adoption among SMEs by formulating initiatives aimed at augmenting fundamental digital competencies. This may encompass the development of targeted training programs, provision of financial support or grants for technology integration, and

enabling partnerships between SMEs and educational institutions or research centres. Moreover, developing AI competencies within education systems is crucial (Grădinaru et al., 2024). Through active promotion of digital skills and capability development within SMEs, policymakers can significantly contribute to propelling innovation, productivity, and competitiveness within the wider economy.

Nevertheless, this study has limitations. Specifically, the majority of variables employed in the econometric analysis are dichotomous. The future study could use Likert scales to encompass the intensity of responses. Moreover, although the insights presented in this paper hold significant value with regard to Spanish SMEs, it is essential to acknowledge the context-dependent of the observed results. Therefore, future research is essential for the generalisation of findings and assessment of their applicability to other countries. Furthermore, subsequent studies could explore the consistency of these conclusions within larger enterprises across diverse industries.

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CHAPTER VI

CONCLUSION

This chapter serves as a comprehensive synthesis of the research journey undertaken in this dissertation. It integrates the insights derived from the four analyses presented in this thesis. The objective is to interlace the developed understanding from each chapter, presenting a coherent narrative that elucidates the intricate dynamics involved in the digitalisation process of SMEs. As technologies continue to advance, digitalisation has become not just an option but a necessity for SMEs striving to remain competitive and agile, as the pace of technological transformation accelerates and shapes the global economy.

The dissertation employs a variety of methodological and theoretical frameworks, offering valuable insights into the digitalisation of SMEs. By harnessing digital technologies, SMEs can revolutionise how they monitor, control, and automate their internal operations, business models, products, and services, driving greater efficiency, accuracy, and scalability. This shift enables businesses to leverage real-time data analytics, enhance decision-making processes, streamline supply chains, and integrate more agile responses to market demands, ultimately improving their overall business performance and competitiveness in a rapidly evolving digital economy. At the same time, SMEs experience difficulties in their advances toward digitalisation due to their limited size and low level of professionalisation of their management, and constrained access to financial, technological, and human resources.

Regarding the insights of the thesis, first, a literature review is conducted by employing bibliometric analysis to understand the current trend of academic works on the digitalisation of SMEs in Italy and Spain. Moreover, it followed three quantitative studies that used a dataset from a survey carried out in 2022 among Spanish SMEs. In this regard, the key factors that drive the digital transformation of SMEs are explored. Particularly, the first study approaches digital transformation as an innovation process within the enterprise, leading to the adoption of new or significantly enhanced products and processes through digital technologies. Furthermore, the barriers to the adoption of e-commerce technologies within SMEs, as well as the factors influencing these barriers, are studied in the second

empirical study. Finally, the dissertation continued with an analysis of the factors affecting the adoption of AI in SMEs, with a particular focus on the role of competencies and skills.

6.1. Summary of Findings and Main Contributions

In Chapter 2, a comprehensive analysis of 125 publications from top-tier journals, comprising 85 from Italy and 40 from Spain, covering the period of 2018 and 2023, was conducted. In summary of findings, there has been a clear rise in interest in digitalisation within SMEs in both Italy and Spain. Italy indicates notable strength in terms of publications and citations, with longer author timelines. However, both countries' research themes lack diversity. Spanish universities prioritise frequent and international partnerships. Spain's internal collaboration is particularly strong, and both countries collaborate extensively with the United Kingdom. Additionally, the literature is predominantly theoretical, pointing to a need for more empirical studies.

In Chapter 3, the analysis provides compelling empirical evidence on a relatively unexplored subject further enriching the study's comprehensive examination of the drivers and barriers to digital innovation in SMEs from a holistic perspective. These findings highlight that the main barrier to SMEs' digitalisation is not technological, as the necessary resources are already accessible. Instead, it is human capital and organisational factors that shape SMEs' digital transformation. Apart from external resources, a company's ability to integrate digital technologies also relies heavily on its internal digital skills, which enable innovation in products and processes. Organisational and relational factors are also key drivers of digital innovation. The findings suggest that a spontaneous, unplanned approach led by the entrepreneur’s/manager’s individual initiative is insufficient. SMEs must adopt a formal, strategic plan for digital transformation, fostering open innovation through collaboration with ICT consultants, suppliers, universities, and research centres. Additionally, SMEs should adjust their organisational capabilities as they grow to handle the increasing complexity of digital innovation. Furthermore, the additional analysis demonstrate that the impact of digital innovation determinants differs between microenterprises and other SMEs. Microenterprises rely on entrepreneurs' traits and external collaborations for specialized knowledge, while SMEs require complex knowledge inputs, staff involvement, and professional management to navigate digital innovation. The findings also suggest that SMEs must

adjust their organizational capabilities as they grow to manage the increasing complexity of digital innovation effectively.

In Chapter 4, the possible obstacles and drivers that impact the implementation of e-commerce in SMEs were studied. The findings illustrate those financial constraints, particularly the lack of funds and financing, significantly hinder e-commerce adoption in SMEs. Investment in ICT, software, consulting, R&D, and innovation is crucial, and restrictions in these areas negatively impact e-commerce uptake. On the organisational side, limited digital skills, forecasting abilities, and entrepreneurial growth also pose challenges. In the environmental dimension, reduced competitive intensity and limited engagement with clients and competitors hinder e-commerce adoption. Additionally, difficulties in finding suitable collaborators, advisors, or suppliers further complicate e-commerce implementation.

In Chapter 5, the empirical analysis of the adoption of AI in SMEs with a particular focus on competencies and skills was conducted. The findings suggest that SMEs with owners or managers holding university degrees or advanced training, employing IT experts, and offering IT-related training are more likely to adopt AI. Additionally, SMEs with advanced digital management skills, such as ERP systems and marketing analytics, and those partnering with universities and research centres, show greater AI integration potential. ERP systems streamline operations and provide structured data for AI models, while marketing analytics enables informed decision-making. Together, these technologies create a strong data foundation for AI implementation, enhancing automation, trend prediction, and customer interaction. Partnerships with universities further support SMEs by providing access to external expertise critical for AI adoption.

Those findings pose a meaningful contribution for the empirical perspective to the literature on business digitalisation, as studies in this field focus on large enterprises and quantitative evidence on SMEs is scarce. Apart from its empirical findings, the thesis also offers relevant theoretical and methodological contributions. In this regard, the chapter on digital innovation provides an analytical framework for studying the determinants of digitalisation from a holistic perspective, with a particular focus on SMEs. It distinguishes between three dimensions and three levels of analysis, offering a valuable tool for adopting a holistic approach. This framework can be applied to other dimensions of digitalisation, not only digital innovation. Moreover, the TEO model used in the e-commerce chapter is also innovative. It incorporates not only the technological and organisational dimensions but also the environmental dimension, providing a more comprehensive approach to the analysis. Furthermore, from a methodological

perspective, the use of bibliometric analysis in a comparative way is novel, where the findings from Spain and Italy are distinguished. From that methodological perspective, the use of GANs in Chapter 5 to balance datasets is also innovative in research on enterprises.

6.2. Implications for Research, Business Management and Public Policy

The findings of this dissertation reveal several significant implications, which underscore the need for SMEs to adapt their strategies and operations to the evolving digital landscape. These implications provide a framework for SMEs, policymakers, and researchers to support and enhance the digital transformation journey.

The findings from the bibliometric analysis in Chapter 2 provide crucial insights for academics, universities, and government bodies, highlighting the importance of SME digitalisation as a key research area in Italy and Spain. Academic institutions should prioritise this field and allocate resources to support further studies. Interdisciplinary and cross-border collaborations are essential for improving research quality and impact. The presence of multiple author clusters in Italy indicates opportunities for creating specialized research groups, with universities playing a crucial role in fostering these initiatives. Governments should increase funding for SME digitalisation research, recognising its potential for economic growth and competitiveness, and support programs that facilitate international research collaborations and align with broader economic and technological goals.

Moreover, the findings from Chapter 3 have important implications for management and public policy. They highlight the necessity of investing in human capital and training to address the digital transformation challenges faced by SMEs. Managers should prioritise continuous workforce development by customising training programs and fostering a culture of adaptability. Public administration should support this by incentivising training initiatives and improving access to ICT consulting services rather than running training programs directly. Additionally, the research underscores the importance of interaction within digital ecosystems in which companies, universities and research institutions and administrations collaborate. SMEs are encouraged to engage with and contribute to these networks, where management can also benefit from leveraging ICT consulting services for specialised expertise, allowing for optimised resource allocation. While public administration can play a key role in developing and enhancing digital ecosystems to support SME participation.

Furthermore, the outcomes of Chapter 4 have substantial implications for managerial practice. They underscore the critical importance of investing in human capital, particularly by enhancing digital awareness and skills, as a cornerstone of any comprehensive strategy to overcome obstacles to e-commerce adoption in SMEs. This investment not only addresses the immediate challenges but also builds a foundation for long-term success in the digital landscape. In addition, the findings highlight the significance of financial factors, such as access to funding and a robust support ecosystem, which are essential for facilitating e-commerce acceptance. Ensuring that SMEs have adequate financial resources and are part of a well-developed ecosystem can significantly impact their ability to adapt and thrive with digital technologies. The results also suggest the value of proactive interaction and collaboration with other industry players. SMEs should actively engage with and contribute to industry networks and partnerships to leverage collective expertise and resources. Building and maintaining these relationships within their organizational structure can help SMEs navigate the complexities of digital transformation more effectively by developing e-commerce.

Lastly, the findings from Chapter 5 corresponding to the implementation of AI in SMEs yields also substantial implications for management and public policy. From a managerial perspective, the results underscore the need to enhance digital skills within companies for successful AI adoption. Recruiting IT specialists is crucial for SMEs, as they provide essential expertise in needs assessment, systems integration, data management, and cybersecurity, key components for effective AI implementation. Additionally, investing in training programs to improve both personnel and managerial skills is vital for integrating AI successfully. From the policy view, public administrations can play a significant role by creating initiatives to boost fundamental digital competencies. This includes developing targeted training programs, offering financial support or grants for technology integration, and fostering partnerships between SMEs and educational institutions or research centres. Furthermore, incorporating AI competencies into education systems is essential. By promoting digital skills and capabilities within SMEs, policymakers can drive innovation, enhance productivity, and improve competitiveness across the broader economy.

If we sum up the implications from Chapters 3, 4, and 5, we can see the critical importance of human capital and investment in the digitalisation process. Enhancing digital skills, defining strategic management and investing in relevant training are essential for successful digital transformation. Equally important is the availability and engagement within a digital ecosystem. Effective collaboration with technology providers, industry partners, and research institutions is vital for accessing the resources and expertise necessary for digital adoption. Together, strategic

investment in human capital and active participation in digital ecosystems significantly accelerate the digitalisation process and support sustainable growth.

6.3 Limitations and Prospects for Future Studies

In Chapter 2, several limitations of this research are acknowledged. To begin with, the study relied exclusively on data from the Scopus database, which may limit the scope of available articles in other databases. Furthermore, the analysis was restricted to performance evaluation alone. This approach was intentionally chosen to maintain the paper's clarity and brevity. When it comes to future study prospects, it would be interesting to explore the co-citation analysis within the same context. In this regard, it is suggested to merge several databases for this analysis.

In Chapter 3, the findings may be influenced by the exceptional circumstances and rapid changes brought about by the pandemic. Therefore, future research should consider a comparative analysis of the pre- and post-COVID-19 periods to better understand the long-term impacts of the pandemic on various industries. Moreover, it could also be interesting to investigate digitalisation through organisational change and marketing techniques. Additionally, it could also be curious to employ ISEE and PITEC databases for the same type of analysis in the case of Italy.

In Chapter 4, limitations start with a focus on the COVID-19 pandemic and its impact on e-commerce. Firstly, the findings may be influenced by the pandemic, potentially limiting the generalisability of the results to other periods. Secondly, the dynamic nature of the e-commerce landscape during this time may have introduced heterogeneity in the data, as enterprises likely adopted a wide variety of individual strategies and practices. This variability could affect the consistency of the findings. Thirdly, while the TEO framework addresses broader groups, it may oversimplify the complex real-world implications. In practice, further subcategorisation might be necessary for a more accurate application.

In Chapter 5, most notably, the majority of variables in the econometric analysis are dichotomous. Future research could benefit from using Likert scales to capture the intensity of responses more effectively. As can be seen, the

COVID-19 period and its impact were the main limitations that also yielded new research directions. It would be interesting to investigate the long-term impacts of the pandemic by comparing data from pre- and post-COVID-19 periods. While the insights are valuable for Spanish SMEs, the context-dependent nature of the results must be recognised. Thus, further studies are needed to generalise the findings and assess their applicability in other countries.

Additionally, future research could investigate whether the conclusions of this thesis hold true for larger enterprises across various industries. Such studies could assess whether the changes observed during the pandemic are permanent shifts or temporary adaptations. Additionally, understanding the sustained effects of organisational change, marketing strategies, and customer behaviour would offer a more comprehensive perspective. Moreover, future research could focus on understanding the factors that influence cybersecurity practices in SMEs. Research could examine how awareness of cyber threats, financial constraints, and the presence of a clear digital strategy affect SMEs' ability to adopt advanced cybersecurity measures.

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