

Digital Transformation in Family Firms: Evidence from the European Union

Isaac Ribeiro Moreira

Doutoramento

**Digital Transformation in Family Firms:
Evidence from the European Union**

Orientação: Professora Doutora Sofia Elisabete Ferreira Gomes

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DEDICATORY

*À minha família,
minha mãe, minha irmã,
minha companheira e
meu filho Bernardo.*

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The journey of this thesis began with a single step and unfolded across many places and through the support of numerous individuals. While it would be impossible to name every person who contributed to this endeavor, I feel compelled to highlight some particularly meaningful collaborations.

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ABSTRACT

Recent global events, such as the Covid-19 pandemic and the disruptive advance of digital technologies, have triggered profound transformations in the European business landscape, particularly affecting small and medium-sized family-owned enterprises. Representing between 65% and 80% of businesses in the European Union and employing around 100 million people, these firms now face the challenge of reconciling foundational family values with the urgent need for technological adaptation. Digital transformation has evolved from a strategic opportunity into a critical condition for competitiveness, innovation, and sustainability.

However, the adoption of digital technologies is not uniform. Internal factors, such as governance structures, organizational culture, digital skills, and technological infrastructure, significantly shape companies' readiness for digitalization. At the same time, external factors, such as access to public and private financing, the strength of local business ecosystems, regional innovation networks, and regulatory clarity, are crucial for enabling the adoption of technologies, particularly those with higher complexity.

In this context, this thesis aims to analyse in an exploratory way how family businesses in the European Union are adopting digital transformation, analysing their implementation patterns, the internal and external factors that influence this process, as well as the capabilities and strategies that can facilitate effective adoption of digital technologies.

The results obtained show a strong complementarity, allowing for a comprehensive and articulated understanding of digital transformation in European family businesses. Study 1 highlighted the following theoretical domains: i) "Digital Transformation: Dynamic Capabilities and Organizational Strategies", ii) "Challenges, Facilitators, Innovation, and Entrepreneurship in Technological Ecosystems," and iii) "Cooperation and Sustainability in the Digital Age". Study 2 reveals a still low and uneven adoption of digital technologies, identifying three distinct implementation patterns conditioned by factors such as sector, size, seniority and financial capacity. Finally, Study 3 shows that companies with internal and external conditions positively influence the adoption of digital technologies, especially when they have a favourable attitude towards digital transformation. This attitude, known as the 'technological approach', proved to be essential, in that the more positive it is, the greater the likelihood of adopting technologies.

This research proposes an integrated model that links dynamic capabilities, contextual enablers, and organizational strategies, contributing to theoretical development and offering practical recommendations for business leaders and policymakers. The findings highlight the importance of fostering a more inclusive, strategic, and sustainable digital transition for family businesses in a rapidly evolving global environment.

Keywords: Digital transformation; Family businesses; Dynamic Capabilities; Organizational Strategies; Flash Eurobarometer 486.

Digital Transformation in Family Firms: Evidence from the European Union

RESUMO:

Eventos recentes à escala global, como a pandemia de Covid-19 e os avanços disruptivos das tecnologias, catalisaram profundas transformações no tecido empresarial europeu, com especial impacto nas pequenas e médias empresas de cariz familiar. Estas organizações, que representam entre 65% a 80% das empresas na União Europeia e empregam cerca de 100 milhões de pessoas, enfrentam o desafio de conciliar os seus valores fundacionais com a necessidade urgente de adaptação tecnológica. A transformação digital passou de oportunidade estratégica a uma condição essencial de competitividade, inovação e sustentabilidade.

Contudo, a adoção de tecnologias digitais não ocorre de forma uniforme. Fatores internos, como a estrutura de governança, a cultura organizacional, as competências digitais e as infraestruturas tecnológicas, influenciam significativamente a predisposição para a digitalização. Simultaneamente, fatores externos como o acesso a financiamento, a força dos ecossistemas empresariais, a existência de redes de inovação e a clareza do enquadramento legal e administrativo revelam-se determinantes, sobretudo na adoção de tecnologias mais complexas.

Neste contexto, esta tese visa analisar de forma exploratória como as empresas familiares da União Europeia estão a adotar a transformação digital, analisando os seus padrões de implementação, os fatores internos e externos que influenciam esse processo, bem como as capacidades e estratégias que podem facilitar uma adoção eficaz das tecnologias digitais.

Os resultados obtidos demonstram uma forte complementaridade, permitindo uma compreensão abrangente e articulada da transformação digital nas empresas familiares europeias. O Estudo 1 evidenciou como domínios teóricos: i) "Transformação Digital: Capacidades Dinâmicas e Estratégias Organizacionais", ii) "Desafios, Facilitadores, Inovação e Empreendedorismo em Ecossistemas Tecnológicos" e iii) "Cooperação e Sustentabilidade na Era Digital". O Estudo 2 revela uma adoção baixa e desigual de tecnologias digitais, identificando três padrões distintos de implementação condicionados por fatores como setor, dimensão, antiguidade e capacidade financeira. Por fim, o Estudo 3 demonstra que as condições internas e externas das empresas influenciam positivamente a adoção de tecnologias digitais, sobretudo quando têm uma atitude favorável à transformação digital. Esta atitude, designada por "abordagem tecnológica", revelou-se essencial, na medida em que quanto mais positiva for, maior é a probabilidade de adoção de tecnologias.

No final, esta investigação propõe um modelo integrado que articula capacidades dinâmicas, fatores contextuais e estratégias organizacionais, contribuindo para o avanço do conhecimento teórico e oferecendo recomendações práticas para gestores e decisores públicos, com vista a uma transição digital mais inclusiva e sustentável.

Palavras-chave: Transformação Digital; Empresas Familiares; Capacidades Dinâmicas; Estratégias Organizacionais; Flash Eurobarómetro 486.

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PART I

CHAPTER 1 – INTRODUCTION

1.1 Motivation and Rationale

Digital transformation has emerged as one of the main strategic axes for business development in the 21st century. Its importance lies not only in the adoption of new technologies but above all, in the profound reconfiguration of processes, business models and organizational structures, guiding companies toward greater efficiency, agility and innovation (Vial, 2021; Beverungen et al., 2022). In a global scenario marked by technological acceleration, increasing connectivity and uncontrollable aspects such as the COVID-19 pandemic, the digital transition is no longer a competitive advantage but has become an imperative for survival, including for small and medium-sized enterprises (Nguyen, 2024; Roblek et al., 2021).

In this context, family businesses play a key role. They represent between 65% and 80% of all businesses in the European Union, employing approximately 100 million people in the private sector (European Family Businesses, 2024). These organizations are known for their resilience, long-term orientation, and strong connection to the territories in which they operate. However, these same structural and cultural characteristics can make digital transformation particularly challenging. Studies show that factors such as resistance to change, centralization of decision-making among senior leaders, concern for preserving the legacy, and a lack of digital skills among family members constitute critical barriers to the implementation of emerging technologies (Massis et al., 2020; Bürgel et al., 2023; Civelek et al., 2023).

Despite the increase in research on digital transformation, a significant gap remains in its analysis within family contexts. Most studies focus on non-family businesses, often large or in the technology sector, neglecting the unique characteristics and dynamics of family businesses. Existing research tends to be qualitative or theoretical, with a scarcity of comprehensive empirical analyses that explore regional, technological, and strategic patterns. There is, therefore, a legitimate need to advance our understanding of how these companies are tackling the digital transformation process and what factors are shaping their technological trajectory (Soluk & Kammerlander, 2021; Rashid & Ratten, 2020; Prügl & Spitzley, 2021).

This thesis aims to fill this gap by comprehensively and empirically investigating the patterns of digital technology adoption by European companies and identifying the drivers of this adoption. Using a robust database from Flash Eurobarometer 486, which covers 2,523 family businesses from the 27 Member States of the European Union, a

research model was developed that integrates three dimensions: the internal environment (human resources, infrastructure and organizational culture), the external environment (access to finance, institutional support and regulatory context) and the strategic approach adopted by companies towards digitalization. This model was constructed in light of the contingency model framework (Müller et al., 2024; Broccardo et al., 2023), according to which there are no universal solutions, and the effectiveness of digital transformation depends on the degree of alignment between contextual factors and strategic decisions.

Theoretically, the thesis contributes to the advancement of the debate on digital transformation in family businesses, proposing an integrative approach that recognizes the multidimensional nature of the problem. By introducing the variable 'approach to digital technologies' as a mediator between context and technology adoption, it offers an innovative explanatory lens with an empirical basis and concrete applicability. In practice, the results obtained have direct implications for managers, consultants, policymakers, and business support institutions. By identifying the factors that most influence different levels of digital maturity, the study offers valuable guidelines for the design of training, financing, mentoring, and targeted fiscal policy strategies (Sati, 2024).

The choice of this subject of study also stems from personal, professional, and intellectual motivation. Throughout my academic and professional career, I have been able to observe first-hand the dilemmas faced by family businesses in the digital transition. This proximity has sparked a genuine interest in understanding how these organizations can incorporate technologies without compromising their values, identity, and purpose.

Ignoring this issue has significant consequences. Failure to adopt technologies by family businesses can mean a loss of competitiveness, stagnation of innovation processes, worsening generational succession difficulties and, ultimately, the closure of businesses that are historically relevant to the regional and national economy. Furthermore, it compromises the effectiveness of the European Union's public policies on cohesion and digital inclusion, which depend on the active involvement of this business segment to ensure a sustainable and equitable digital transition. Thus, studying digital transformation in family businesses is not only relevant — it is also an academic, economic and social urgency.

1.2 Objectives of the work

This doctoral thesis aims to provide an in-depth understanding of the factors that influence the adoption of digital transformation by family businesses in the European Union. The relevance of the topic is justified both by the structural role that these companies play in national and regional economies and by the specific characteristics that make them particularly challenging in processes of technological change. Recent studies show that, although digital technologies are recognized as critical drivers of innovation, efficiency and sustainability, their integration into family businesses is uneven and often limited (Massis et al., 2020; Civelek et al., 2023; Soluk & Kammerlander, 2021).

Thus, the overall objective of this thesis is to explore how family businesses in the European Union are adopting digital transformation, analyzing their implementation patterns, the internal and external factors that influence this process, as well as the capabilities and strategies that can facilitate the effective adoption of digital technologies.

To operationalize this central objective, four specific objectives were defined, aligned with the empirical phases of the research, corresponding to the three scientific articles that comprise the central chapters of the thesis. First, to conduct a systematic review of the literature on digital transformation in family businesses, to identify theoretical, methodological and empirical gaps that have yet to be explored. The second aims to map and characterize the patterns of digital technology adoption in family businesses in the 27 Member States of the European Union, based on a set of seven advanced technologies — artificial intelligence, big data analytics, blockchain, cloud computing, robotics, smart devices and high-speed infrastructure — selected for their relevance and recurrence in the European business context, as evidenced by data from Flash Eurobarometer 486 and recent studies (Kumar, 2024; Nguyen et al., 2023). The third objective comprises an integrated analysis of the contextual, internal, and external factors that condition technological adoption in this type of organization. The analysis considers variables such as the availability of skilled human resources, the adequacy of technological infrastructure, the cultural orientation of the company, access to financing, institutional support, the maturity of the regional digital ecosystem, and the regulatory framework. This objective also includes investigating the mediating role of the strategic approach adopted by family businesses in the digital transformation process, understood as the deliberate predisposition to incorporate digital technologies into the business model (Ferreira et al., 2023; Rashid & Ratten, 2020; Überbacher et al., 2020). Finally, the fourth objective consists of the construction and empirical validation of an integrated theoretical model that represents the interactions between the organizational environment, business strategy, and the digital transformation process.

The articulation between these objectives aims not only to deepen scientific

knowledge about digital transformation in family contexts but also to generate practical evidence that can support managers, policymakers, and development institutions in designing more effective and contextualized strategies. Recognizing the structural and cultural heterogeneity of family businesses in Europe, this thesis aims to contribute to a more inclusive and sustainable digital transition that is aligned with the specificities of this business segment (Table 1).

Table 1 - Research questions and proposed objectives.

	Objectives Chapters	Objective 1 Chapter 2	Objective 2 Chapter 3	Objective 3 Chapter 4	Objective 4 Chapter 5
Research Questions		Conduct a systematic review of the literature on digital transformation in family businesses with the aim of identifying theoretical, methodological and empirical gaps that have yet to be explored.	Map and characterize patterns of digital technology adoption in family businesses in the 27 Member States of the European Union, based on a set of seven advanced technologies.	Analyze the internal and external factors that influence the adoption of technologies in family businesses. This also includes investigating the mediating role of the strategic approach in the digital transformation process.	Construct and empirically validate an integrated theoretical model that represents the interactions between the organizational environment, business strategy, and the digital transformation process.
What are the main thematic areas, gaps and opportunities identified by the scientific literature on digital transformation in family businesses?		✓			
What patterns can be identified in the adoption of digital technologies by European family businesses?			✓		
How do organizational characteristics (sector, employees, seniority, performance) influence these patterns?			✓		
What is the influence of internal and external environments on the adoption of digital technologies by family businesses?				✓	
What is the mediating role of the strategic approach adopted by companies in implementing digital transformation?				✓	

Source: Own elaboration

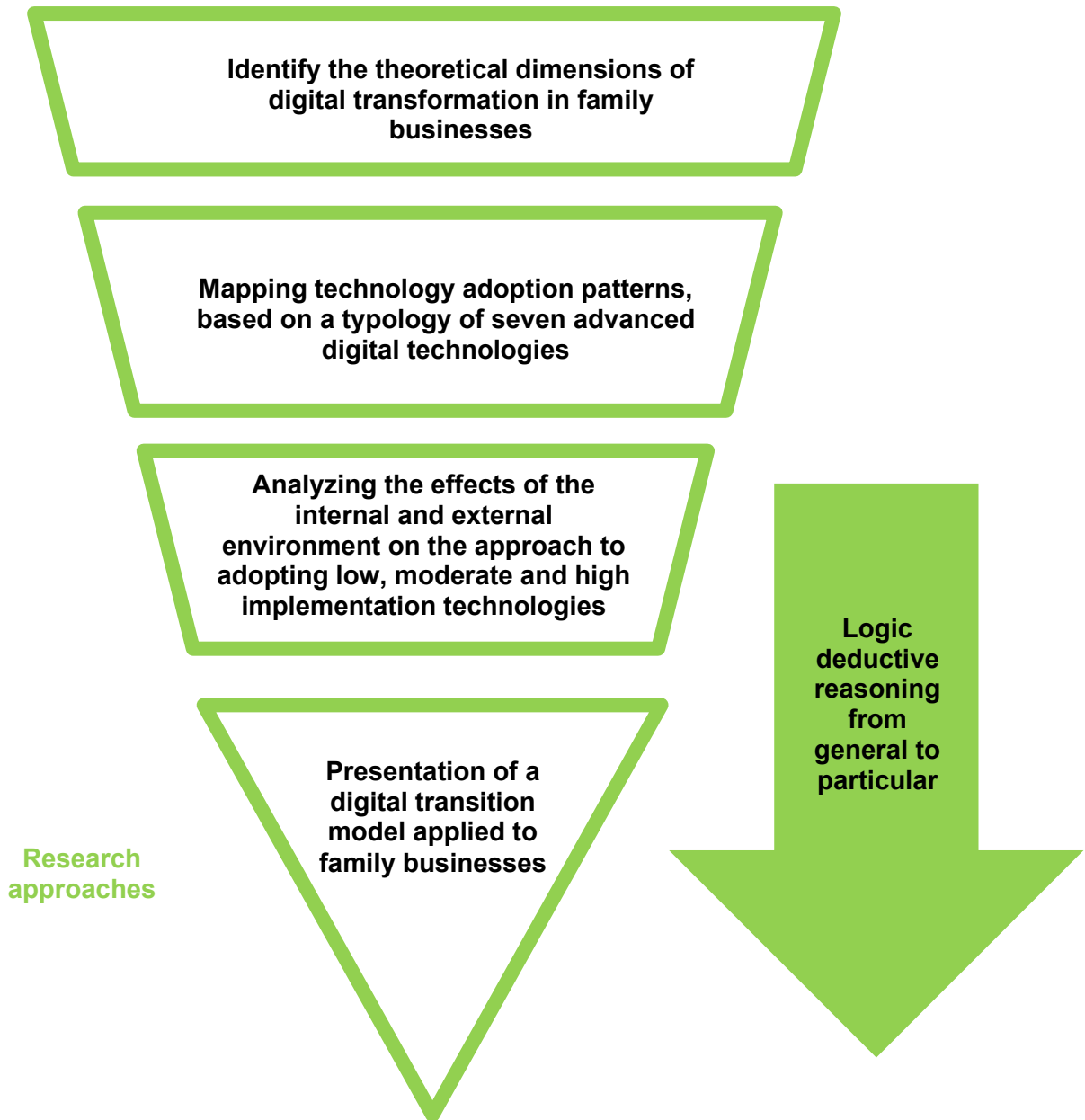
1.3 Methodology

The methodological construction of this thesis is based on the assumption that epistemological adequacy and rigor in the choice of scientific methods directly impact the validity, reliability, and applicability of the results achieved (Scandura & Williams, 2000). Based on an analysis of how knowledge is conceived and developed in science, this research recognizes the importance of epistemological foundations as a guiding basis for methodological decisions. In this sense, and in light of the debate proposed by Mantere and Ketokivi (2013), this work adopts a deductive reasoning logic, following a descending chain of reflection that starts from general theoretical premises to formulate testable hypotheses applicable to specific empirical contexts.

According to the literature, there are three fundamental forms of scientific reasoning: abduction, induction, and deduction (Scandura & Williams, 2000). In the case of this thesis, the reasoning is eminently deductive, given that it starts from a previously established theoretical model supported by international scientific literature to empirically test specific hypotheses related to digital transformation in family businesses. According to Behfar and Okhuysen (2018), deductive reasoning ensures a higher degree of certainty: if the premises are true, the conclusions will necessarily be valid as well. In contrast, inductive reasoning offers probable explanations (based on the observation of patterns) and abductive reasoning proposes plausible explanations, still subject to review (Behfar & Okhuysen, 2018).

The structure of this thesis, composed of three empirical studies and anchored in consolidated theoretical models, follows this deductive logic. The theoretical model that guides the research is based on the Organisational Contingency Model (Müller et al., 2024; Broccardo et al., 2023) and the dynamic capabilities framework (Teece, 2007; Soluk & Kammerlander, 2021), proposing that the effectiveness of digital transformation depends on the congruence between the internal conditions of the organization, the external environment and the strategic orientation adopted by family businesses (Figure 1).

Figure 1 - Research scientific method.



Source: Own elaboration.

1.3.1 Approaches in individual chapters

Each chapter used different methodologies. Part II, which includes chapters 2, 3, and 4, concisely summarises the study, with the techniques used in each chapter described in Table 2. Below is additional information about the methodological approach of the thesis.

Chapter 1 introduces the topic of this thesis, and Chapter 5 presents the final conclusions drawn.

Table 2 - Systematization of the adopted methodology.

Chapter	Methodology
Chapter 2	Bibliometric study - VOSviewer version 1.6.17.
Chapter 3	Quantitative - SPSS v.25 - statistical analysis e correspondences analysis; R package multilevLCA – Latent Class Analysis.
Chapter 4	Quantitative - SPSS v.25 - statistical analysis; Smart PLS 4.0 software - Partial Least Square method.

Source: Own elaboration.

The research was organized into three distinct phases, reflected in the scientific articles that make up the empirical chapters of the thesis. Each phase aligns with the deductive approach adopted: a general premise is formulated, hypotheses are identified on this basis, and their validity is then tested with empirical data.

In Chapter 2, a systematic review of the literature was conducted. The general theoretical basis was constructed from the identification and categorization of recurring themes in the scientific literature on digital transformation in family businesses. Using VOSviewer software (van Eck & Waltman, 2010), co-occurrences of keywords and citation networks in articles indexed in the Web of Science database were analysed. This analysis resulted in the proposal of an integrative conceptual model composed of three dimensions: (i) Digital Transformation: Dynamic Capabilities and Organisational Strategies; (ii) Challenges, Facilitators, Innovation, and Entrepreneurship in Technological Ecosystems; and (iii) Cooperation and Sustainability in the Digital Age.

Chapter 3 consisted of mapping the adoption patterns of seven digital technologies (artificial intelligence, big data, blockchain, cloud computing, robotics, smart devices and high-speed networks) in family businesses in the European Union. Using a sample composed of data from Flash Eurobarometer 486, the Latent Class Analysis (LCA) method was applied (Linzer & Lewis, 2011). In this way, the digital maturity profiles of companies were identified based on these seven technologies (Nguyen et al., 2023; Kumar, 2024). In addition, a correspondence analysis was carried out to verify the relationship between the identified patterns and the characteristics of the companies, such as size measured by number of employees, sector of activity, year of foundation, turnover and turnover performance. This stage, although exploratory, was based on the assumption that company characteristics significantly influence patterns of technology adoption (Massis et al., 2020; Prüggl & Spitzley, 2021).

In Chapter 4, a research model formulated based on the literature review was tested, which assumes that internal and external conditions influence the adoption of

digital technologies, with this effect being mediated by the strategic approach adopted by family businesses. The constructs, internal environment, external environment, strategic predisposition, and technology adoption, were measured with data collected in the Eurobarometer 486 questionnaire. The research model formulated was tested using the Partial Least Squares - Structural Equation Modelling (PLS-SEM) method, using SmartPLS 4.0 software.

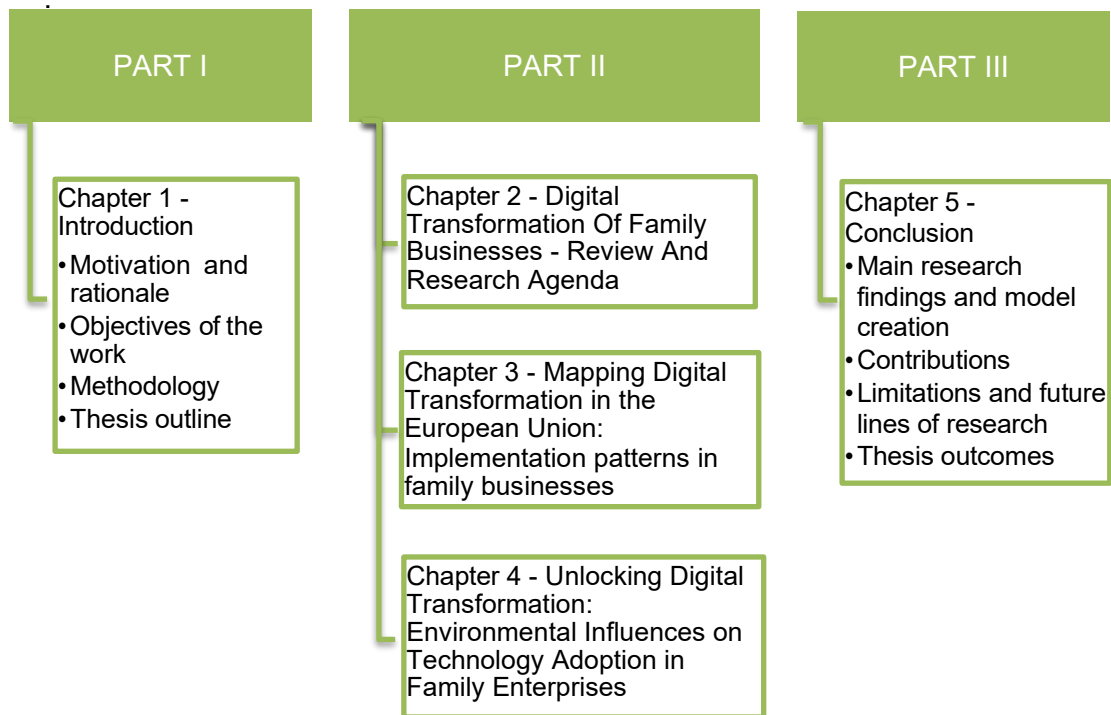
In summary, the methodology of this thesis was designed based on a structured deductive process, in which hypotheses formulated from theoretical premises are tested with empirical data. This epistemological approach supports the robustness of the results obtained and ensures internal consistency between the research objectives, the methods applied, and the contributions generated for theory and practice.

1.4 Thesis outline

This thesis is structured in three parts (Figure 2). Part I consists of Chapter 1 — Introduction. In this chapter, the motivation and rationale, the objectives of the work, the methodology and the thesis outline are presented. Part II consists of three chapters, which are interrelated and contribute to the main objective of thesis. They are the Chapter 2 - Digital Transformation Of Family Businesses - Review And Research Agenda; Chapter 3 - Mapping Digital Transformation in the European Union: Implementation patterns in family businesses; and Chapter 4 - Unlocking Digital Transformation: Environmental Influences on Technology Adoption in Family Enterprises. In each of these chapters, a study is presented that focuses on each of the three specific objectives.

Finally, Part III presents the Chapter 5 - Conclusion, where the main research findings, the proposed model, contributions to theory and practice, research limitations and future lines of research are presented. At the end of this chapter, the studies that make up the body of work of this thesis that have already been published are presented.

Figure 2 - Thesis outline



Source: Own elaboration.

Part II

CHAPTER 2 - DIGITAL TRANSFORMATION OF FAMILY BUSINESSES - REVIEW AND RESEARCH AGENDA

Abstract:

The Family businesses increasingly adopt digital technologies for sustainable growth, navigating challenges and opportunities. This study analyzed 156 Web of Science articles using VOSviewer, identifying three domains: i) "Digital Transformation: Dynamic Capabilities and Organizational Strategies," ii) "Challenges, Facilitators, Innovation, and Entrepreneurship in Technological Ecosystems," and iii) "Cooperation and Sustainability in the Digital Age." Findings emphasize dynamic capabilities for adapting to trends, preserving legacy, and fostering resilience. Technological innovation and intergenerational cooperation are vital for sustainable models. Digital transformation requires cultural alignment, digital skills, and collaboration. The framework developed provides practical strategies for balancing tradition and innovation in family businesses.

Keywords: Family Businesses; Digital Transformation; Family Ownership; Dynamic Capabilities; Organizational Strategies.

2.1. Introduction

Family businesses are the oldest organizational type in the world. They represent an essential wealth creation pillar in emerging and more developed economies (Soluk & Kammerlander, 2021). These companies stand out for long-term stability and resilience (Ren et al., 2023). They can cross generations, responding to market changes and consumer demands (Roth, 2023). However, the digital transformation has brought new challenges and opportunities for family businesses. While it has facilitated business operational efficiency, it has also led to intergenerational conflicts, especially in leadership and strategic decisions (Bürgel & Hiebl, 2023).

Digital transformation refers to the renewal of processes, competencies and strategies by adopting emerging technologies (Lin et al., 2024). Some of the emerging technologies include artificial intelligence, internet of things, blockchain, robotics, big data, high-speed infrastructures, smart devices and cloud computing (Hsiung & Wang, 2022; Kumar, 2024; Nguyen et al., 2023; Saghiri et al., 2020; Tuncalp, 2024). This process goes beyond introducing technologies, involving cultural and structural changes, altering how companies operate and compete (Begnini et al., 2023; Vial, 2021). Digital transformation faces barriers in family businesses (Begnini et al., 2023). Aspects such as conservatism, a focus on non-economic objectives and a preference for incremental innovations hinder the digital evolution process in this type of economic organization (Begnini et al., 2023).

The family's involvement in the strategic decisions of companies plays a decisive role in the digital evolution of these organizations in the contemporary context (Cree & Mackenzie, 2023). Previous literature has explored the motivations, challenges and opportunities associated with digital transformation in family businesses. Among the main motivations identified are technological advances and the need to innovate for competitiveness (Verma et al., 2023; Cannas, 2023). However, there is still a need for further research into the dynamic capabilities of family businesses, turning them into an efficient path to achieving the benefits offered by digital transformation.

This study fills this gap by conducting a systematic literature review based on 156 articles, resulting in the development of a framework that structures three essential dimensions for achieving the benefits of digital transformation. This framework includes: (i) dynamic capabilities and organizational strategies, which involve identifying technological trends, harnessing innovations for new products and services and reconfiguring processes in an inclusive and sustainable way; (ii) challenges and facilitators of the digital transformation process, which include barriers such as resistance to change, lack of digital knowledge and limited resources, as well as facilitating factors

such as upskilling, promoting a culture of innovation and establishing strategic partnerships; and (iii) expected performance results, which include increased organizational resilience, improvements in efficiency, greater capacity for innovation and strengthening intergenerational collaboration.

This work contributes to the literature by presenting a systematic approach that integrates consolidated theories and empirical evidence, highlighting the benefits of digital transformation, such as greater efficiency, innovation, organizational resilience and sustainable competitiveness in family businesses. In addition, the study aims to provide practical guidance for family managers by promoting strategies that balance technological innovation with the values and dynamics of this type of organization. Thus, by exploring the key dimensions of the framework, the aim is not only to understand the challenges and opportunities associated with digital transformation, but also to propose solutions that enhance the sustainability and success of family businesses in a context of constant technological evolution.

2.2 Methodology

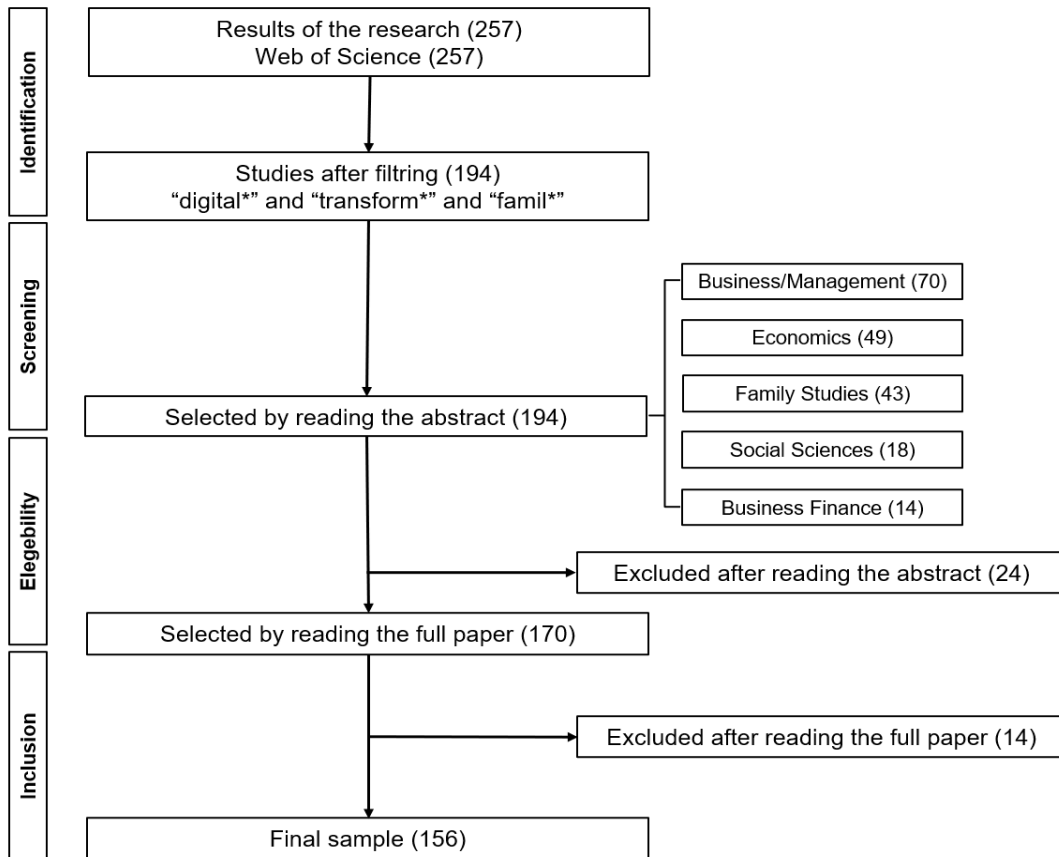
The current systematic literature review followed the methodological protocol of Brizola (2016). The process was organized into four main stages: sample identification, screening, eligibility assessment and inclusion of the studies selected for analysis. This method ensured rigor, reliability and validity throughout the investigation.

The search was carried out in December 2024, using the Web of Science database, due to its thematic scope, advanced search tools and organized citation data, which are fundamental aspects for systematic literature reviews (Saura et al., 2023). The keywords "digital*", "transform*" and "famil*" were used, combined according to the protocols suggested by (Saura et al., 2023; Vial, 2021). This initial cross-check identified 257 studies.

To refine the results, filters were applied to restrict the search to specific areas of interest, such as "Economics", "Business/Management", "Family Studies", "Business Finance" and "Social Sciences". In addition, only articles and review articles written in English were considered, resulting in a sample of 194 studies.

Of the 194 studies obtained, 24 were excluded after reading the abstract. 170 studies were then selected for full reading. This detailed reading led to the exclusion of 14 studies due to lack of relevance, resulting in a final sample of 156 studies selected for bibliometric analysis and discussion, as seen in Figure 3.

Figure 3 - Steps involved in the methodology.



Source: Own elaboration

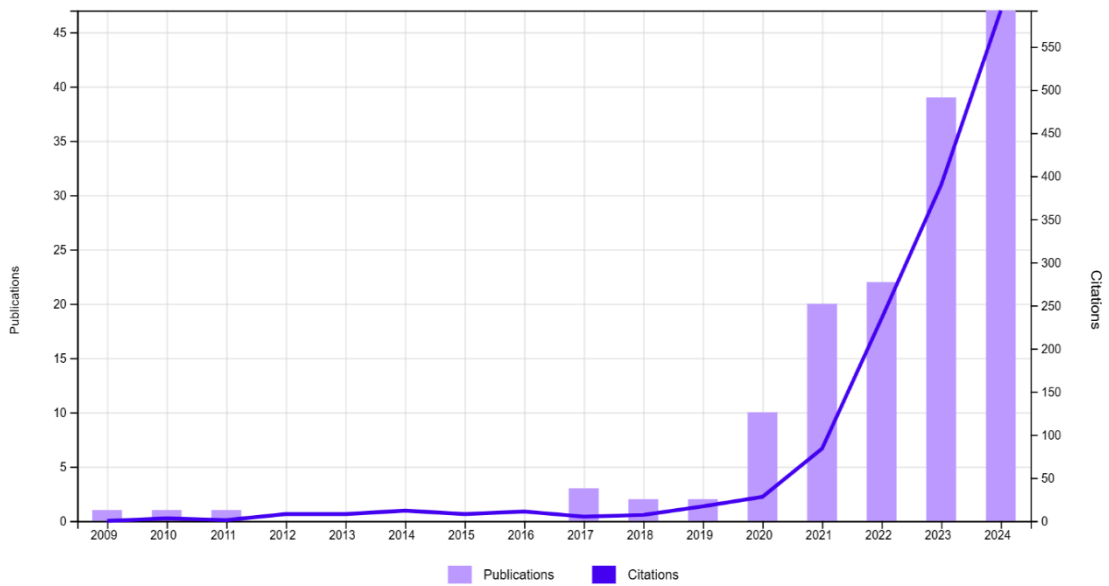
The bibliographic coupling was conducted with the help of VOSviewer software, which is widely recognized in bibliometric network analysis (Effendi et al., 2021). This software can map connections between authors, documents and key terms, enabling the identification of research patterns and the construction of thematic clusters (Putri et al., 2021). The use of VOSviewer provided significant insights by highlighting trends and recurring focuses in the field of digital transformation in family businesses.

2.3 Results

2.3.1 Sample evolution

An analysis of publications and citations provides an insight into the evolution of the topic. Figure 4 highlights the increase in academic interest in digital transformation in family businesses, reflecting its growing relevance in the current context.

Figure 4 - Evolution of publications.



Source: Own elaboration based on data available at <https://www.webofscience.com/>.

Between 2009 and 2016, the number of publications remained very low, varying between 0 and 5 per year. This indicates that the topic was still little explored. The topic can be considered emerging during this period, but with little attention from the scientific community.

Since 2017, there has been a gradual increase in the volume of publications. This period suggests that the topic is beginning to consolidate, possibly driven by technological advances or the growing importance of digital transformation. Between 2017 and 2019, the number of publications was still moderate, but already showing consistent growth. From 2020 onwards, there was an exponential increase in publications, peaking in 2023 and 2024. This growth, driven by the COVID-19 pandemic, has accelerated the digital transformation in various sectors, including family businesses. In 2024, the number of publications peaked, consolidating digital transformation as a central topic of academic research.

The number of citations has also evolved remarkably over time. Between 2009 and 2016, citations were very low, in line with the small volume of publications. In this initial period, the studies published did not yet have much impact in the scientific world. Between 2017 and 2019, citations grew gradually, vying for wider recognition of the topic by the scientific community. The first published works began to be used as a basis for new research, signalling the start of a consolidated knowledge network around the topic. After 2020, citations grew rapidly, accompanied by an increase in publications. In 2023 and 2024, the figures reached a high level, exceeding 500 citations in 2024. This growth indicates that the studies published in this period have high scientific relevance, showing

the topic's emergence in the scientific environment.

The search was carried out in December 2024, using the Web of Science database, due to its thematic scope, advanced search tools and organized citation data, which are fundamental aspects for systematic literature reviews (Saura et al., 2023). The keywords "digital*", "transform*" and "famil*" were used, combined according to the protocols suggested by (Saura et al., 2023; Vial, 2021). This initial cross-check identified 257 studies.

2.3.2 Most cited magazines

Table 3 shows the data from the 10 journals that have published the most articles in the field of digital transformation in family businesses. In all, 156 articles were published in 39 journals. These 10 journals concentrate a significant part of the publications and citations, playing a central role in disseminating of knowledge on the subject.

Table 3 – Most relevant journals

Source	Documents	Citations	Total Link Strength
Journal of Family Business Management	13	73	858
IEEE Transactions on Engineering Management	4	18	637
European Journal of Innovation Management	3	9	546
European Journal of Information Systems	3	9	546
International Journal of Innovation Management	2	4	538
Journal of Business Research	5	141	438
European Journal of Information Systems	1	141	309
Journal of the Knowledge Economy	4	76	262
Technology in Society	4	28	240
Journal of Management Studies	2	69	201

Source: Own elaboration based on data available at <https://www.webofscience.com/>.

The Journal of Family Business Management is the most relevant. This journal published 13 articles, which represents 8.78% of the sample. It also has 73 citations and the highest Total Link Strength. The other journals have fewer publications, but some stand out for their impact. For example, the Journal of Business Research has only

published 5 articles, but has 141 citations. This demonstrates the relevance and quality of the work published. Similarly, the journal "IEEE Transactions on Engineering Management" has 4 published articles and 18 citations, with a Total Link Strength of 637.

The 10 journals together published 42 articles. This is equivalent to 28.38% of the total number of publications in the sample. In terms of citations, these journals have accumulated 338 citations. This represents 87.17% of the total number of citations. These figures show that a few journals concentrate the majority of citations, reinforcing their importance in the scientific environment.

The total link strength also reflects the relevance of these journals. The journals with the highest link strength, such as "Journal of Family Business Management" and "IEEE Transactions on Engineering Management", are the ones that contribute most to the dissemination of knowledge in the field of digital transformation in family businesses.

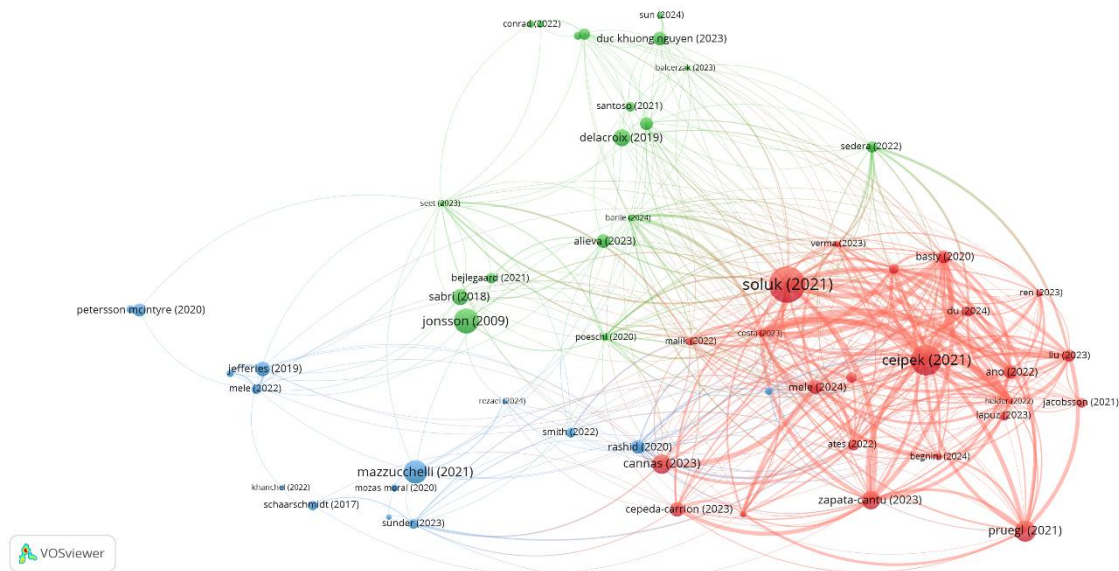
2.3.3 Co-occurrence analysis

As this is a topical issue, it is also important to understand which topics academics have focused on over time and which are the most recent and relevant fields to study. To this end, VOSviewer was used to analyze publication trends over the years by applying a co-occurrence analysis of the keywords in the 156 articles under study. A minimum of two occurrences was defined as a criterion, and this minimum was set to make the results more robust. On the other hand, excluding less relevant words makes the map more graphically appealing and easier to interpret. Other authors have already applied this filtering, such as Putri et al. (2021) and Effendi et al. (2021). Figure 5 shows the 37 most relevant keywords in the subject under study, divided into 4 thematic groups.

The first cluster, colored red, covers topics related to digital transformation, entrepreneurship and emerging technologies. Words such as "impact", "entrepreneurship" and "management" stand out, indicating their centrality in scientific circles. The second cluster, in green, explores topics related to business, dynamic capabilities and value creation. Terms such as "strategy", "value creation" and "information-technology" appear as central elements. The third cluster, in blue, focuses on family businesses, socio-emotional wealth and innovation. Words such as "family business", "socio-emotional wealth" and "digital transformation" are the most frequently mentioned, showing the relevance of these themes. The fourth cluster, in yellow, deals with open innovation and knowledge management in family businesses. Terms such as "open innovation" and "knowledge management" are the most prominent in this cluster.

and Entrepreneurship in Technological Ecosystems" with 47 articles and blue to cluster 3 called "Dynamics of Cooperation and Sustainability in the Digital Age" with 43 articles.

Figure 6 – Bibliographic coupling analysis.



Source: Own elaboration.

2.3.4.1 Cluster 1 – “Digital Transformation: Dynamic Capabilities and Organizational Strategies”

The studies in this cluster approach digital transformation in family businesses from different theoretical and practical perspectives. The authors Soluk et al. (2021), Ceipek et al. (2021) Prügl and Spitzley (2021) and highlight the role of dynamic capabilities in responding to the demands of technological innovation, such as the Internet of Things, and in exploiting digital innovations. Family management is a determining factor, influencing technological diversification strategies and adaptation to digital transformation.

The studies by Ano & Bent (2022), Malik et al. (2022) Verma et al. (2023) and emphasize cultural and relational factors, such as the will and capacity of the family, in the success of digital transformation. Family business identity and communication patterns, as explored by Prügl & Spitzley (2021) are also highlighted as key elements for strategies such as corporate venturing. Studies such as those by Cepeda-Carrion et al. (2023) explore the role of knowledge creation processes mediated by social networks and open innovation. Du et al. (2023) and Liu et al. (2023) analyze the governance of

non-family shareholders in the context of digital transformation. Costa et al. (2023) and Jacobsson & Linderoth (2021) highlight local dynamics, such as community empowerment and its impact on digital transformation in sectors such as rural tourism and family wineries.

In addition, Cannas (2023) and Kathuria et al. (2023) analyze the challenges of technological integration and adapting business models in a digital economy. Together, these studies provide a solid basis for understanding the challenges and the opportunities of digital transformation in family businesses, suggesting avenues for future research.

2.3.4.2 Cluster 2 – “Digital Transformation - Challenges and Facilitators, Innovation and Entrepreneurship in Technological Ecosystems”

The studies in this cluster explore, in the context of family businesses, the complex interactions between digital transformation, technological innovation and entrepreneurship, with special emphasis on the evolution of technological ecosystems and their impact on various sectors and organizational contexts. The research by Alieva and Powell (2023) highlights the importance of employee behavior and management practices in the context of digital transformations, emphasizing the need to avoid digital waste when implementing new technologies. In a complementary way, Delacroix et al. (2019) investigate the role of digital entrepreneurs on platforms such as Facebook, illustrating how these digital spaces have become crucial to sustaining new business models.

Digital transformation in specific sectors is also gaining prominence. According to the study by Barile et al. (2024), the concept of "Food 4.0" is proposed, which addresses how family businesses in the food sector have used digitalization to respond to the pressures of the COVID-19 pandemic. On the other hand, Laukka et al. (2022) explore the vision of healthcare leaders regarding the impact of artificial intelligence on specialized medical services, highlighting both the challenges and opportunities brought by this emerging technology.

In addition, the studies in this cluster address the dynamics of the digital economy and the new horizons created by advanced technologies. Nguyen et al. (2023) analyzed how big data and artificial intelligence create a transformative symbiosis in the financial sector, promoting significant innovations. The study by Sun & Xie (2024) investigated how digital finance contributes to fostering entrepreneurship, emphasising the strategic role played by large technology companies (BigTech). In the same vein, Zheng et al. (2024) assess the efficiency of the digital economy in promoting sustainable innovation

and development in family businesses.

Finally, this cluster explores future trends and social transformations brought about by digital technologies. Roblek et al. (2021) introduce the concept of Society 5.0, proposing an integration between digital technologies and social welfare objectives, suggesting an evolution beyond the economic focus. In the same vein, Sedera et al. (2022) examine how digital transformation drives entrepreneurship and innovation, highlighting the cultural and technological challenges involved in this process.

2.3.4.3 Cluster 3 – “Dynamics of Cooperation and Sustainability in the Digital Age”

The studies in this cluster address how technological advances have changed organizational practices, interactions between institutions and strategies for overcoming economic and social challenges in family businesses. Ferraro and Cristiano (2021) 's study explored changes in the perception of economic value in family businesses in the digital age, highlighting the importance of transformation in management and performance. Similarly, Rashid and Ratten (2020) analyzed the dynamic capabilities necessary for the survival of family businesses in Pakistan, identifying critical factors for their adaptation to the digital world.

Another aspect that has been researched relates to collaboration and innovation in response to global crises. According to Martinez et al. (2022), the role of online health communities was a great response to the COVID-19 pandemic, highlighting the power of digital platforms in creating collaborative solutions. Nguyen (2024) discussed partnerships between universities and companies to develop skilled human resources for the digital economy, highlighting inter-institutional cooperation's importance in fostering innovation.

Issues of sustainability and innovative practices are also addressed in this cluster. The study by Mazzucchelli et al. (2021) investigated the key factors for the success of digital platforms for sharing and selling expired food, demonstrating how technology can ally in the fight against food waste. In another vein, Khanchel (2022) analyzed innovative practices to improve workplace safety during the pandemic, focusing on health and well-being.

Studies in this cluster have also explored the challenges and opportunities of digital transformation in services and the financial sector. McDonald & Dan (2021) analyzed how digital platforms such as Ant Credit Pay have reshaped online credit, addressing the adaptation of financial services to the digital environment. Mele et al. (2022) investigated the role of cognitive assistants in value co-creation practices, highlighting the implications of these technologies for the consumer experience. Similarly, Schaarschmidt and Höber

(2017) compare digital and telephone booking services, analyzing the influence of technology on the consumer experience.

The adoption of digital technologies by entrepreneurs also received attention in this cluster. Smith et al. (2022) investigated how entrepreneurs deal with resilience in adverse environments, analyzing micro-level responses to existing threats. Similarly, Sunder et al. (2023) explored how organizational empowerment is the first step towards Industry 4.0, thus driving improvements in business performance.

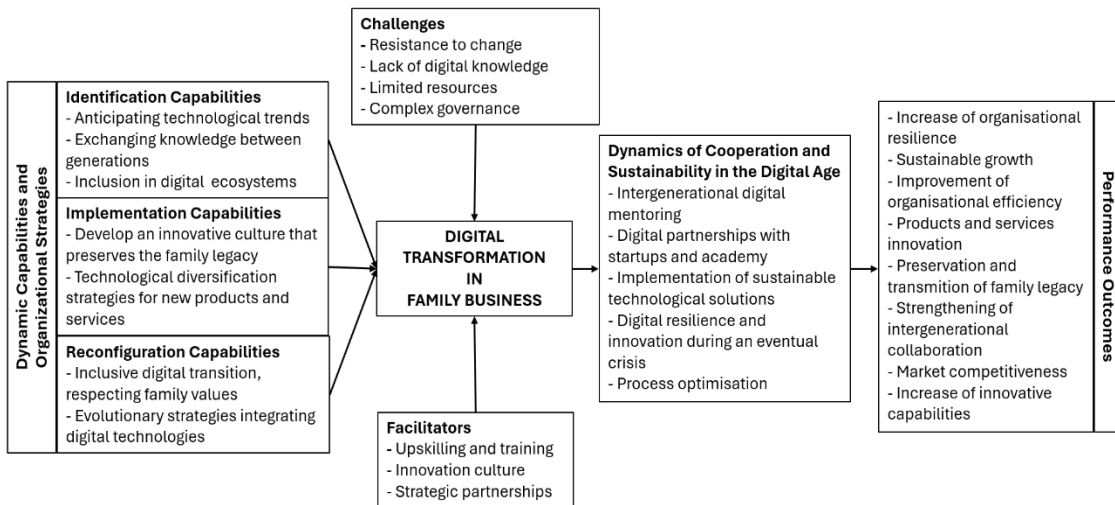
Finally, Rezaei et al. (2024) examined how the COVID-19 pandemic has positively impacted knowledge sharing in family businesses, showing changes in collaborative practices in a context of crisis. In this sense, the studies in this cluster have revealed how the digital transformation reconfigures traditional practices and opens up new possibilities for innovation and cooperation, both locally and globally.

2.4 Theoretical Framework

The results obtained through the bibliographic coupling highlight the relevance of dynamic capabilities and organizational strategies to face the challenges and take advantage of the opportunities of digital transformation in family businesses. In this sense, digital transformation emerges as a multifaceted process, mediated by identification, utilization and reconfiguration capabilities. These are fundamental to anticipating technological trends, preserving the family legacy and integrating digital technologies inclusively and strategically. These capabilities are enabled by factors such as a culture of innovation, upskilling and strategic partnerships, allowing family businesses to overcome challenges such as resistance to change and limited resources.

At the same time, the results obtained, connect these capabilities to the dynamics of cooperation and sustainability, addressing the intersection between innovation, resilience and process optimization in a context of rapid digital evolution, in line with the findings of the studies analyzed. Thus, a framework was developed to understand how dynamic capabilities and organizational strategies interact with facilitators, challenges and cooperation dynamics to drive digital transformation in family businesses. This framework (figure 7) highlights the importance of integrating innovative and sustainable practices, promoting digital resilience, innovation in products and services, strengthening intergenerational collaboration and preserving the family legacy. In this way, it is believed to be a tool to guide family businesses in building effective strategies that align tradition with technological progress, ensuring competitiveness and sustainable growth in the global market.

Figure 7 – Theoretical framework



Source: Own elaboration.

This framework presents a systematic approach to integrating technological innovation practices within an organizational context that preserves family values and legacy. The model's core elements are dynamic capabilities, challenges, facilitators, cooperation dynamics and sustainability, culminating in Performance Outcomes.

Dynamic capabilities are fundamental to the success of the digital transformation and are divided into three main categories: identification, exploitation and reconfiguration (Soluk et al., 2021). The ability to identify is essential for anticipating technological trends, transferring knowledge between generations and including the company in digital ecosystems (Cannas, 2023). This stage requires continuous observation of the external environment and the ability to interpret technological innovations that can be adapted to the family business (Prügl & Spitzley, 2021). Harnessing capabilities are characterized by implementing an innovative culture that respects the family legacy and long-term technological diversification strategies that promote new products and services (Cepeda-Carrion et al., 2023). On the other hand, reconfiguration capabilities refer to the inclusive digital transition, which respects family values, and the progressive integration of digital technologies, ensuring the organizational flexibility needed to keep up with rapid changes in the market (Ano & Bent, 2022).

The challenges that hinder this digital transformation include resistance to change, lack of digital knowledge, limited resources and complex governance (Alieva & Powell, 2023). Resistance to change, often present in family businesses, is rooted in organizational culture, where different generations can have opposing views on adopting new technologies (Bürgel & Hiebl, 2023). The lack of digital knowledge limits the ability to understand and implement innovative technological solutions, while limited financial and human resources make it difficult to execute robust digital strategies (Malik et al.,

2022). In addition, the complex governance characteristic of family businesses adds an extra level of difficulty, as it is necessary to balance family interests and business objectives, which can delay important strategic decisions (Du et al., 2023).

To overcome these challenges, the framework points to essential facilitators, such as upskilling and training human resources, promoting a culture of innovation and forming strategic partnerships (Ano & Bent, 2022). Upskilling is essential to prepare family members and employees to deal with the demands of the digital age. At the same time, a culture of innovation creates an environment that encourages experimentation and reduces resistance to change (Khanchel, 2022). In turn, strategic partnerships, especially with startups and academic institutions, offer access to external resources and knowledge that complement the organization's internal capabilities (Nguyen, 2024).

The dynamics of cooperation and sustainability in the digital age play a crucial role in the proposed model. Intergenerational cooperation is especially highlighted as a key factor in ensuring the organisation's continuity, through digital mentoring between generations, which facilitates the transmission of knowledge and promotes technological integration (Ren et al., 2023). Partnerships with startups and academic institutions offer opportunities to access emerging technologies and apply innovative practices (Nguyen, 2024). Implementing sustainable technological solutions demonstrates a commitment to social and environmental responsibility, which is essential for long-term competitiveness (Ferreira et al., 2023). In addition, the framework emphasizes the importance of digital resilience and the ability to innovate during crises, allowing companies to overcome adversity and maintain their position in the market (Godjali & Supramaniam, 2024; Khanchel, 2022). Optimizing processes through digital transformation contributes to efficiency gains, reducing operating costs and increasing productivity (Zheng et al., 2024).

The expected results of this digital transformation are largely positive and impact various aspects of organizational performance. Organizational resilience is strengthened, enabling family businesses to effectively face crises and market changes (Bürgel & Hiebl, 2023). Sustainable growth becomes feasible through technologies that balance economic efficiency and environmental impact (Nguyen, 2024). Operational efficiency is improved, resulting in greater productivity and reduced waste (Zheng et al., 2024). In addition, innovation in products and services opens up new market opportunities, while preserving the family legacy is ensured (Khanchel, 2022). Intergenerational collaboration strengthens family ties and enhances the organization's human capital (Ren et al., 2023). Finally, market competitiveness and innovation capacity are significantly increased, strategically positioning the company in a dynamic and digital environment (Barile et al., 2024).

In summary, this framework offers a comprehensive, science-based vision for digital transformation in family businesses. Technical and cultural elements are integrated, recognizing family businesses' unique challenges. The proposed approach balances the need for innovation with respect for family values, providing a clear path to sustainable growth and long-term success.

2.5 Theoretical and Practical Implications

The results of this study have theoretical implications in the context of family businesses. In this sense, we identified: (i) Contribution to the existing literature on digital transformation in family businesses. Currently, no known studies analyze research trends on digital transformation in family businesses and develop a theoretical framework to help family managers achieve the benefits of digital transformation; (ii) New perspectives on management theory and digital innovation. By analyzing the interaction between dynamic capabilities and digital transformation, this study offers new perspectives for management, innovation and entrepreneurship theories, especially in the context of family businesses. The development of the proposed theoretical framework offers an integrated model that can be used to test new hypotheses related to the adaptation and implementation of emerging technologies in family businesses; (iii) Sustainability and intergenerational innovation. The importance of intergenerational cooperation and implementing sustainable practices as strategies to strengthen digital resilience opens up new possibilities for studying sustainability and innovation in family businesses. The integration of intergenerational aspects offers an innovative lens for family management research, addressing how tradition and innovation can coexist strategically.

In practical terms, the results of this study have led to the following conclusions: (i) Leadership and organizational change in family businesses. For owners and managers of family businesses, the main practical implication is the need for leadership committed to innovation and capable of promoting cultural and organizational changes that strategically integrate digital technologies. The study highlights the importance of proactive leaders in identifying technological trends and promoting a culture of innovation; (ii) Digital training and skills development: The digital transformation imposes the need for employees to adapt to new processes and technological tools. For family businesses, it is essential to implement training programs that develop digital skills, promote the adoption of emerging technologies and help with the transition to new ways of working. Adopting remote working and using collaborative tools are suggested; (iii) Strategic partnerships and collaborative innovation: Family businesses should invest in

strategic partnerships, such as collaborations between companies and academic institutions, to speed up the adoption of technological innovations. This includes the creation of collaborative networks that facilitate the exchange of knowledge and the joint development of digital solutions; (iv) Sustainability as a competitive advantage: The adoption of sustainable digital practices can become a competitive advantage for family businesses, both in terms of operational efficiency and the creation of value for customers. Investing in technological solutions that reduce waste and improve environmental and social sustainability can be an important differentiator for attracting conscious customers and improving brand image; (v) Organizational resilience in times of crisis: Digital transformation can also strengthen organizational resilience, especially in times of global crisis, such as the COVID-19 pandemic. Family businesses can benefit from adopting technologies that allow them to adapt quickly to external changes, ensuring business continuity and the ability to innovate during challenging times.

2.6 Future Lines of Research

Table 4 summarizes the main future lines of research identified in the most recent studies, categorized into six thematic axes: (i) digital transformation and organizational strategies; (ii) sustainability and emerging technologies; (iii) public policies and support for innovation; (iv) training human resources; (v) the social impact of digital transformation; and (vi) the impact of digital transformation on specific sectors. These axes represent priority areas for theoretical and empirical study, highlighting the challenges and opportunities inherent in digital transformation in different organizational and social contexts.

In the context of digital transformation and organizational strategies, the literature suggests the need to explore effective practices and strategies that integrate organizational change, governance and intergenerational dynamics (Alieva & Powell, 2023; Begnini et al., 2023; Cannas, 2023; Bürgel & Hiebl, 2023; Du & Ma, 2023). This topic highlights the importance of understanding how different generations interact and contribute to digital transformation processes, and is an interesting field for studies aimed at innovation in organizational structures (Ren & Ding, 2023; Lapuz, 2023; Verma et al., 2023).

Table 4 – Future lines of research

General Theme	Future Lines of Research	Authors and Year
Digital transformation and organizational strategies	Investigate effective practices and strategies for digital transformation, addressing organizational change, governance and intergenerational dynamics	Alieva & Powell (2023); Begnini et al. (2023); Cannas (2023); Bürgel & Hiebl (2023); Du & Ma (2023); Ren & Ding (2023); Lapuz (2023); Verma et al. (2023)
Sustainability and emerging technologies	Analyze the impact of emerging technologies and the sustainable viability of these solutions in the digital transformation process, especially in small and medium-sized enterprises (SMEs).	Barile & Del Vecchio (2024); Kumar (2024); Saura & Barbosa (2023); Zheng & Chen (2024); Tuncalp (2024)
Public policies and support for innovation	Studying the role of public policies in supporting innovation in family businesses	Costa & Abbate (2023); Nguyen (2024); Cepeda-Carrion et al. (2023)
Training human resources	Investigating the impact of human resources training programs on the digital transformation process of family businesses	Sunder et al. (2023); Liu et al. (2023); Rezaei et al. (2024)
The social impact of digital transformation	Investigate how digital technologies influence social assistance, strengthen organizational resilience and transform financial processes, with a focus on promoting social inclusion and supporting entrepreneurs and vulnerable populations.	Cree & Mackenzie (2023); Sun & Xie (2024); Rezaei et al. (2024)
Impacts of digital transformation on specific sectors	Analyze the specific impacts of digital transformation in sectors such as agri-food, rural tourism, wineries and other cultural industries	Cannas (2023); Verma et al. (2023); Costa & Abbate (2023)

Source: Own elaboration.

The role of public policies and support for innovation has also been identified as a promising line, emphasising analyzing how government initiatives can facilitate technological innovation in family businesses (Cepeda-Carrion et al., 2023). This axis highlights the interaction between regulation, financial incentives and the adoption of digital technologies as crucial elements for the success of digital transformation in different contexts (Costa & Abbate, 2023; Nguyen, 2024).

Regarding human resource training, training programs are relevant to preparing company teams for the challenges of digital transformation (Rezaei et al., 2024). Future studies could investigate how specific skills training in the digital area directly impacts on the success of companies during this process (Sunder et al., 2023; Liu et al., 2023).

In turn, the social impact of digital transformation is proving to be a highly relevant

area of research, addressing issues such as social inclusion, organizational resilience and the transformation of financial processes (Sun & Xie, 2024). This axis seeks to understand how digital technologies can empower entrepreneurs and support vulnerable populations, promoting positive and inclusive social impact (Cree & Mackenzie, 2023; Rezaei et al., 2024).

Finally, the impacts of digital transformation on specific sectors represent an essential field of study for understanding the particularities of digital transformation in sectors such as agri-food, rural tourism, wineries and cultural industries (Costa & Abbate, 2023). Analysing these sectors' benefits, challenges and adaptations can generate valuable insights for maximizing the results of digital transformation in different contexts (Cannas, 2023; Verma et al., 2023).

These lines of research reinforce the relevance of exploring how digital transformation can be directed to create economic, social and environmental value, highlighting the importance of interdisciplinary approaches to tackling contemporary challenges.

2.7 Conclusions

Family businesses are facing increasing pressure to incorporate new technologies into their business models to adapt to digital dynamics and increase their competitiveness. In this adaptation, it is necessary to balance family values and openness whilst integrating technological innovations, promoting a sustainable and efficient digital transformation.

With this in mind, this bibliometric review aims to describe and contextualize the state of the art of the digital transformation of family businesses, addressing emerging trends, the main challenges faced and the strategies adopted. The aim is to provide a comprehensive overview of the current scenario, highlighting the theoretical and practical implications identified in the literature.

Scientific publications on the digital transformation of Family Businesses have been increasing, especially since 2017, resulting in a greater number of citations. The year 2024 was the year with the highest number of publications and citations, indicating a period of intense research activity and interest.

The bibliometric analysis made it possible to identify three clusters, which were named: (i) "Digital Transformation in Family Businesses: Dynamic Capabilities and Organizational Strategies" (ii) "Digital Transformation - Challenges and Facilitators, Innovation and Entrepreneurship in Technological Ecosystems"; and (iii) "Dynamics of Cooperation and Sustainability in the Digital Age".

The main theme of the first cluster of studies is digital transformation in family

businesses, explored from different perspectives. The studies analyze technological innovation (Ceipek et al., 2021; Prügl & Spitzley, 2021), highlighting the dynamic capabilities and strategic adaptation of companies (Ano & Bent, 2022), as well as the cultural and relational factors that influence the success of this transformation (Malik et al., 2022; Verma et al., 2023). In addition, aspects such as knowledge creation through social networks (Cepeda-Carrion et al. (2023) and the impact of non-family shareholder governance (Du et al., 2023; Liu et al., 2023) are discussed. Historical, social and technological challenges related to digital integration are also addressed (Cannas, 2023; Heider et al., 2022; Lapuz, 2023 and Kathuria et al., 2023). Overall, the studies highlight the importance of dynamic capacity, cultural alignment and collaborative innovation for the success of digital transformation in family businesses.

The second cluster explores the interaction between digital transformation, innovation and entrepreneurship. The studies analyse how digital technologies influence different sectors and how organizations adapt to these changes. This cluster analyzes employee behaviors and management practices to avoid digital waste (Alieva & Powell, 2023). It looks at digital entrepreneurs on platforms such as Facebook (Delacroix et al., 2019), as well as the impact of digital technologies on supply chains (Bejlegaard et al., 2021). Structural changes resulting from innovation are also analyzed (Sabri et al., 2018), as are digital transformation strategies and the application of emerging technologies in business (Santoso et al., 2021; Barile et al., 2024; Laukka et al., 2022; Nguyen et al., 2023 and Sun & Xie, 2024). Together, the studies in this cluster highlight the importance of digital transformation and technological innovation for the development of new business models, with an emphasis on the challenges and facilitators of this adaptation.

The third cluster analyses the impact of digital transformation on management, collaboration and sustainability within various organizational contexts. It looks at how organizations adapt management practices and cooperation strategies (Rashid & Ratten, 2020), while incorporating digital solutions to promote sustainability and innovation (Ferraro & Cristiano, 2021). In this cluster, the use of food sharing platforms to reduce waste (Mazzucchelli et al., 2021), security in remote work (Khanchel (2022) and the role of cognitive assistants in value co-creation (Mele et al., 2022) are also addressed. It also highlights organizational resilience in Industry 4.0 (Sunder et al., 2023) and collaboration in family businesses during global crises (Rezaei et al., 2024). This cluster focuses on how digitalization transforms collaboration, innovation and sustainability in organizations, promoting new forms of cooperation in times of crisis.

A theoretical framework was also developed to synthesize the results of the bibliometric analysis. This model highlights the importance of dynamic capabilities such as identifying, harnessing and reconfiguring resources, which are essential for

anticipating technological trends, preserving the family legacy and integrating innovations strategically. The framework also addresses the main challenges faced by family businesses, such as resistance to change, lack of digital knowledge and limited resources, proposing solutions based on developing skills, promoting a culture of innovation and forming strategic partnerships. It also emphasizes the importance of sustainable practices and intergenerational cooperation to strengthen digital resilience and ensure competitiveness in the global market. Thus, the framework emerges as a tool for aligning tradition and technological progress, promoting sustainable growth and innovation in family businesses.

Finally, this bibliometric review shows that digital transformation in family businesses is a multifaceted phenomenon, which incorporates integrated theoretical and practical approaches to balance tradition and innovation. The cluster analysis provides a solid basis for future research, highlighting the relevance of collaborative strategies, technological innovation and sustainable practices in building a more inclusive and resilient digital future.

From this study, several implications can be drawn in various spheres. For family owners and managers, there is a need for leadership committed to innovation and capable of driving significant cultural and organizational change. On the other hand, for employees and collaborators, the digital transformation represents the need to adapt to new work processes and tools and develop digital skills. For customers and suppliers, digital transformation can result in an improved experience, with more personalized and efficient services, as well as facilitating communication and collaboration. In addition, family businesses can positively impact the community and society in general by adopting sustainable practices, creating jobs and contributing to local economic development.

By specifically targeting the influence of family management on digital transformation, the study highlights the specific opportunities and challenges faced by Family Businesses, enriching existing knowledge. This unique approach contributes significantly to a deeper and more specific understanding of this phenomenon, standing out as a unique contribution to academic literature and business practice

Based on the conclusions presented, future lines of research highlight the importance of deepening knowledge in areas such as digital transformation and organizational strategies, sustainability and emerging technologies, and the role of public policies in supporting innovation. In addition, human resource training and the social impact of digital transformation represent crucial themes for understanding how family businesses can adapt to change and maximize their benefits. Finally, the impacts of digital transformation on specific sectors, such as agri-food, rural tourism and cultural

industries, emerge as priority areas for studies aimed at promoting economic, social and environmental value through interdisciplinary approaches and technological innovations.

2.8 Limitations

Finally, it is important to highlight some of the limitations of this study. Only articles indexed in the Web of Science were considered, leaving out relevant articles from other databases. Similar studies could be replicated in databases such as B-on, SCOPUS, EBSCO or SciELO. In addition, only scientific articles were analyzed. Other types of publications such as book chapters, books, proceedings and abstracts could be included in future studies. Similarly, software tools could have been used to build and visualize bibliometric networks, such as "The R Project for Statistical Computing", Bibexcel, Bibliometrix/Biblioshiny, CiteSpace, CoPalRed, INSPIRE and InCites.

CHAPTER 3 - MAPPING DIGITAL TRANSFORMATION IN THE EUROPEAN UNION: IMPLEMENTATION PATTERNS IN FAMILY BUSINESSES

Abstract:

The European Union promotes Small and Medium Enterprises (SME) digital transformation through programs like Enterprise Europe Network, InvestEU, and Digital Europe. These initiatives emphasize the need for more knowledge on digital adoption, particularly in SMEs. Unlike previous studies that examine digital transformation in a global context, this study focuses on how European family businesses adopt digital technologies. Using a sample of 2,532 European family businesses and a quantitative methodology, the study employs latent class analysis to identify digitalization patterns and correspondence analysis to explore business characteristics influencing digital transformation. Findings reveal diverse digital adoption patterns across EU-27 family businesses, shaped by organizational, sectoral, and financial factors. Northern and Central European countries lead in digital adoption, while Southern European nations lag. Factors such as company size, turnover, and turnover growth positively impact digital implementation, whereas older companies show lower adoption rates. The study also examines the impact of seven digital technologies, identifying varying levels of digital maturity. Results highlight the need for region-specific policies to ensure a more inclusive digital transformation across the European Union.

Keywords: Digital Transformation, Digital Technologies, Family Businesses, European Union.

3.1 Introduction

Digital transformation (DT) is a global trend that has been changing the sectors of activity (Gonzalez-Varona et al., 2024). It is defined as a process of integrating digital technologies into organizations, with the aim of creating new business models, redefining products and services, and enabling companies to compete in a global digital ecosystem (Beverungen et al., 2022; Vial, 2021).

Although digitization is often associated with DT, the concepts differ in their scope. Digitization refers to the conversion of analog processes into digital formats without changing business models (Vasilev et al., 2020). DT, on the other hand, is a broader and deeper concept, ranging from the reformulation of business models to organizational strategy (Matt et al., 2015). In this sense, while digitalization uses technology to improve existing processes, TD strategically integrates technologies, representing a more profound change (Vrana et al., 2021).

In the European Union (EU), this process is promoted by strategies focused on accelerating digitalization (Burinskienė et al., 2024). Through initiatives such as the digital single market, investment in digital infrastructures, the digitization of Small and Medium-sized Enterprises (SMEs), data protection, cybersecurity, and innovation and research, the EU seeks to create a uniform environment where citizens and businesses can enjoy a secure and barrier-free digital market (Sati, 2024; Clemente-Almendros et al., 2024). However, the way in which digital transformation takes place can vary from sector to sector and especially between different types of companies (Magaz-González et al., 2024). Although DT is widely promoted as a crucial factor for competitiveness and innovation, the way in which these changes are applied in family businesses can be significantly different from that of other organizations (Civelek et al., 2023).

Family businesses account for between 65% and 80% of all companies in the European Union, employing approximately 100 million people in the private sector (Rovelli et al., 2022). They play a crucial role in job creation and regional economic growth (European Family Businesses, 2024). Defined as organizations in which a family holds the majority of the capital and has a direct influence on management decisions, family businesses have distinct internal characteristics that differentiate them from non-family businesses, especially in terms of organizational dynamics (Batt et al., 2020; Bürgel et al., 2023). The TD of family businesses is a fundamental process for the modernization and competitiveness of this type of organization in an increasingly technological global scenario (Thrassou et al., 2020). However, there are internal gaps that make this process a challenge at various levels (Rovelli et al., 2022). Aspects such as organizational culture, lack of strategic planning, limited technological investment, centralized decision-making, and intergenerational conflicts condition the integration of

new technologies into family businesses (Civelek et al., 2023).

Recent studies on family businesses highlight the unique challenges and opportunities these companies face in the digital transformation process (Ano & Bent, 2022) emphasized how multigenerational family businesses deal with digital transformation, focusing on cultural and human aspects. These include emotional attachment to the business, long-term orientation, and the influence of business legacies, which often guide the digital strategy of these companies. The authors also concluded that family businesses can take advantage of their distinctive resources to drive innovation. However, it can be complicated to balance non-financial objectives with the need for digitization. Furthermore, Soluk et al. (2021) identify barriers such as paternalistic decision-making and resistance to change in family businesses. However, they also found that digital transformation can be catalyzed by crises such as the COVID-19 pandemic, which has forced companies to adapt quickly and embrace innovation. In this context, two important research questions arise: What kind of patterns can be identified in the adoption of digital technologies in European family businesses? How do company characteristics relate to the adoption of these digital technologies?

This study aims to map and analyze the implementation patterns of digital technologies in family businesses in the European Union. For this purpose, a quantitative approach was used, and a sample of 2,523 European family businesses was collected from Flash Eurobarometer 486. Our study considers seven digital technologies (Artificial Intelligence (AI), Cloud Computing, Robotics, Smart Devices, Big Data Analytics (BDA), High-Speed Infrastructures, and Blockchain). The digital technologies to be studied in this article were chosen because of the frequency with which they are implemented in the family SMEs that participated in the database sample.

This study makes three main contributions. Firstly, this study contributes to recent work on digital transformation in family businesses. Currently, there are no known studies that simultaneously analyze the contributions of seven digital technologies to the digital transformation process in both family businesses and non-family businesses. Previous studies have mapped DT in the EU, mainly after COVID-19 and in specific sectors (e.g., (Georgescu et al., 2022; Magaz-González et al., 2024). However, our study highlights those digital technologies such as Artificial Intelligence (AI), Cloud Computing, Robotics, Smart Devices, Big Data Analytics (BDA), High-Speed Infrastructures, and Blockchain have positive impacts on family businesses and can be sources of competitiveness creation. Secondly, this study identifies three patterns of implementation of digital technologies in EU family businesses: digital transformation not implemented, rarely implemented, and moderately implemented. The EU-27 countries most advanced in the digital implementation process are also identified, as well as the countries facing the most

difficulties and delays in digital implementation. Finally, this study provides insights into how managers and policymakers can accelerate the competitiveness of family SMEs through DT. We found that there is an unequal contribution of the different digital technologies in the digital transformation process, essentially due to implementation costs (Überbacher et al., 2020). Technologies such as Cloud Computing, High-Speed Infrastructures, and Smart Devices are the most widely implemented. Conversely, artificial intelligence and blockchain have the least implementation. In this sense, this study highlights the need to create regional policies that are more targeted at family businesses. Boosting digital mentoring networks, regional e-commerce platforms, partnerships with tech start-ups, and even tax incentives and exemptions can help strengthen confidence in the use of technologies and increase the competitiveness of family businesses in the European digital market, promoting a more inclusive and equitable digital transformation.

3.2 Digital Transformation and Family Business

Several recent studies have defined digital transformation as the integration of digital technologies into the digital economy, leading to a transformation of products, processes, and organizational aspects (Bethlendi et al., 2022; Liu et al., 2011). However, the digital transformation process is multifaceted as it combines various tools with different objectives, forcing the reconfiguration of strategic assets that only a few companies are capable of doing (Williams, 2021). According to the Flash Eurobarometer survey, 486 (European Commission, 2020) of the 16,365 companies surveyed in the EU-27 in 2019, 20% had a high level of digitalization, 52% had a medium level of digitalization, and 28% had a low level of digitalization. Companies with a high level of digitalization are often start-ups, Small and Medium-sized Enterprises (SMEs) that have experienced recent growth, companies with a higher turnover, companies belonging to industrial clusters, and companies active in the IT sector. Furthermore, according to the same report, countries such as Denmark, Finland, the Netherlands, Luxembourg, and Sweden stand out in terms of technology adoption rates of around 80%. Among the technologies adopted, cloud computing and high-speed infrastructures are the most widely adopted. In contrast, countries such as Italy and Lithuania have technology adoption levels of 34% and 37%, respectively (European Commission, 2020). Technologies such as Blockchain, despite their potential, are still new to companies in countries with a low technological adoption rate. The lack of technological knowledge, the associated implementation costs, and the lack of skilled labor are some of the aspects that make blockchain a less accessible and attractive technology (Lanzini et al., 2021).

Family businesses play a key role in world economies. In the European context,

they account for between 65% and 80% of all companies, employing approximately 100 million people in the private sector (Rovelli et al., 2022). Defined as organizations in which a family holds the majority of the capital, family businesses have a direct influence on management and decision-making (Batt et al., 2020). However, incorporating digital technologies into these types of companies presents specific challenges and opportunities due to their organizational structure, internal governance processes, and intergenerational values (Massis et al., 2020).

Although the adoption of digital technologies offers family businesses opportunities to improve their operational efficiency, explore new markets, and create value in innovative ways, these types of businesses are more resistant to change than non-family businesses (Quarato et al., 2020). Some of the factors that influence this resistance include the owners' strong emotional attachment to the companies, risk aversion, and the desire to preserve the family legacy. These factors combined can limit the realization of deep digital transformations and delay the competitiveness of family businesses (Rashid & Ratten, 2020). In addition, compared to non-family businesses, family businesses have a more concentrated structure and slower processes, where generational transfer does not always occur. In addition, the lack of financial resources dedicated to innovation, combined with the absence of technology experts within the family framework, are factors that can hinder the adoption of complex technological solutions (Zapata-Cantu et al., 2023).

However, when family businesses overcome these barriers, they can gain a powerful competitive advantage. The fact that their ownership structure is highly concentrated in family-connected individuals allows for greater agility and ease in decision-making, making adaptation to technological changes simpler and faster. In addition, family involvement in management can promote a long-term vision, which, combined with digitalization, offers a strategic approach geared toward sustainability and digital growth (Bürgel et al., 2023). By adopting digital technologies, family businesses can align with modern market demands, customize products and services, and optimize the customer experience. This allows these companies, often known for their closeness and trusting customer relationships, to use technology to reinforce these distinctive characteristics (Massis et al., 2020). With the evolution of digital technologies, companies have found an opportunity to reach a new level of growth and competitiveness (Zapata-Cantu et al., 2023). However, adopting these technologies requires cultural and structural change, where the balance between family tradition and technological innovation plays a key role. Overcoming challenges related to governance, generational transfer, and resistance to change are key to the success of family businesses in the digital environment (Saura et al., 2023).

3.3 Methods

3.3.1 Sample and Data

This study aims to explore the implementation patterns of seven digital technologies (Artificial Intelligence, Cloud Computing, Robotics, Smart Devices, Big Data, High-Speed Infrastructures, and Blockchain) in EU-27 family businesses. To this end, we begin with a brief definition of the technologies covered (Table 5).

To this end, this study uses a sample of SMEs collected from the Gesis - Leibniz Institute for Social Sciences database in Flash Eurobarometer 486 published in 2020 (European Commission, 2020). Data collection was carried out between February 19 and May 5, 2020, by telephone using a computer-assisted interview. The companies surveyed are located in 27 EU Member States, Bosnia and Herzegovina, the United Kingdom, Norway, Iceland, North Macedonia, Serbia, Turkey, Kosovo, Brazil, Canada, Japan and the USA.

Table 5 – Definition of the digital technologies.

Technology	Definition	Authors
Artificial Intelligence (AI)	Computer systems capable of performing tasks that normally require human intelligence	(Clemente-Almendros et al., 2024; Saghiri et al., 2020)
Cloud Computing	Technology that allows remote access to computer resources via the internet, with high flexibility and low cost	(Quarato et al., 2020; Skafi et al., 2020)
Robotics	Use of programmable machines to automate tasks, increasing efficiency and precision in industrial and service processes	(Gonzalez-Varona et al., 2024; Matt et al., 2015)
Smart Devices	Equipment connected to the internet and integrated with sensors and software to perform advanced functions such as monitoring and remote control.	(Kahle et al., 2020; Matteo et al., 2023)
Big Data Analytics	Process of analyzing large volumes of complex data to extract valuable information and support strategic decision-making	(Agostini & Filippini, 2019; Mazzarol, 2015)
High-Speed Infrastructure	Telecommunications networks that allow high-speed data transmission are essential for supporting advanced digital applications.	(Matteo et al., 2023; Skafi et al., 2020)
Blockchain	It is distributed ledger technology that guarantees security, transparency, and immutability in digital transactions without the need for intermediaries.	(Clemente-Almendros et al., 2024; Saghiri et al., 2020)

Source: Own elaboration.

The original database contains 16,365 companies from various sectors, and two filters were used to restrict the sample of this study to family businesses in the EU-27.

The first filter was applied to question 13 of the survey ("In terms of ownership, your company is predominantly family-owned"), resulting in 3,343 results. Since the study aims to assess the contribution of digital technologies in EU-27 family businesses, only family businesses belonging to the EU-27 were included, resulting in a final sample of 2,523 family businesses.

The final sample is slightly unbalanced in terms of geographical dispersion. There were fewer family businesses located in Romania (0.32%), Estonia (0.55%), and Lithuania (0.79%). On the other hand, countries such as Portugal and Spain accounted for the largest share of the sample, 7.73% and 9.04% respectively. In terms of the year of foundation, the most recent company in the sample was registered in 2020, and the oldest in 1850. In terms of the number of employees, 50.6% of the companies had up to 49 workers in the last three years, 47.07% of the companies had between 50 and 249 employees, and 2.33% had more than 250 employees. In terms of turnover, since 2016, 35.2% of companies have seen a growth in turnover of up to 30%, 26.2% of companies have remained stable, 15.5% have seen a decrease in turnover, and 20.6% of companies have increased their turnover by at least 30%. Finally, with regard to the growth in the number of full-time employees, since 2016, 17.1% of companies have seen an increase in turnover of up to 30%, 16.2% of companies have remained stable, 5.1% have seen a decrease in the number of employees and 9% of companies have increased their number of employees by at least 30%.

3.3.2 Variables

3.3.2.1 Measures of digitalization

In the Flash Eurobarometer 486 survey, in question Q23, companies were asked: "Which of the following digital technologies, if any, has your company adopted so far?". The following possible answers were presented (Table 6), and companies could choose more than one option. The answers are binary: 1 - yes, the technologies have been implemented; 0 - no, the technologies have not been implemented.

Table 6 - Digital technology options

1	Artificial intelligence, e.g., machine learning or technologies for identifying objects or people, etc.
2	Cloud computing, i.e., storage and processing of files or data on remote servers hosted on the Internet
3	Robotics, i.e., robots used to automate processes, e.g., in construction or design, etc.
4	Smart devices, e.g., smart sensors, smart thermostats, etc.
5	Big data analytics, e.g., data mining and predictive analytics
6	High-speed infrastructure
7	Blockchain
8	None of the above

Source: Own elaboration.

3.3.2.2 Measures of propriety and business activity

The properties of family businesses were measured using a set of five indicators: (a) size of the business measured in the number of employees (micro-businesses 1-9, small businesses 10-49, medium businesses 50-249 or large businesses 250 or more); (b) year the business was founded; (c) turnover of the business (eight categories ranging from less than 100.000 euros to more than 50 million euros); (d) change in the company's turnover from 2016 to 2019 (four categories, from an increase of more than 30% to a negative change - decrease); (e) Statistical Classification of Economic Activities - NACE. In this survey, the NACE classification considered 16 industries: (1) agriculture, animal husbandry, hunting, forestry, and fishing; (2) mining and quarrying; (3) manufacturing; (4) electricity, gas, steam and air conditioning; (5) water supply, sewerage, waste management and remediation; (6) construction; (7) wholesale and retail trade and repair of motor vehicles; (8) transportation and storage; (9) accommodation and food service activities; (10) information and communication technologies; (11) financial and insurance activities; (12) real estate activities; (13) consulting, scientific and technical activities; (14) administrative activities and support services; (15) public administration and defense; (16) education.

3.3.3 Data Analysis

Firstly, a statistical analysis of the variables was carried out using SPSS (V.25). Subsequently, using Latent Class Analysis (LCA), subgroups of European family businesses with similar digital technology adoption patterns were identified, even if these subgroups were not immediately visible in the initial analysis. LCA is a methodology that makes it possible to detect 'latent classes,' i.e., groups of companies that share common

characteristics related to technological adoption, even if these similarities are not directly observable. This technique, previously adopted in the studies by Bassi et al. (2023), Bassi & Dias (2020) and Genge (2014) has proven effective in grouping hidden or latent patterns and providing a detailed view of different company profiles. Lastly, a Correspondence Analysis was carried out based on the approach of Belas et al., (2020) to explore the relationship between company characteristics and the digital technology adoption patterns identified by LCA.

3.4 Results

3.4.1 Descriptive statistics

Of the 16,365 companies surveyed through FE 486, we filtered the sample by family businesses, obtaining a sample of 3,343 companies, which represents approximately 20.9% of the initial total. Since the aim of the study is to analyze the adoption of digital technologies by family businesses belonging to the 27 member states, we only considered family businesses located in the countries of the European Union (EU-27), resulting in a sample of 2,523 companies. In other words, 75.5% of the family businesses identified are in the EU-27. These results show a significant concentration of family businesses within the EU in relation to the total number of family businesses identified in the initial sample.

The frequency of adoption of digital technologies by European family businesses is shown in Table 7. Cloud Computing is the most widely adopted technology, with 53% of the companies surveyed adopting it in their business models. This is followed by High-Speed Infrastructures and Smart Devices, with adoption rates of 39% and 31.9%, respectively. More complex technologies, such as Big Data and Robotics, have also been implemented, but to a lesser extent, with 15.2% and 10.7% respectively. It is also important to note that 25.6% of the family businesses in the sample do not use any of the technologies mentioned, which suggests that a significant proportion of these organizations are still in the process of transitioning or evaluating the adoption of digital technologies. (Kumar, 2024).

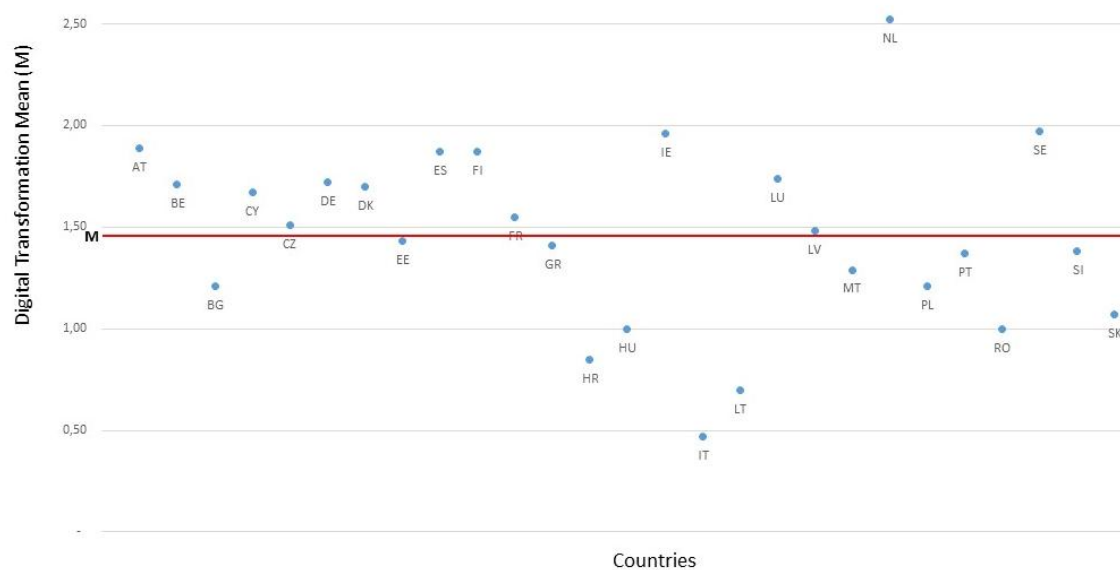
Table 7 - Frequency of implementation of digital technologies in family SMEs

Digital Technology	Frequency (%)
1 - Artificial intelligence, for example, machine learning or technologies for identifying objects or people, etc.	8,4%
2 - Cloud computing, i.e., storage and processing of files or data on remote servers hosted on the Internet	53,0%
3 - Robotics, i.e., robots used to automate processes, for example, in construction or design, etc.	10,7%
4 - Smart devices, e.g., smart sensors, smart thermostats, etc.	31,9%
5 - Big data analytics, for example, data mining and predictive analytics	15,2%
6 - High-speed infrastructure	39,0%
7 - Blockchain	3,6%
8 - None of the above	25,6%

Source: Own elaboration.

After addressing the frequency of implementation of digital technologies, it is important to highlight the family business countries in which this implementation is most pronounced (figure 8).

Figure 8 - Average implementation of Digital Transformation activities of family companies by countries.

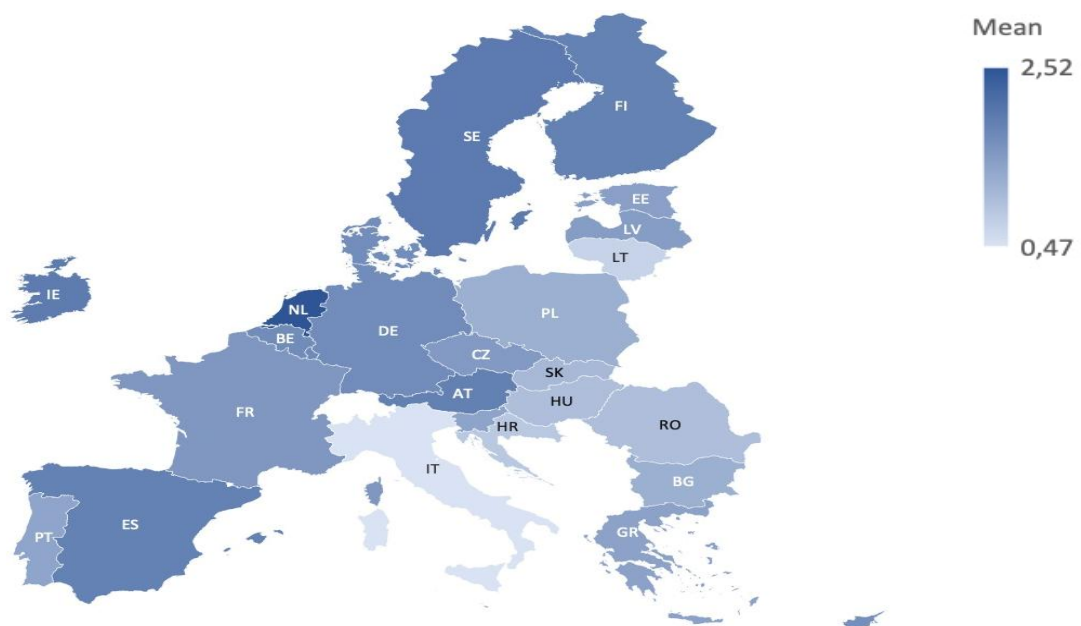


Note: Countries are: AT - Austria; BE - Belgium; BG - Bulgaria; CY - Cyprus; CZ - Czech Republic; DE - Germany; DK - Denmark; EE - Estonia; ES - Spain; FI - Finland; FR - France; GR - Greece; HR - Croatia; HU - Hungary; IE - Ireland; IT - Italy; LT - Lithuania; LU - Luxembourg; LV - Latvia; MT - Malta; NL - Netherlands; PL - Poland; PT - Portugal; RO - Romania; SE - Sweden; SI - Slovenia; SK - Slovakia.

The intensity of technology adoption by family businesses was calculated, ranging from 0 technologies to 7 technologies adopted, showing considerable heterogeneity between the different EU countries. The average value of technology adoption ranges from 0.47 in Italy to 2.52 in the Netherlands. The average technological adoption in family businesses belonging to the EU-27 is 1.46, which represents a low level out of a total of 2,523 companies observed. Countries like the Netherlands and Sweden prove to be in an advanced position in terms of technological adoption, while countries like Italy and Lithuania show relatively low levels.

Geographically, northern and central European countries stand out with higher levels of digital intensity. Conversely, countries in southern Europe have lower rates of technological adoption (figure 9).

Figure 9 - Average intensity of Digital Transformation activities of family SMEs by countries



Note: Countries are: AT - Austria; BE - Belgium; BG - Bulgaria; CY - Cyprus; CZ - Czech Republic; DE - Germany; DK - Denmark; EE - Estonia; ES - Spain; FI - Finland; FR - France; GR - Greece; HR - Croatia; HU - Hungary; IE - Ireland; IT - Italy; LT - Lithuania; LU - Luxembourg; LV - Latvia; MT - Malta; NL - Netherlands; PL - Poland; PT - Portugal; RO - Romania; SE - Sweden; SI - Slovenia; SK - Slovakia

3.4.2 Patterns of Digital Transformation in Family Business

3.4.2.1 Model selection

Table 8 presents a set of statistical indicators used to evaluate alternative models. According to Linzer et al. (2011) the indicators for selecting a model that best reflects the number of distinct patterns are those with the lowest BIC and CAIC values. Also, Nylund et al. (2007) point out that the model with the lowest CAIC is often the most reliable for selecting the correct number of classes.

Table 8 - Model selection.

Model	Log-likelihood	Resid. df	BIC	CAIC	Likelihood ratio
M1	-8055.737	2502	16275.97	16153.47	1245.402
M2	-7541.134	2480	15419.1	15168.27	216.1972
M3	-7498.732	2458	<u>15506.62</u>	<u>15127.46</u>	131.3938
M4	-7482.663	2436	15646.81	15139.33	99.25435
M5	-7475.723	2414	15805.27	15169.45	85.37482
M6	-7470.966	2392	15968.08	15203.93	75.86131

Note: BIC: Bayesian information criterion; CAIC: Akaike information criterion

However, it is important to balance the CAIC with the BIC to avoid choosing an overly complex model. Table 3 shows that the lowest BIC values are found in Model 2 and Model 3. The models with the lowest CAIC values are Model 3 and Model 4. In this sense, it is suggested that Model 3 is the most reliable choice as it fits the data better (Linzer et al., 2011). This allows us to reduce the original number of 189 combinations (27 countries times 7 technologies) to three patterns of technological adoption.

3.4.2.2 Interpretation of patterns of digital transformation

Having determined that the three-pattern model is the best fit for the data, we analyzed the digital technologies included in each pattern and the size represented by each pattern in the sample as a whole. To this end, Table 9 shows the proportion (pk) and conditional probabilities of digital technologies in each pattern or class. The underlined numbers highlight, for each class, the highest probability of implementing each digital technology.

Table 9 - Conditional probabilities of having implemented the seven digital technologies.

	Class 1 no implemented	Class 2 rarely implemented	Class 3 moderate implementation
Class size (%)	0.5436	0.2935	0.1629
Artificial Intelligence			
1 - not implemented	<u>0.9909</u>	0.9572	0.5941
2 - implemented	0.0091	0.0428	0.4059
Cloud Computing			
1 - not implemented	0.7401	0.1089	0.2174
2 - implemented	0.2599	<u>0.8911</u>	<u>0.7826</u>
Robotics			
1 - not implemented	0.9582	0.9587	0.5593
2 - implemented	0.0418	0.0413	0.4407
Smart Devices			
1 - not implemented	0.8665	0.5843	0.2359
2 - implemented	0.1335	0.4157	<u>0.7641</u>
Big Data Analytics			
1 - not implemented	0.9708	0.7863	0.5506
2 - implemented	0.0292	0.2137	0.4494
High Speed Infrastructure			
1 - not implemented	0.8020	0.4078	0.3337
2 - implemented	0.1980	<u>0.5922</u>	<u>0.6663</u>
Blockchain			
1 - not implemented	<u>0.9998</u>	0.9530	0.8664
2 - implemented	0.0002	0.0470	0.1336

Source: Own elaboration.

In this sense, Class 1 shows that 54.36% of the family businesses in the sample do not implement digital technologies in their business models, with Blockchain standing out with a conditional probability of 99.98%, followed by AI with 99.09% of non-implementation. With regard to Class 2, 29.35% of the family businesses in the sample rarely implement digital technologies. Cloud computing and high-speed infrastructures are the technologies most likely to be adopted (89.11% and 59.22% respectively). Finally, class 3 includes 16.29% of the family businesses in the sample with a moderate level of

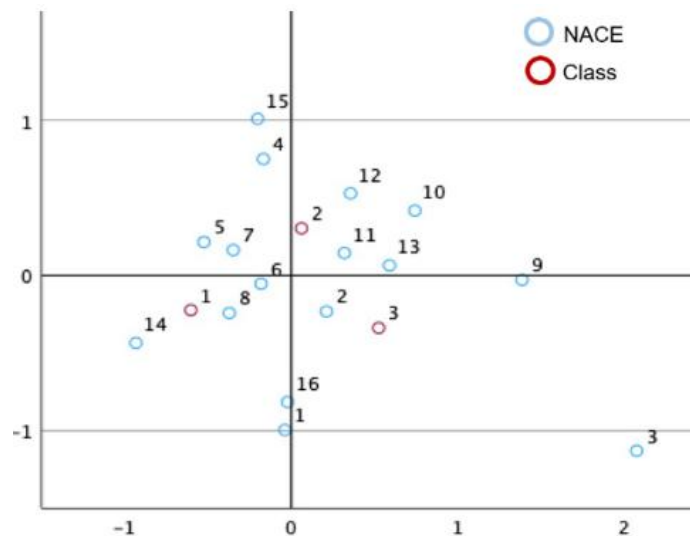
implementation of digital technologies. Technologies such as Cloud Computing (78.26% conditional probability), Smart Devices (76.41% conditional probability) and High Speed Infrastructures (66.63% conditional probability) are the digital technologies most adopted by these family businesses surveyed.

3.4.3 Correspondence Analysis

Latent Class Analysis (LCA) and Correspondence Analysis (CA) are statistical tools that, although distinct, can be used as a complement to explore the digital adoption patterns obtained. Since LCA identified three patterns of adoption of digital technologies by family businesses, Correspondence Analysis seeks to explore how these three patterns relate to the characteristics of European family businesses.

The first correspondence analysis (figure 10) looks at the relationship between NACE and the patterns of adoption of digital technologies by the family businesses in the sample (Class).

Figure 10 - Industry sector (NACE) and technological adoption (Class).



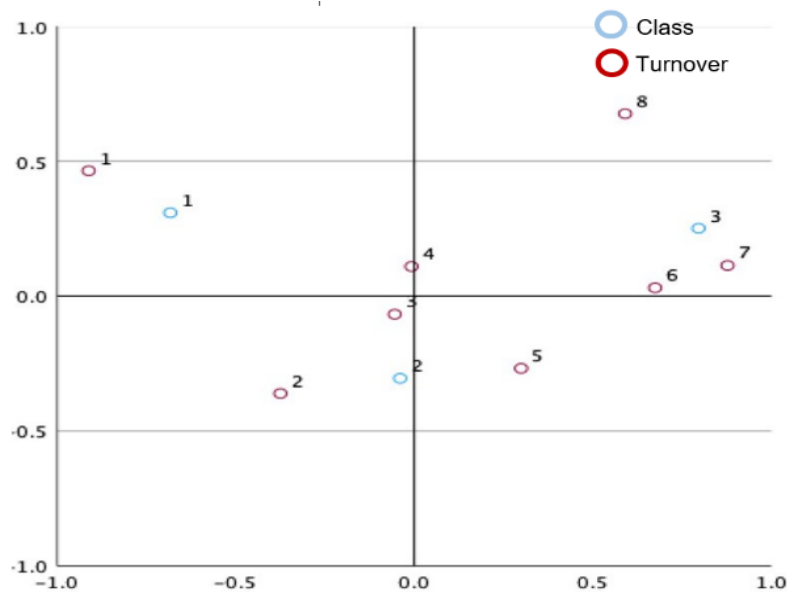
Note: NACE (1) agriculture, animal husbandry, hunting, forestry and fishing; (2) mining and quarrying; (3) manufacturing; (4) electricity, gas, steam and air conditioning; (5) water supply, sanitation, waste management and remediation; (6) construction; (7) wholesale and retail trade and repair of motor vehicles; (8) transportation and storage; (9) accommodation and food service activities; (10) information and communication technologies; (11) financial and insurance activities; (12) real estate activities; (13) consulting, scientific and technical activities; (14) administrative activities and support services; (15) public administration and defence; (16) education. Class (1) no implemented; (2) rarely implemented; (3) moderate implementation

Class 1, where digital technologies are not implemented, includes companies in the construction (6), transportation and storage (8) and administrative activities and

support services (14) sectors. Class 2, where digital technologies are rarely implemented, includes companies in the information and communication technologies (10), financial activities and insurance (11), real estate (12) and consulting, scientific and technical activities (13) sectors. Finally, the family businesses where the adoption of digital technologies is higher belonged to the extractive industries sector (2), manufacturing (3) and accommodation and food service activities (9).

In the second correspondence analysis (figure 11), the turnover and digital technology adoption patterns of the family businesses in the sample are related. In Class 1, corresponding to family businesses that do not implement digital technologies, we find companies whose turnover does not exceed €100,000. In Class 2, which includes companies that rarely implement digital technologies, we find family businesses whose turnover varies between €100,000 and €500,000 and between €500,000 and €1,000,000. Finally, companies with a moderate level of technological implementation (Class 3) are family businesses whose turnover exceeds €5,000,000.

Figure 11 - Company Turnover and technological adoption (Class).

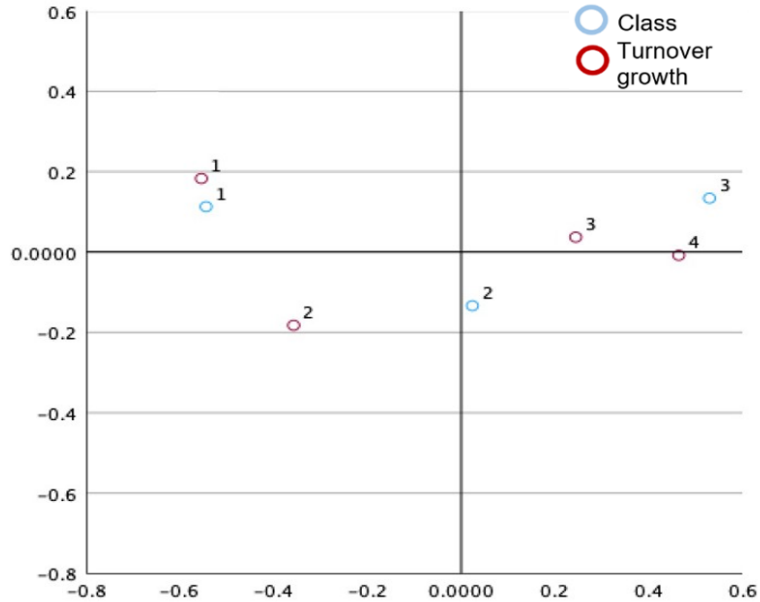


Note: Turnover (1) -100k; (2) 100k-500k; (3) 500k - 1M (4) 1M-2M; (5) 2M-5M; (6) 5M-10M; (7) 10M-50M; (8) +50M.
 Class (1) no implemented; (2) rarely implemented; (3) moderate implementation

In the third correspondence analysis (figure 12), the variation in turnover and the patterns of adoption of digital technologies by companies are related. Class 1 includes family businesses whose change in turnover has decreased, this class being associated with the non-implementation of digital technologies. Next, in class 2, where family businesses rarely adopt digital technologies, there are family businesses whose change in turnover was greater than 30% (4). Finally, in the pattern where technology is modernly

implemented (Class 3), there are family businesses whose change in turnover was less than 30%.

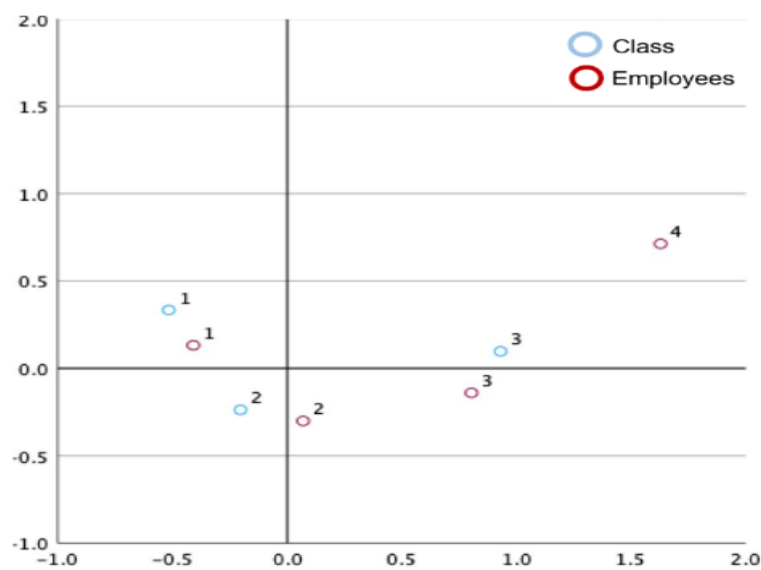
Figure 12 - Company Turnover growth and technological adoption (Class).



Note: Turnover growth (1) decreased; (2) stable; (3) grew less than 30%; (4) grew by at least 30%. Class (1) no implemented; (2) rarely implemented; (3) moderate implementation

In the fourth correspondence analysis (figure 13), the number of employees of family businesses and the patterns of adoption of digital technologies by the businesses are related.

Figure 13 - Company Employees and technological adoption (Class).

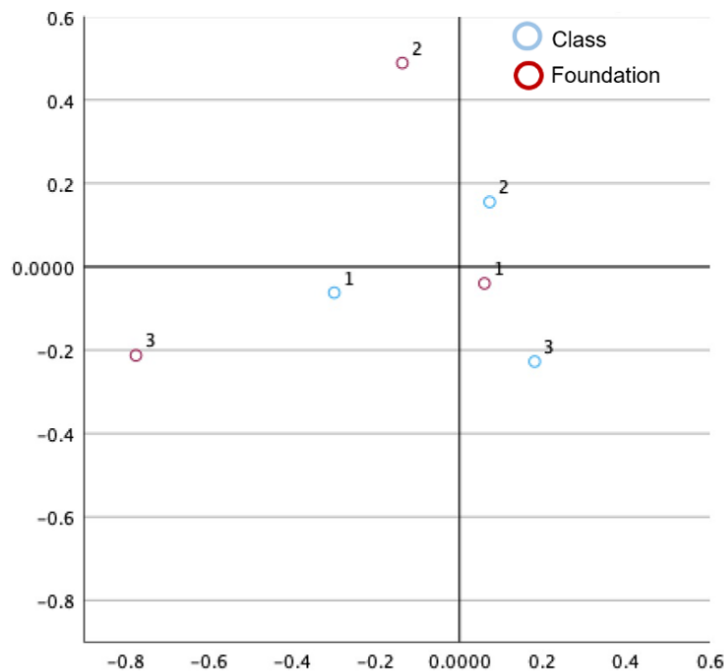


Note: Employees (1) 1-9 employees; (2) 10-49 employees; (3) 50-249 employees; (4) +250 employees. Class (1) no implemented; (2) rarely implemented; (3) moderate implementation.

Class 1, which includes family businesses that have not adopted digital technologies, includes companies whose number of employees varies between 1 and 9 (micro-entities). Although there is no correspondence for class 2, class 3 includes companies with more than 250 employees (large companies), with a moderate digital technology implementation pattern.

In the fifth correspondence analysis (figure 14), the year in which family businesses were founded is correlated with technology adoption patterns.

Figure 14 - Company Foundation and technological adoption (Class)



Note: Foundation (1) < 2010; (2) 2011- 2015; (3) > 2015. Class (1) no implemented; (2) rarely implemented; (3) moderate implementation

Class 1 includes companies founded after 2015 (3), means that the most recent family businesses that have not implemented these digital technologies. Although there are no matches associated with class 2, class 3 includes older family businesses whose founding year was before 2010 (1), thus justifying the moderate level of technological implementation.

3.5 Discussion and implications

3.5.1 Discussion of results

For digital technologies to bring benefits to EU family businesses, a deeper insight into the patterns of digital implementation and the correspondences associated with each pattern is needed. This article contributes to understanding the conditions under which

family businesses in different EU countries adopt seven interdependent digital technologies. We present findings that show patterns of involvement where the level of adoption of digital technologies is associated with the organizational characteristics of the companies, with heterogeneities in the levels of technological implementation.

This study considered seven digital technologies - Artificial Intelligence (AI), Cloud Computing, Robotics, Smart Devices, Big Data Analytics, High-Speed Infrastructure and Blockchain - as enablers of the digital transformation of EU family businesses. Overall, it was found that all digital technologies are adopted by EU family businesses, although there are significant heterogeneities in technological implementation.

Our results suggest three patterns of digital technology implementation in EU family businesses. In the first pattern, where family businesses that do not implement digital technologies are found, Artificial Intelligence and Blockchain are the technologies most likely not to be implemented. According to Saghiri et al. (2020) both technologies are complex and require skilled labor, which creates barriers to implementation among family businesses. In addition, AI and Blockchain are often seen as disruptive technologies that require profound changes in organizational structure and business processes. As FEs are characterized by their focus on traditional business models, these are technologies that tend to avoid (Clemente-Almendros et al., 2024).

In the second pattern, which includes family businesses that rarely implement digital technologies, Cloud Computing and High-Speed Infrastructures are the most adopted technologies. According to Skafi et al. (2020), Cloud Computing is growing among family businesses due to its accessibility, flexibility and low cost. This technology offers high security, with continuous updates, where it is possible to optimize operations in a simpler and more economical way (Quarato et al., 2020). In addition, High-Speed Infrastructures are also more likely to be deployed. Although they are developed by telecommunications companies, access to High-Speed Infrastructure is directly related to the support and investment of each region's government. Without this basic infrastructure, the competitiveness of family businesses could be compromised (Matteo et al., 2023).

In the third deployment pattern, where technologies are moderately deployed, Cloud Computing, High-Speed Infrastructures and Intelligent Devices stand out the most. Cloud Computing remains a central technology due to its cost-effectiveness (Skafi et al., 2020). High-Speed Infrastructures facilitate the connectivity required for advanced technologies, enabling the use of smart devices and other connected technologies (Matteo et al., 2023). Finally, Smart Devices are widely implemented in this class, probably due to their usefulness in improving operational efficiency and process control, something valued by companies looking to innovate without compromising their traditional base (Kahle et al., 2020).

Correspondence analysis suggests that digital technology adoption patterns vary between sectors of activity (NACE) due to specific characteristics of each sector. As discussed in the study by Agostini and Filippini (2019) there are specific characteristics of each sector that facilitate or hinder digitization. Family businesses in sectors such as construction, transport and administrative activities, which make up Class 1, tend to have lower adoption of digital technologies, as many activities depend intensively on labour and physical infrastructure, with fewer opportunities for digitization (Clemente-Almendros et al., 2024). On the other hand, companies in sectors such as ICT and consultancy that fall into Class 2 for implementing digital technologies have a greater affinity with digital innovation due to the very nature of their operations, which depend on digital services and information. Family businesses in the manufacturing and accommodation sectors (Class 3), which are more complex and competitive, tend to incorporate technologies for efficiency and automation, in line with studies by Matt et al. (2015) on digitalization in complex manufacturing and service sectors.

The results also show a relationship between turnover and the adoption of digital technologies, where family businesses with lower turnover (<100,000€) tend not to implement digital technologies (Class 1). This pattern is supported by studies associating available budget with the ability to invest in innovation (e.g., Anderson & Tushman, 2018). Companies with intermediate turnover (Class 2) implement technologies sporadically, which can be justified by the need to maintain a strong and efficient structure to sustain competitiveness. In this sense, these companies are characterized by selected investments in innovation, prioritizing technologies that offer clear returns and are aligned with their market strategy and financial capacity (Anderson & Tushman, 2018). Companies with higher turnover (Class 3) that show greater digital adoption reflect the trend that companies with greater financial capacity are more willing to invest in technologies to gain competitiveness (Cillo et al., 2019). The results demonstrate the positive relationship between financial capacity and the propensity to adopt emerging digital technologies (Mazzarol, 2015).

The results of the relationship between turnover variation and digital technology adoption patterns suggest that family businesses with declining turnover (Class 1) avoid investing in technology, which is consistent with the findings of Cillo et al. (2021), who showed that the propensity to innovate is lower in periods of financial downturn. In Class 2, where the adoption of digital technologies is rare, there are family businesses whose turnover has grown significantly (>30%). This can be explained by the need for some companies to seek out technologies as an opportunity to conquer new markets. Finally, Class 3 includes family businesses with moderate turnover growth (<30%) characterized by a consistent growth rate and moderate technological adoption. This relationship is supported by the innovation theory of Vial (2021) which argues that companies in a

growth phase generally invest in innovation to stabilize and expand operations.

The results also highlight that family businesses with fewer employees (1-9) and low technological adoption (Class 1) face barriers in adopting new technologies, especially related to the lack of skilled labor and traditional management policies (Georgescu et al., 2022). In contrast, companies with more than 250 employees (Class 3) have a more robust organizational capacity, facilitating the absorption and use of technologies, according to the dynamic capabilities model of Gonzalez-Varona et al. (2024). This theory suggests that larger companies have internal resources that support innovation, justifying their greater digital adherence.

Finally, the results suggest that newer family businesses (founded after 2015) tend not to implement digital technologies (Class 1), possibly due to the early stage of their operations. Cillo et al. (2019), proposed that young companies face market stabilization challenges before adopting innovative technologies. On the other hand, older companies, founded before 2010, which have greater technological implementation (Class 3), have already reached organizational maturity and may be more aligned with digital transformation. This observation is justified by the study by Vial (2021) which argues that older companies with consolidated operations find it easier to adopt digital technologies without compromising stability. The study also highlights that organizational maturity can facilitate the incorporation of innovative technologies, especially in companies that have already gone through phases of growth and development.

3.5.2 Theoretical implications

The results of this study have theoretical implications in the context of family businesses in the European Union. In this sense, we identify: (i) a contribution to the existing literature on digital transformation in family businesses. Currently, there are no known studies that simultaneously analyze the contributions of seven digital technologies in the digital transformation process in both family businesses and non-family businesses; (ii) identification of three digital maturity patterns present in EU family businesses: digital transformation not implemented, rarely implemented and moderately implemented; (iii) unequal contribution of the different digital technologies in the context of family businesses. Digital technologies that are more cost-effective are the most implemented, while complex digital technologies that require skilled labor and higher investment are the least implemented. Theoretically, the study expands knowledge about the different levels of digital maturity and the unequal impact of technologies on family businesses.

3.5.3 Practical implications

In practical terms, the results of this study have led to the following conclusions: (i) the implementation of digital technologies in European family businesses is still low. In this sense, government officials have an important role to play, particularly in terms of granting subsidies to strengthen confidence in the use of technologies and increase the competitiveness of family businesses in the European digital market; (ii) the need to develop organizational capacities and human resources. The implementation of complex technologies such as AI and Blockchain is essentially due to a lack of skilled labor. In this sense, investment in human resources training programs, partnerships with universities or research centers can help overcome the barrier to implementing more complex technologies, making EU-27 family businesses more competitive; (iii) newer family businesses, with lower turnover and in the construction and transport sectors are the ones that implement the fewest digital technologies. It is suggested that these family businesses, before starting the intensive digitalization process, adopt easy-to-implement technologies that improve their operational efficiency without changing their organizational structure, such as business management software (ERP), digital collaboration tools (such as Microsoft Teams or Slack), digital accounting systems, or simple e-commerce platforms. This progressive digital development will enable a higher level of technological uptake, making European family businesses more competitive.

Country-level policies should not be adopted, but regional policies, taking into account the heterogeneities in the adoption of digital technologies between family businesses and between countries. Thus, the results of this study contribute to the advancement of digitalization policies and practices for family businesses in the EU-27, offering a basis for interventions that promote digital transformation in a way that is adapted to their needs. In practical terms, it indicates the need for greater government support, human resources training and the progressive adoption of technologies to strengthen the competitiveness of family businesses in the European market.

3.5.4 Limitations and Future Lines of Research

This study has some limitations. Firstly, we only used secondary data from a single database, which restricts us to the sample of indicators collected by that specific source. In addition, the data is from 2020 and only includes companies from the 27 EU member states. Therefore, future studies could incorporate more recent data and include additional variables from other databases. It would also be relevant in future research to explore other digital technologies, such as augmented reality, machine learning and IoT. New studies could also be replicated in other continents and in non-family businesses.

The following questions are also suggested for future studies: how quickly can the investment made in digital technologies be recovered? What is the impact of implementing digital technologies on cost reduction? How does the digital maturity of family businesses evolve over time? What is the financial and organizational impact of digital transformation on family businesses and how does this influence their sustainability and competitiveness?

3.6 Conclusions

Family businesses have been under increasing pressure to implement digital technologies into their business models in order to become more competitive. In this context, this study aimed to analyze and map the implementation patterns of digital technologies in family businesses in the European Union and to relate the implementation of these technologies to the characteristics of European family businesses.

The literature review shows that family businesses in the EU still face significant barriers in adopting digital technologies, such as a lack of financial resources and skilled labor, and are particularly affected in less digitally developed regions. Although family businesses are more resistant to change, those that overcome this obstacle find digital transformation an important competitive advantage.

In this study, we show that the implementation of digital technologies (Artificial Intelligence, Cloud Computing, Robotics, Smart Devices, Big Data, High Speed Infrastructure and Blockchain) is influenced by the sector of activity, turnover, turnover growth, number of employees and year of foundation of EU-27 family businesses. In addition, this study shows, through the diagnosis of 2,523 family businesses in Europe, that the implementation of digital technologies is still low and that the contribution of the implementation of digital technologies is uneven, leading companies to prioritize investment in more cost-effective technologies, to the detriment of more complex technologies with higher implementation costs that require skilled labor.

This conclusion is possible because, in a single study, it was possible to compare the contribution of seven different digital technologies, resulting in three patterns of adoption of digital technologies by European family businesses. It was found that Cloud Computing and Smart Devices are the most widely adopted in EU-27 family businesses, to the detriment of Artificial Intelligence and Blockchain. It should also be noted that the majority of family businesses in the sample do not adopt any digital technology.

Based on the research questions presented, we can answer as follows: "What kind of patterns can be identified in the adoption of digital technologies in European family businesses?" - The results identify three main patterns in the adoption of digital

technologies in European family businesses, classified according to the level of technological implementation. The first pattern includes European family businesses that do not adopt digital technologies. In this group, Artificial Intelligence (AI) and Blockchain are the least implemented technologies due to their complexity and the need for skilled labor, as well as being seen as disruptive and incompatible with the traditional model of these companies. In the second pattern, there are European family businesses that implement digital technologies to a limited extent. The most common technologies here are cloud computing and high-speed infrastructures, which are accessible and economically viable for companies, as well as being supported by government initiatives that promote connectivity infrastructures. Finally, the third pattern includes European family businesses with a moderate implementation of digital technologies. The most adopted technologies in this group include Cloud Computing, High-Speed Infrastructures and Smart Devices, which are valued for their cost-effectiveness and the possibility of innovation without compromising traditional models. These patterns show that digital adoption varies widely among family businesses, depending on factors such as the complexity of the technology, accessibility and government support, as well as the propensity for innovation.

In the same vein, a second research question was formulated: "How do the characteristics of companies relate to the adoption of these digital technologies?". The adoption of digital technologies is closely related to the organizational, financial and sectoral characteristics of family businesses. The analysis of the Sector of Activity (NACE) led to the conclusion that family businesses in sectors such as construction and transport tend to have lower digital adoption due to their heavy dependence on unskilled labor and physical infrastructure. On the other hand, family businesses in the ICT and consultancy sectors have a greater affinity with digital innovation due to their technological nature and Manufacturing and Services industries adopt technologies to improve efficiency and automation. The analysis of Turnover and Turnover Growth highlighted that family businesses with greater financial capacity tend to invest more in digital technologies, while companies with lower turnover generally avoid this adoption due to their financial capacities. Companies with moderate financial growth are more inclined to adopt technologies in order to remain competitive. Analysis of the number of employees showed that family businesses with more than 250 employees are better able to absorb digital technologies, while companies with up to 9 employees face difficulties due to a lack of skilled labor and more traditional management practices. Finally, the analysis of the age of family businesses highlighted that newer companies, founded after 2015, avoid digital adoption due to their focus on long-term stabilization. On the other hand, older companies (founded before 2010), which have a more stable base, are more likely to incorporate digital technologies into their business models.

CHAPTER 4 - UNLOCKING DIGITAL TRANSFORMATION: ENVIRONMENTAL INFLUENCES ON TECHNOLOGY ADOPTION IN FAMILY ENTERPRISES

Abstract

Digital transformation has been a determining factor for the competitiveness of family businesses. However, the adoption of advanced digital technologies is not homogeneous and is conditioned by internal and external factors. This study investigates how the internal and external environment influences family businesses' approach to digital technologies and, consequently, the degree of adoption of these solutions. Based on data from Flash Eurobarometer 486, referring to 2,523 family businesses in the European Union, a research model was formulated to which Partial Least Squares (PLS) was applied. The results show that companies with both internal and external conditions positively influence the adoption of digital technologies, especially when they have a favourable attitude toward digital transformation. This attitude, referred to as the "technological approach", proved to be essential, in that the more positive it is, the greater the likelihood of adopting technologies. It was also found that the external environment has a more significant impact than the internal environment, especially on the adoption of more advanced digital technologies. This study also contributes to understanding the main challenges and opportunities of digital transformation in family businesses, offering practical guidelines for managers and formulating public policies that aim to support this transition.

Keywords: Digital Transformation; family businesses; digital technologies; Flash Eurobarometer 486; Partial Least Square (PLS).

4.1 Introduction

Digital transformation has established itself as an essential strategic vector for business competitiveness, driving innovation, operational efficiency, and the creation of new business models (Beverungen et al., 2022; Vial, 2021a). However, the adoption of digital technologies occurs heterogeneously between organizations, especially in the case of family businesses, whose governance structure, organizational culture, and intergenerational dynamics introduce specificities that influence the pace, depth and direction of the digital transformation (Ano & Bent, 2022; Civelek et al., 2023).

Family businesses play a central role in the global economy, particularly in the European Union, where they represent between 65% and 80% of companies and employ around 100 million people (European Family Businesses, 2024). Despite their relevance, they face specific challenges in adopting digital technologies, stemming from factors such as conservative organizational culture, risk aversion and long-term orientation (Massis et al., 2020; Bürgel et al., 2023). Although two-thirds of these companies recognize the importance of digital technologies, only one-third have started implementing them (European Union, 2018), which suggests the need for targeted strategies to overcome cultural and structural barriers and promote digital transformation in this sector.

The literature has shown that technological adoption is influenced by a set of internal factors, such as the qualifications of human resources, the culture of innovation and governance capacity, and external factors, such as institutional support, access to funding and the maturity of technological ecosystems (Burinskienė et al., 2024; Soluk & Kammerlander, 2021). However, in the context of family businesses, the interaction between these factors becomes more complex and is often mediated by the organization's strategic approach to adopting digital technologies (Ferreira et al., 2023). In fact, the way in which these companies approach technology - whether proactively or reactively, can act as a crucial moderating factor in the level of implementation of different technologies, from low-complexity solutions such as Cloud Computing and Smart Devices, to more advanced tools such as Big Data Analytics and Robotics (Magaz-González et al., 2024).

In this context, two research questions were formulated: i) What is the influence of the internal and external environments on the adoption of digital technologies by family businesses? ii) What role does the digital strategic approach of family businesses play in implementing of digital technologies? Thus, the main objective of this study is to analyze the factors that condition the adoption of digital technologies in European family businesses. To this end, based on data from Flash Eurobarometer 486, a sample of

2,523 family businesses in the 27 Member States of the European Union was used. The empirical analysis was carried out using SPSS software and the Partial Least Squares (PLS) method, allowing us to test a theoretical model based on the influence of internal and external variables, as well as the moderating role of the companies' digital approach.

The contributions of this study are manifold. Firstly, it fills a gap in the literature by addressing digital transformation from the perspective of family businesses, a segment often neglected in quantitative research on corporate digitalization (European Family Businesses, 2024; Gonzalez-Varona et al. 2024). Secondly, by considering the complexity of the digital technologies studied (such as AI, Blockchain, Robotics and Big Data), the study offers a more detailed view of the different levels of digital maturity of these organizations. Thirdly, the study contributes to the theoretical discussion on corporate digital engagement as a multidimensional concept that involves attitudes, strategies and organizational capabilities, going beyond simple technological adoption (Überbacher et al., 2020; Vrana et al., 2021). Finally, the results indicate that the adoption of digital technologies depends on the dynamic interaction between contextual and cultural factors, suggesting that more tailored public policies, such as tax incentives, regional e-commerce platforms, digital mentoring networks and partnerships with start-ups, can be decisive in accelerating digital transformation within family businesses. This study thus offers relevant practical implications for managers, policymakers and business entities seeking to strengthen the competitiveness of family SMEs in the European digital landscape.

4.2 Framework

The Contingency Model can be adapted to explain how family businesses face digital transformation, as evidenced by Müller et al., (2024). Although the literature does not highlight an ideal approach to technology adoption, the effectiveness of digital transformation in family businesses depends on the interaction between various internal and external factors (Furr et al., 2022; Vrana et al., 2021). Developed in the field of organizational theory, the Contingency Model argues that companies must adjust their structure, strategy and processes to the environment in which they operate. This alignment increases efficiency and competitiveness (Broccardo et al., 2023). According to Soluk and Kammerlander (2021), the way family businesses face digital transformation is related to three main dimensions: environmental, organizational and technological factors. Environmental factors refer to competitive pressures, changes in consumption patterns and market demands (Ferreira et al., 2023). Organizational factors involve the company's internal structure, the prevailing culture and the family governance model

(Agostini & Filippini, 2019). Finally, technological factors concern the available technologies' characteristics and suitability for the organization's reality (Kumar, 2024). By considering these three dimensions, the Contingency Model becomes a framework for diagnosing the level of digital maturity of family businesses (Müller et al., 2024). This diagnosis makes it possible to identify the barriers and opportunities specific to each organization, guiding the development of tailor-made strategies for technology adoption. In addition, the model helps managers make more informed decisions, promoting a more effective digital transformation that is aligned with the company's context.

4.2.1 The Family Business Approach to Digital Technologies

Introducing advanced technologies is essential for family businesses to remain competitive in an increasingly digital market (Barile et al., 2024). Their adoption allows for the optimization of processes, improved operational efficiency and adaptation to new consumer needs (Basly & Hammouda, 2020). Technologies such as Artificial Intelligence, Big Data and Cloud Computing favor strategic decision-making based on data (De Santis & D'Onza, 2021; Tuncalp, 2024). In addition, family businesses that invest in digital transformation increase their capacity for sustainable growth and generational succession, guaranteeing business continuity in the long term (Soluk & Kammerlander, 2021).

The literature suggests that family businesses tend to be more cautious about adopting digital technologies than non-family businesses (Sihombing & Lumbantobing, 2024). This hesitation may be related to a conservative mindset and the fear that digital transformation could compromise the company's core values (Lin et al., 2024). However, some research indicates that family businesses that manage to overcome these barriers become highly innovative, as their long-term vision allows for continuous investment in technology (Zaoui & Souissi, 2020). Resistance to change is one of the main barriers faced by family businesses in adopting digital technologies (Ano & Bent, 2022). Despite recognizing the importance of innovation, many of these companies are hesitant to transform their processes. This resistance is mainly due to strong ties to traditions and established practices (Kumar, 2024).

The adoption of digital technologies is a dynamic and multifaceted process, influenced by factors such as the availability of infrastructure, technical training and operational challenges (Vial, 2021). The implementation of these technologies occurs at different levels of complexity, ranging from low to high, depending on the resources required and the organizational impacts. Low implementation technologies, such as Cloud Computing, Smart Devices and High-Speed Infrastructures, are widely accessible

due to their ease of integration. These technologies allow for rapid adoption and provide immediate benefits without requiring large financial investments or complex technical skills. On the other hand, technologies with moderate implementation, such as artificial intelligence and Blockchain, require a higher level of specialization and deeper organizational adaptation (Tuncalp, 2024). Although they offer significant advantages in terms of automation and data security, their incorporation requires investment in training and technological infrastructure (De Santis & D'Onza, 2021). Finally, highly implemented technologies, such as robotics and Big Data, present more complex challenges, as they require the use of advanced infrastructures and highly qualified teams (De Santis & D'Onza, 2021; Hsiung & Wang, 2022). Their adoption profoundly transforms production and strategic processes, constituting a differentiating factor in sectors marked by innovation.

Based on the literature review, we classified advanced digital technologies into three groups - low, moderate and high implementation difficulty (table 10).

Table 10. Classification of Advanced Digital Technologies by Level of Implementation Difficulty

Difficulty of Implementation	Advanced Digital Technology	Definition	Authors
Low	Cloud Computing	Delivery of IT services, such as storage and processing, via the Internet, allowing on-demand access and scalability.	(Kumar, 2024; Skafi et al., 2020)
	Smart Devices	Internet-connected devices collect, process and transmit data, interacting with users and other devices.	(Haar & Wilkinson, 2024; Kahle et al., 2020)
	High-speed infrastructure	Advanced networks, such as 5G and fiber optics, offer high data transmission capacity and low latency.	(Bialkova & Ros, 2021; Matteo et al., 2023)
Moderate	AI	Computer systems that perform tasks that require human intelligence, such as pattern recognition and decision-making.	(Sawang & Kivits, 2024; Tuncalp, 2024)
	Blockchain	Digital registration systems are designed to keep data secure, without the need for a central authority or third party.	(Kumar, 2024; Saghiri et al., 2020)
High	Robotics	Automatic machines capable of performing physical tasks autonomously	(Hsiung & Wang, 2022)
	Big Data	Analysis of large volumes of varied and fast data to extract insights and support decisions.	(De Santis & D'Onza, 2021; D. K. Nguyen et al., 2023)

Source: Own elaboration.

Family classifying these technologies into different levels of implementation allows

for a more structured approach to their adoption, considering the challenges and benefits inherent to each one (Begnini et al., 2024). With this in mind, the first research hypothesis is formulated:

H1: The favorable approach to advanced digital technologies by family businesses positively influences the adoption of advanced digital technologies with (a) low implementation difficulty, (b) moderate implementation difficulty, and (c) high implementation difficulty.

4.2.2 Digital Technologies and the Internal and External Environment of Family Businesses

Digital transformation is vital for the competitiveness of family businesses in the current scenario (Begnini et al., 2023). However, adopting digital technologies in these organizations faces internal and external challenges that directly influence this process (Ferreira et al., 2023).

Internally, the availability of human resources with digital skills is essential for effectively implementing new technologies. Family businesses often face difficulties in training and retaining specialized talent, especially when managers belonging to previous generations show resistance to change (J. Müller & Potzel, 2024). In addition, adequate technological infrastructure, including quality hardware, software and connectivity, is essential to support new digital tools and processes (Zapata-Cantu et al., 2023). The absence of a robust technological base can limit a company's ability to integrate and benefit from digital solutions (Pöschl & Freiling, 2020).

Another relevant internal factor is the vitality and performance of the business environment in the region where the company is located (Cillo et al., 2019). A dynamic and innovative business ecosystem can stimulate digital transformation by providing easy access to support networks, strategic partnerships and training opportunities (Vasilev et al., 2020). In contrast, regions with a poorly developed business fabric, with weak links between companies, educational institutions and innovation centers, can represent an obstacle to the adoption of new technologies (Begnini et al., 2023). The degree of local competitiveness also has an influence, as companies in more dynamic markets tend to look for digital solutions to differentiate themselves and ensure their continuity in the market (Basly & Hammouda, 2020). These factors support the following research hypothesis:

H2: The company's internal environment positively influences a favorable approach

to digital technologies by family businesses.

Externally, access to funding, both public and private, is crucial to making investments in technology, training human resources and restructuring processes viable. Incentive programs promoted by the government and specific credit lines can alleviate the financial limitations that characterize many of these organizations (Pöschl & Freiling, 2020). At the same time, a favorable legal and administrative framework - with clear regulations and institutional support - can facilitate and encourage the adoption of digital technologies. On the other hand, excessive bureaucracy or overly restrictive legislation can discourage the implementation of innovative initiatives (Barile et al., 2022). These elements, therefore, support the formulation of the following hypothesis:

H3: The company's external environment positively influences a favorable approach to digital technologies by family businesses.

Digital transformation in family businesses is based on internal and external factors (Pöschl & Freiling, 2020; Zapata-Cantu et al., 2023). Understanding and developing these elements is key to facilitating the digital transition, ensuring the competitiveness and sustainability of these organizations in today's market (Burinskienė et al., 2024).

The implementation of advanced digital technologies, such as Cloud Computing, Smart Devices, High-Speed Infrastructures, Artificial Intelligence, Blockchain, Robotics and Big Data, has become essential for the competitiveness of family businesses in the current scenario (Hsiung & Wang, 2022; Kumar, 2024; Nguyen, 2024; Sawang & Kivits, 2024). However, the adoption of these technologies is strongly conditioned by internal and external factors that directly influence this process. Internally, the availability of employees with digital skills and the existence of suitable technological infrastructures are crucial aspects for the effective implementation of these technologies (J. Müller & Potzel, 2024). The presence of qualified professionals facilitates the integration of solutions such as Cloud Computing and Smart Devices, whose implementation complexity is relatively low (Skafi et al., 2020). On the other hand, technologies with a moderate degree of implementation, such as AI and Blockchain, require specialized technical knowledge and a more robust technological infrastructure (Kumar, 2024; Tuncalp, 2024). On the other hand, adopting technologies with a high level of implementation difficulty, such as Robotics and Big Data, requires significant investments in advanced equipment and systems, as well as highly trained technical teams to make them operational (De Santis & D'Onza, 2021; Hsiung & Wang, 2022). These aspects support the following hypothesis:

H4: A favorable internal company environment positively influences the adoption of advanced digital technologies (a) low implementation difficulty; b) moderate implementation difficulty; c) high implementation difficulty).

Externally, access to financing, both public and private, as well as the legal and administrative framework, play a decisive role in the adoption of digital technologies (Pöschl & Freiling, 2020). The availability of financial resources is essential to enable the investments in infrastructure and training needed to implement technologies with varying degrees of complexity (Hsiung & Wang, 2022; T. H. Nguyen, 2023). Incentive programs promoted by the state and specific credit lines can facilitate introducing solutions such as Cloud Computing and Smart Devices (Haar & Wilkinson, 2024; Skafi et al., 2020). However, the adoption of more advanced technologies, such as robotics and big data, may require more structured public policies, as well as a regulatory environment that favors innovation (De Santis & D'Onza, 2021). These elements therefore, support the formulation of the following hypothesis:

H5: A company's favorable external environment positively influences the adoption of advanced digital technologies (a) low implementation difficulty; b) moderate implementation difficulty; c) high implementation difficulty).

4.2.3 Association between Internal and External Environment and Difficulty in Implementing Digital Technologies: mediating effect of the approach to digital technologies

The adoption of advanced digital technologies is fundamental to the competitiveness of family businesses in the current context (Furr et al., 2022). However, the implementation of these technologies faces different challenges, which vary depending on the complexity of the technological solutions and the internal and external factors of the organization (Barile et al., 2022; J. Müller & Potzel, 2024). Furthermore, how the company views and manages the digital transformation can mediate the relationship between these factors and effective technological adoption (Rashid & Ratten, 2020).

In fact, the existence of employees with digital skills facilitates the implementation of low-complexity technologies, such as Cloud Computing and Smart Devices (Zapata-Cantu et al., 2023). In the case of technologies with moderate complexity, such as artificial intelligence and Blockchain, a higher level of technical specialization and a more robust technological infrastructure are required (Lanzini et al., 2021; Tuncalp, 2024). The

integration of highly complex technologies, such as robotics and big data, requires significant investment in advanced equipment and highly qualified teams (Al Lawati et al., 2024; Hsiung & Wang, 2022). In this sense, it is pertinent to formulate the following research hypothesis:

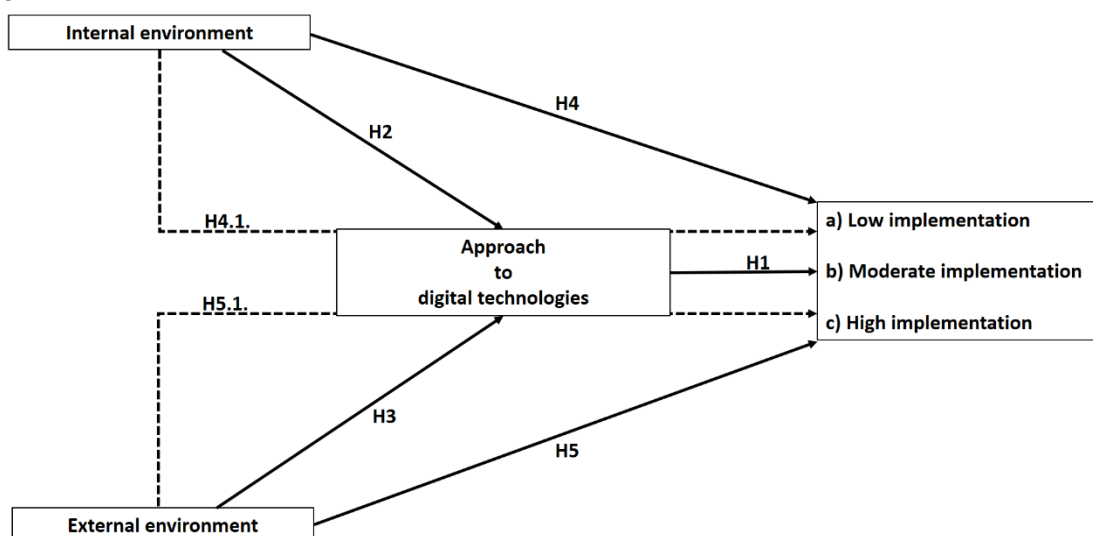
H4.1: A favorable internal company environment positively influences the adoption of advanced digital technologies (a) low implementation difficulty; (b) moderate implementation difficulty; (c) high implementation difficulty, when moderated by a favorable approach to digital technologies."

From another perspective, access to financial resources plays a vital role in investing in infrastructure and the training needed to implement technologies with different levels of complexity (Nguyen, 2023). Government incentive programs and specific credit lines can facilitate the adoption of technological solutions (Pöschl & Freiling, 2020). At the same time, a favorable legal and administrative framework - with clear regulations and institutional support - is also essential to stimulate technological innovation (De Santis & D'Onza, 2021). In this context, the following research hypothesis emerges:

H5.1: A favorable external environment of the company positively influences the adoption of advanced digital technologies (a) low implementation difficulty; b) moderate implementation difficulty; c) high implementation difficulty), when moderated by the favorable approach to digital technologies.

The research model shown in Figure 15 synthesizes the formulated hypotheses.

Figure 15 - Research model.



Source: Own elaboration. Note: direct effects (→) and mediating effects (→→).

4.3 Methods

4.3.1 Sample

The sample for this study was collected from the Gesis - Leibniz Institute for Social Sciences database, using data from Flash Eurobarometer 486 published in 2020 (European Commission, 2020). Data collection took place between February 19 and May 5, 2020 through computer-assisted telephone interviews.

Companies located in the 27 EU member states were surveyed, as well as in Bosnia and Herzegovina, the UK, Norway, Iceland, North Macedonia, Serbia, Turkey, Kosovo, Brazil, Canada, Japan and the USA. The original database contained 16,365 companies from various sectors. Two filters were applied to tailor the sample to the subject of the study, restricting it to family businesses in the EU-27. The first filter was based on question 13 of the survey ("In terms of ownership, is your company predominantly family-owned?"), resulting in 3,343 companies. The second filter excluded companies outside the EU-27, resulting in a final sample of 2,523 family businesses.

The geographical distribution of the sample shows some asymmetry, with the lowest representation of family businesses in Romania (0.32%), Estonia (0.55%) and Lithuania (0.79%). On the other hand, Portugal and Spain were the most represented countries, making up 7.73% and 9.04% of the sample respectively. Regarding the characteristics of the companies, the most recent was founded in 2020 and the oldest in 1850. With regard to the number of employees in the last three years, 50.6% of the companies had up to 49 workers, 47.07% had between 50 and 249 employees and 2.33% employed more than 250 workers. As for turnover since 2016, 35.2% of companies have seen growth of up to 30%, 26.2% have remained stable, 15.5% have seen a reduction and 20.6% have increased turnover by at least 30%. About the growth in the number of full-time employees since 2016, 17.1% of companies have seen an increase of up to 30%, 16.2% have remained stable, 5.1% have reduced the number of employees and 9% have seen an increase of at least 30%.

4.3.2 Data measurement

Considering the aim of the study and the availability of data in the Flash Eurobarometer 486 database, three constructs were developed (see table A1). The first group addressed the internal and external environment of family businesses, based on question 16 of the Flash Eurobarometer 486. The internal environment was assessed in terms of the availability of qualified human resources and adequate infrastructure for businesses. The external environment was analyzed in terms of the strength and performance of the business environment in the region, access to public and private

funding, as well as the legal and administrative framework for family businesses.

The second group focused on family businesses' approach to digital technologies, according to the data in question 22 of the survey. Three categories were considered: low approach, characterized by the non-adoption of digital technologies due to lack of knowledge, skills or funding; moderate approach, which reflects knowledge of digital technologies and the possibility of future adoption; and high approach, in which the company already has knowledge of the technologies and has adopted them into its operational structure.

The third group examined the difficulty of implementing digital technologies, based on question 23 of the Flash Eurobarometer 486, classifying it into three levels. Low implementation includes High-Speed Infrastructures, Smart Devices and Cloud Computing. Moderate implementation involves technologies such as Artificial Intelligence and Blockchain. High implementation corresponds to the adoption of advanced technologies such as Robotics and Big Data.

4.3.3 Data analysis

Initially, a statistical analysis of the items making up the constructs of the research model was carried out using SPSS software (v. 29). Next a factor analysis was carried out, implementing an Exploratory Factor Analysis (EFA) to group the items into factors, evaluate the variance explained by each factor and the total accumulated variance. A Confirmatory Factor Analysis (CFA) was then carried out to validate the factor loadings of each item and confirm the reflective structure of the model. After this stage, the Partial Least Squares (PLS) method was applied to the research model, using SmartPLS software (version 4.0). PLS combines factor analysis with linear regressions estimated using the ordinary least squares method, and is a deterministic approach that analyzes the covariances between one or more independent variables and a dependent variable (Hair et al., 2021). This method has been widely used in research on family businesses (Basco et al., 2022; Hair et al., 2021; Yildiz et al., 2024). The resulting model was evaluated in terms of reliability, convergent validity and discriminant validity, adopting the metrics recommended by Hair et al. (2022): (i) Cronbach's Alpha ($C\alpha > 0.70$), (ii) composite reliability ($CR > 0.70$), (iii) average variance extracted ($AVE > 0.50$) and (iv) discriminant validity, analyzed by the heterotrait-monotrait (HTMT) criterion.) In addition, the model's overall fit, the existence of collinearity between variables, the predictive relevance of the model and its explanatory power were examined. Finally, a bootstrapping analysis was carried out in SmartPLS (version 4.0) to test the hypotheses proposed in the research model.

4.4 Results

4.4.1 Data analysis

Tables 11, 12 and 13 show the frequencies of factors affecting the adoption of digital technologies in family businesses.

Table 11 - Results Frequency of the internal and external environment of family SMEs.

Variables	Items	Frequency (%)				
		Very good	Good	Bad	Very bad	N/A
Internal environment	I1. Skilled human resources	12,29	44,97	30,52	10,62	2,50
	I2. Infrastructures for companies	15,46	56,96	17,12	4,88	5,59
External environment	E1. Strength and performance	19,06	60,88	19,91	2,89	3,25
	E2. Access to public and private financing	14,31	46,69	18,19	7,09	13,71
	E3. Legal and administrative environment	8,76	40,82	27,39	9,79	13,24

Source: Own elaboration. Note: Obs. = 2.523 Family SMEs

Regarding the internal level, only 12.29% of companies consider their qualified human resources to be "very good" and 44.97% "good". While 30.52% rate this variable as "bad", a further 10.62% of family SMEs rate their human resources as "very bad". As for infrastructure, the majority of companies (56.96%) consider it to be "good", while 17.12% rate it as "bad" and 4.88% as "very bad", showing some heterogeneity in the structural conditions of companies.

Regarding the external environment, the strength and performance of companies is considered "good" by 60.88% of respondents, but 19.91% indicate that the situation is "bad". Access to public and private funding is rated as "good" by 46.69% of companies, while 18.19% rate it as "bad" and 7.09% as "very bad". In addition, 13.71% indicate that this criterion does not apply to their reality. The legal and administrative environment is perceived as "good" by 40.82% of companies, but 27.39% consider it "bad" and 9.79% as "very bad", revealing regulatory challenges that can affect companies competitiveness.

Table 12 - Frequency of difficulties in implementing digital technologies in family SMEs

Variables	Items	Frequency (%)						
		AI	Cloud Computing	Robotics	Smart Devices	Big Data	High-Speed	Blockchain
Difficulty implementing Digital Transformation	D1. Low	-	53,01	-	31,89	-	38,99	-
	D2. Moderate	8,36	-	-	-	-	-	3,57
	D3. High	-	-	10,66	-	15,17	-	-

Source: Own elaboration. Note: Obs. = 2523 Family SMEs

The difficulty in implementing digital technologies in family SMEs is analyzed based on the different levels of difficulty (low, moderate and high) associated with the adoption of each technology. The technologies with the highest frequency of low implementation difficulty are Cloud Computing (53.01%), Smart Devices (31.89%) and High-Speed infrastructures (38.99%). With regard to moderate difficulty, AI registers a frequency of 8.36% and Blockchain technology 3.57%, revealing that these technologies are not widely adopted in EU SMEs. With regard to high implementation difficulty, Robotics stands out with 10.66% and Big Data with 15.17%.

Table 13 - Frequency of approach to Digital Technologies in family SMEs.

Variables	Items	Frequency (%)
Approach to Digital Technologies	A1. Low	7,02
	A2. Medium	11,69
	A3. High	31,03

Source: Own elaboration. Note: Obs. = 2,523 Family SMEs

Finally, the approach to digital technologies classifies companies according to their level of adoption of these technologies. Frequency analysis shows that companies are unevenly distributed. Only 7.02% of companies have a low level of technological adoption, while 11.69% have a medium level of adoption. On the other hand, 31.03% of the companies have a high level of adoption, showing a growing digitalization movement in the family SME sector.

4.4.2 Factorial Analysis

Testing the reliability and validity of the model was preceded by an exploratory and confirmatory factor analysis (table 14). These items were divided into four factors. Factor 1 represents the internal environment of family SMEs (made up of three items). Factor 2 represents the external environment and is made up of two items. Factor 3 incorporates family SMEs' approach to digital transformation and factor 4 includes the technologies

adopted by this type of organization. The four factors have a cumulative variance of 58.44%, and no factor explains more than 50% of the variance.

Table 14 - Exploratory factor analysis

	Factor 1	Factor 2	Factor 3	Factor 4	Commonalities	Outer Loadings
Skilled human resources	0.705				0.878	0.762
Infrastructures	0.719				0.896	0.763
Strength and performance	0.715				0.811	0.779
Access to financing		0.786			0.845	0.734
Legal and administrative environment		0.709			0.822	
Approach to Digital Transf.			0.744		0.765	1.000
Artificial Intelligence				0.770	0.741	0.823
Cloud computing				0.768	0.700	0.751
Robotics				0.706	0.723	0.713
Smart devices				0.725	0.795	0.764
Big Data				0.741	0.877	0.879
High Speed Infrastructure				0.882	0.754	0.775
Blockchain				0.718	0.791	0.686

Source: Own elaboration

The results of the Confirmatory Factor Analysis reveal a consistent association between the items observed, with factor loadings higher than 0.6 and then, no items were removed.

4.4.3. Reliability, convergence and discriminant validity

The results show that the model is convergent and reliable since the values (table 16) for (i) Cronbach's alpha ($C\alpha > 0.70$), (ii) composite reliability ($CR > 0.70$), (iii) average variance extracted ($AVE > 0.50$) are higher than the reference values. In addition, the model has discriminant validity according to the HTMT Criterion (table 15).

Table 15. Convergence, reliability, and discriminant validity.

	Cα	CR	AVE	Approach to Digital Transf.	Internal environment	Low difficulty	High difficulty	Moderate difficulty.
Approach to Digital Transf.	1.00	1.00	1.00					
External environ.	0.79	0.74	0.59	0.09				
Internal environ.	0.74	0.71	0.52	0.09	0.22			
Low difficulty	0.77	0.74	0.59	0.25	0.25	0.21		
High difficulty	0.78	0.73	0.58	0.26	0.25	0.16	0.21	
Moderate difficulty	0.76	0.72	0.57	0.24	0.23	0.14	0.22	

Source: Own elaboration

Analysis of the Variance Inflation Factor (VIF) values shown in Table 16 reveals that all the constructs in the model have values significantly below the critical threshold commonly adopted in the literature to assess multicollinearity problems (below 3.3), according to Hair. (2021).

Table 16. Variance Inflation Factor

	VIF
Skilled human resources	1.044
Infrastructures	1.044
Strength and performance	1.096
Access to financing	1.099
Legal and administrative environment	1.144
Approach to DT	1.000
Artificial Intelligence	1.023
Cloud computing	1.113
Robotics	1.027
Smart devices	1.088
Big Data	1.027
High Speed Infrastructure	1.089
Blockchain	1.023

Source: Own elaboration

In addition, the quality of the structural model is assessed by analyzing the coefficients of determination (R^2) and predictive relevance (Q^2), as recommended by Hair (2021) and explained in table 17. The R^2 coefficient represents the proportion of the explained variance of a dependent variable as a function of the independent variables that precede it in the model. This study's results indicate that the Approach to Digital Technologies construct has an R^2 of 0.108, revealing that only 10.8% of the variation in the predisposition of family businesses to adopt digital technologies is explained by the

internal and external factors considered.

Table 17. Predictive relevance and coefficient of determination.

	R Square/ R ²	R Square Adjusted / Q ²
Approach to DT	0.108	0.108
Low difficulty	0.145	0.144
High difficulty	0.127	0.126
Moderate difficulty	0.122	0.121

Source: Own elaboration

Similarly, the R² values recorded for the constructs related to technological adoption - Low difficulty (R² = 0.145), Moderate difficulty (R² = 0.122) and High difficulty (R² = 0.127) - indicate moderate explanatory power as indicated by Basco et al. (2021).

With regard to predictive relevance, assessed by the Q² coefficient, all the endogenous constructs showed positive values: 0.108 for Approach to Digital Technologies, 0.144 for Low difficulty, 0.121 for Moderate difficulty and 0.126 for High difficulty. Hair (2021) states that Q² values greater than zero confirm that the model has predictive capacity.

4.4.4. Bootstrap analysis

The bootstrapping analysis technique, as recommended by Hair et al. (2021), was applied to test the hypotheses formulated in the research model and validate the statistical significance of the relationships established between the constructs (table18).

The analysis of the direct effects revealed that the Approach to Digital Technologies has a positive and statistically significant impact on the three levels of technological adoption considered: (a) low implementation difficulty; (b) moderate implementation difficulty; (c) high implementation difficulty. These results confirm Hypotheses H1a, H1b and H1c respectively, which predicted a positive relationship between the technological approach and the adoption of advanced digital technologies. In addition, the External Environment proved to have positive effects on both the Approach to Technology and directly on the three types of technological adoption: (a) low implementation difficulty; (b) moderate implementation difficulty; (c) high implementation difficulty. These results allow us to accept Hypotheses H3, H5a, H5b and H5c, showing that favorable external conditions, such as access to financing, stable regulations and a favorable institutional environment, are catalysts for digital transformation.

Table 18 - Results of bootstrap analysis - direct effects between constructs.

	β	T Statistics	P Values	Confidence interval		Hypothesis support
				2.5%	97.5%	
(H1a) Approach to DT -> Low difficulty	0.159	8.970	0.000	0.125	0.194	Yes
(H1c) Approach to DT -> High difficulty	0.132	7.044	0.000	0.094	0.169	Yes
(H1b) Approach to DT -> Moderate difficulty	0.120	7.519	0.000	0.090	0.151	Yes
(H3) External environment -> Approach to DT	0.046	2.569	0.010	0.010	0.081	Yes
(H5a) External environment -> Low difficulty	0.096	4.620	0.000	0.056	0.136	Yes
(H5c) External environment -> High difficulty	0.086	4.145	0.000	0.044	0.126	Yes
(H5b) External environment -> Moderate difficulty	0.075	3.830	0.000	0.036	0.114	Yes
(H2) Internal environment -> Approach to DT	0.066	3.156	0.002	0.026	0.106	Yes
(H4a) Internal environment -> Low difficulty	0.059	2.529	0.012	0.017	0.105	Yes
(H4c) Internal environment -> High difficulty	0.012	0.555	0.579	-0.027	0.052	No
(H4b) Internal environment -> Moderate difficulty	0.012	0.637	0.524	-0.023	0.048	No

Source: Own elaboration

According to the Internal Environment, the results indicate a positive and statistically significant influence on the Approach to Digital Technologies, supporting Hypothesis H2. The same internal factor proved to be significant only with regard to investment in low implementation difficulty technologies, allowing Hypothesis H4a to be accepted. However, the relationships with moderate ($\beta = 0.012$; $p = 0.524$) and high implementation difficulty technologies ($\beta = 0.012$; $p = 0.579$) were not statistically significant, leading to the rejection of Hypotheses H4b and H4c, indicating that the internal environment alone does not sufficiently explain the adoption of more sophisticated technologies.

The analysis of the mediating effects (table 19) confirms that the Approach to Digital Technologies acts as an explanatory mechanism between the organizational factors and the different levels of technological adoption. All the mediation paths analyzed proved to be statistically significant. The Internal Environment indirectly

influences the adoption of low, moderate and high difficulty implementation technologies, leading to the acceptance of Hypotheses H41a, H41b and H41c, when mediated by the favorable approach to digital technologies. Similarly, the External Environment also exerts a significant indirect influence on the same three levels of technological adoption, confirming Hypotheses H51a, H51b and H51c, when mediated by the favorable approach to digital technologies.

Table 19 - Results of bootstrap analysis - mediating effects between constructs

	β	T Statistics	P Values	Confidence interval		Hypothesis support
				2.5%	97.5%	
(H41b) Internal environment → Approach to DT → Moderate difficulty	0.108	2.933	0.004	0.003	0.113	Yes
(H51b) External environment → Approach to DT → Moderate difficulty	0.106	2.360	0.019	0.001	0.110	Yes
(H41a) Internal environment → Approach to DT → Low difficulty	0.111	3.055	0.002	0.004	0.117	Yes
(H51c) External environment → Approach to DT → High difficulty	0.106	2.328	0.020	0.001	0.111	Yes
(H51a) External environment → Approach to DT → Low difficulty	0.107	2.440	0.015	0.002	0.113	Yes
(H41c) Internal environment → Approach to DT → High difficulty	0.109	2.834	0.005	0.003	0.115	Yes

Source: Own elaboration. Note: mediating effects make relationships stronger and allow all hypotheses to be confirmed

4.5 Discussion and implications

The results of this study show that the adoption of advanced digital technologies by family businesses is a complex and multifactorial process, influenced by both internal and external factors, as well as the company's strategic attitude towards the adoption of digital technologies (Pöschl & Freiling, 2020; Zapata-Cantu et al., 2023).

The favorable approach to digital technologies has been shown to have a direct and statistically significant influence on the adoption of digital technologies with different levels of implementation difficulty. This result confirms that the strategic predisposition towards innovation favors technological adoption, with the approach to digital transformation being essential, regardless of the complexity of digital solutions (Basco et

al., 2022). The internal environment of the family business, represented by factors such as organizational culture, human resources qualifications, governance structure and innovation capacity, proved to have a positive influence on the digital approach. This finding reinforces that internally prepared organizational contexts are more likely to develop structured digital strategies (Ferreira et al., 2023). The external environment, in turn, also significantly impacted the company's digital attitude. This effect suggests that more mature institutional environments and technological ecosystems encourage family businesses to adopt more open attitudes to innovation, in line with what Basco et al. (2022) state.

When analyzing the direct effects of environments on the adoption of digital technologies, it was observed that the internal environment only directly influenced the adoption of low-complexity technologies. However, the internal environment is not enough to encourage the adoption of more difficult technologies. This result highlights the limitation of the internal structure in investing in more complex technologies (Pöschl & Freiling, 2020). On the other hand, the external environment had a direct positive influence on the adoption of low, moderate and high difficulty technologies. These results confirm the relevance of external conditions, such as funding, public policies and support networks, in making digital transformation projects viable (Basco et al., 2022; Ferreira et al., 2023).

This study's main contribution, lies in analyzing the mediating effects of the strategic approach to digital transformation. The results confirmed that the digital approach significantly mediates the relationship between the internal environment and technological adoption. These indirect effects gain relevance in the face of the rejection of direct effects conditioned by the impact of the internal environment, indicating that the strategic attitude is the mechanism that converts internal capabilities into the adoption of more complex technologies (Saura et al., 2023). The same pattern is observed for the external environment. It is clear that simple access to external resources does not guarantee effective technological adoption, and companies need to adopt a strategic, proactive and integrated stance in order to capitalize on these conditions (Feroz et al., 2021).

4.5.1 Theoretical implications

From a theoretical point of view, this evidence reinforces the Contingency Model by demonstrating that the effectiveness of digital transformation depends on the fit between contextual factors (internal and external) and the organization's strategic structure (Müller et al., 2024). Digital transformation is not a uniform process, but somewhat contingent and highly dependent on the degree of organizational alignment

with the challenges of the digital ecosystem (Vrana et al., 2021). This finding suggests that the approach to digital technologies acts as a critical variable of organizational alignment, translating internal capabilities and external pressures into concrete technological actions. This broadens our understanding of the mediating mechanisms in digital transformation, a point still underexplored in the literature, particularly in the context of family businesses.

Another important theoretical perspective refers to identifying an asymmetry in the influence of the environment. While the external environment has a direct impact on all categories of technology (low, medium and high complexity), the internal environment is limited to those of lower complexity. This result contrasts with approaches that give excessive importance to internal capabilities and highlights the need to include other types of resources, such as institutional partnerships, inter-organizational networks and regional technological infrastructures.

In addition, this study contributes to the advancement of knowledge in the field of organizational strategy in family businesses by demonstrating that family factors - such as a culture of legacy preservation, risk aversion and centralization of decisions - directly influence how organizations respond to digital pressures. This signals the importance of further research into intergenerational dynamics and their impact on digital transformation.

4.5.2 Practical implications

In practical terms, the results of this study provide a solid basis for guiding strategic decisions in family businesses, while supporting the design of more effective public policies. The analysis shows that digital transformation in this type of organization requires coordinated interventions on multiple fronts, human resources, organizational culture, strategy and articulation with the institutional environment.

Firstly, it is important to invest in the digital skills of employees since the adoption of more sophisticated digital technologies requires specific and up-to-date technical skills. In this sense, it is essential to promote continuous digital learning processes at all hierarchical levels, to build a cognitive and cultural base that supports the technological transition. Such investment favors not only the implementation of digital tools, but also the creation of an organizational environment conducive to learning and innovation.

Secondly, it is imperative that family leadership takes an active role in promoting a culture of innovation. Family businesses often face internal resistance to change due to rigid hierarchical structures. In this context, leaders must act as agents of transformation, encouraging the digital transition. Strengthening this culture is decisive in reducing barriers to technological adoption and increasing the organization's ability to respond to

digital challenges.

Thirdly, the results indicate the need for gradual strategies aligned with each company's level of technological maturity. Digital transformation should not be carried out abruptly, especially in family contexts, where the financial and emotional risks tend to be perceived more intensely. Building progressive trajectories is a more realistic and sustainable alternative.

In addition, the findings reveal that the strategic stance adopted towards the external environment is a key factor in the success of digital transformation. Access to institutional resources, such as public policies, tax incentives and innovation support networks, does not automatically translate into innovation, and companies need to develop specific skills to identify digital opportunities. Active management of the institutional environment and strategic inclusion in innovation ecosystems (such as universities, technology hubs and regional clusters) is a significant competitive advantage, especially for family businesses operating in traditionally less innovative sectors.

4.6 Conclusion

This research confirms that the adoption of advanced digital technologies in family businesses is a complex process, strongly dependent on the interaction between internal and external factors, this relationship being mediated by the company's strategic approach to digitalization. This result shows that digital transformation cannot be understood solely on the basis of technological availability, but requires a holistic reading that integrates organizational, contextual and behavioral variables.

The study reinforces that family businesses with a greater strategic predisposition towards digital innovation have higher levels of technological implementation, particularly with regard to medium and highly complex solutions. The existence of qualified human resources, an organizational culture favourable to change and access to infrastructure and institutional support proved to be determining factors in the success of the digital transition process.

In addition, it has been shown that the approach adopted by family businesses towards digital technologies is a critical factor, acting as a mediator between internal and external stimuli and effective technological adoption. This strategic dimension, often overlooked, must be recognized as an essential element in the design of effective public policies and business strategies.

In this way, this study contributes to the advancement of the literature on digital transformation in the context of family businesses, by offering a robust and empirically validated analytical model, supported by data representative of the European space. At the same time, it provides practical guidelines for managers, policymakers and other

stakeholders who want to boost technological innovation in this business segment, which is crucial for economic competitiveness and territorial cohesion.

4.6.1 Limitations

Despite the relevance of the results, this study has some limitations that should be acknowledged. Firstly, the research is based on cross-sectional data, which limits the ability to establish definitive causal relationships between variables. Therefore, the conclusions should be interpreted with caution regarding the direction of the relationships observed. Secondly, the use of secondary data from European surveys imposed restrictions on the choice and operationalization of some variables, especially with regard to qualitative aspects of organizational culture, internal family dynamics or leadership styles. Thirdly, although the analysis model includes the strategic approach to digital transformation as a moderating variable, it did not explore other social or emotional factors that may influence the behavior of family businesses towards technological innovation, such as risk aversion, time orientation or intergenerational values. Finally, the diversity of the European business fabric, with significant structural differences between countries, sectors of activity and levels of technological development, may affect the generalizability of the results. More specific geographical and sectoral studies would be useful, to better understand these contextual variations.

4.6.2 Future lines of research

Future research could explore various avenues identified based on the limitations and results obtained in this study. Firstly, it is recommended that longitudinal studies be carried out to monitor the evolution of digital transformation in family businesses over time. Such an approach would make it possible to observe structural changes, capture organizational learning dynamics and validate the sustained influence of the factors identified. Secondly, it is suggested that the theoretical model be extended to include behavioral variables. The inclusion of family leaders' personality traits, leadership styles, levels of organizational trust and succession mechanisms could provide a richer insight into the determinants of technological adoption. In addition, it would be pertinent to carry out comparative studies between family and non-family businesses, in order to identify the extent to which the factors analyzed manifest themselves differently between these organizational types. This comparative approach could contribute to the formulation of more targeted and effective public policies. Another promising aspect is the analysis of the influence of the regional context and business cooperation networks on the digital transition process. Identifying innovation ecosystems that boost the adoption of

technologies can provide strategic data for territorial development and regional cohesion. Finally, future research should explore the impact of the digital transition on the economic, environmental and social performance of family businesses, allowing for a more comprehensive assessment of the benefits and risks associated with the digital transformation in this segment.

Part III

CHAPTER 5 - CONCLUSION

The compilation of the three articles that make up this thesis aims to address the overall objective of this thesis: to investigate how family businesses in the European Union are adopting digital transformation, analyzing their implementation patterns, the internal and external factors that influence this process, as well as the capabilities and strategies that can facilitate the effective adoption of digital technologies.

To achieve the general objective, specific objectives were established, which correspond to the three chapters that make up Part II. The main conclusions of these studies will be presented in chapter 5, leading to the creation of a model presented here. Theoretical and practical contributions will also be shared. In addition, the limitations of the studies and related future lines of research are identified. Finally, the scientific results generated throughout the research are presented in the form of articles and conference papers.

5.1 Main research findings and integrative model

This section summarises the main empirical and theoretical findings obtained throughout the three studies that comprise this doctoral thesis, corresponding to Chapters 2, 3 and 4. Each of these studies explored distinct but complementary dimensions of the phenomenon of digital transformation in family businesses in the European Union. The main results of each study are described below with scientific rigor, based on the specialized literature.

In the first study (Chapter 2), a bibliometric review of digital transformation in family businesses was conducted. Based on the Web of Science database, publications between 1996 and 2023 were analyzed. The analysis revealed three predominant thematic axes: (i) dynamic capabilities and organizational strategies; (ii) facilitators, barriers and innovation; and (iii) sustainability and cooperation. Authors such as Calabrò et al. (2022) and Soluk et al. (2021) argue that family businesses have specific characteristics that profoundly influence their digital transformation, such as long-term orientation, emotional attachment to the business, and intergenerational leadership.

One of the main findings of this study is that digital transformation goes beyond the mere digitization of processes (Vial, 2021; Beverungen et al., 2022). It represents a structural change that impacts the value proposition, business model, and governance mechanisms. In line with the theory of dynamic capabilities (Teece, 2018), it was evident that the ability to detect, assimilate, and reconfigure resources is essential to meet the demands of a rapidly changing digital environment. In addition, the bibliometric analysis

pointed to a growing concern with the integration of sustainability and inter-organizational collaboration as conditions that facilitate digital innovation (Calabrò et al., 2022).

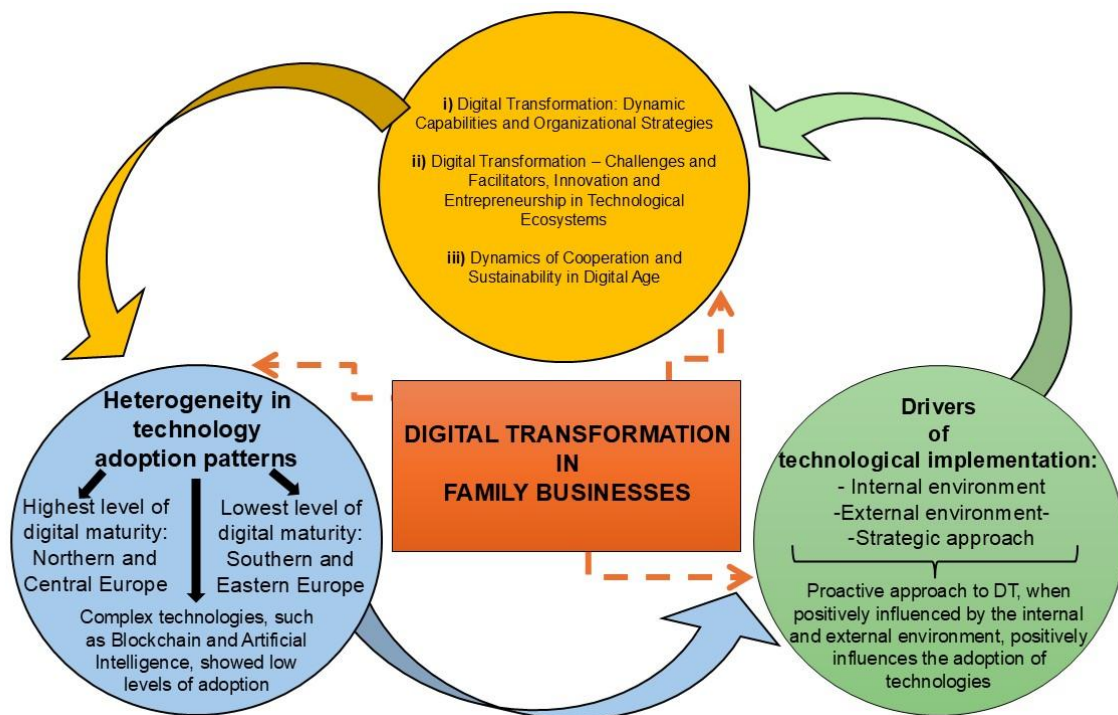
The second study (Chapter 3), which was empirical and quantitative in nature, aimed to identify patterns of digital technology adoption in family businesses in the European Union, using data from Flash Eurobarometer 486, which covered 2,523 companies. Through the application of the Latent Class Analysis (LCA) method, three patterns of technology adoption were identified in European companies: (1) not implemented; (2) rarely implemented; and (3) moderately implemented. This typology reveals considerable heterogeneity in the degree of digitization among European family businesses. The analysis revealed that companies based in Northern and Central Europe, such as the Netherlands and Sweden, had higher levels of digital maturity compared to those located in Southern and Eastern Europe, such as Italy and Lithuania. These results are in line with data from the European Commission (2020) on the DESI index. Factors such as company size, turnover and recent growth were positively associated with technology adoption, as also demonstrated by Civelek et al. (2023) and Magaz-González et al. (2024). In contrast, older companies showed a lower propensity for digital adoption, confirming the hypothesis that older organizational structures are more resistant to innovation (Rashid & Ratten, 2020). In addition, it was found that technologies such as Cloud Computing, High-Speed Infrastructure and Smart Devices are more widely implemented due to their lower cost and greater accessibility. On the other hand, more complex technologies, such as blockchain and artificial intelligence, showed low levels of adoption, confirming the conclusions of Huang et al. (2017) about the high costs and technical barriers to their integration.

The third study (Chapter 4) aimed to test a research model that integrated internal, external, and strategic variables to explain the adoption of digital technologies in family businesses. The Partial Least Square method was used to test a research model formulated based on a literature review, which included internal company variables such as digital skills and infrastructure; external variables such as access to financing and participation in regional networks; and strategic variables such as a proactive or reactive approach to digitalization. The results showed that both internal and external factors significantly influence the adoption of digital technologies. However, the most significant impact was observed when companies adopted a proactive strategic stance. This approach acts as a mediator between organizational contexts and the adoption of technologies, especially those of greater complexity, such as Big Data and AI. These results reinforce the arguments of Zahra and George (2002) on the importance of absorption capabilities and Teece (2018) on the need for dynamic capabilities to sustain digital innovation.

The final model proposed, called the Integrated Digital Transformation Model for

Family Businesses (IDTM4FB), coherently and systemically integrates the three empirical studies developed in Chapters 2, 3 and 4. This model represents a theoretical and practical synthesis of the main internal, external and strategic factors that condition the adoption of digital technologies in family businesses in the European Union, while reflecting the results obtained in the systematic review of the literature, the empirical analysis of technological adoption patterns and the validation of causal relationships through statistical treatment (Figure 16).

Figure 16 - Integrated Digital Transformation Model for Family Businesses



Source: Own elaboration.

IDTM4FB offers an original and valuable contribution by articulating three interdependent dimensions: (i) the conceptual and thematic axes derived from scientific literature (Chapter 2 - orange), (ii) the regional and sectoral heterogeneity of digital maturity patterns (Chapter 3 - blue) and (iii) the organisational and contextual factors that explain technological implementation (Chapter 4 - green). The proposal provides a robust analytical framework to guide managers, policymakers and academics interested in the sustainable and strategic digital transformation of family businesses. The thesis, therefore, contributes to the advancement of the literature by proposing a conceptual framework that synthesizes empirical evidence and theoretical foundations, reinforcing the importance of integration between internal capabilities, environmental conditions, and strategic orientation in the digitalization of these organizations.

The first domain (orange) emerges from the systematic review of the literature

(Chapter 2), which identifies the main thematic axes addressed in scientific production on digital transformation in family businesses: (i) 'Digital Transformation in Family Businesses: Dynamic Capabilities and Organisational Strategies'; (ii) 'Digital Transformation - Challenges and Facilitators, Innovation and Entrepreneurship in Technological Ecosystems'; and (iii) 'Dynamics of Cooperation and Sustainability in the Digital Age'.

This domain provides the theoretical foundation on which the model is built, demonstrating that digital transformation is not limited to operational digitization but implies structural changes in the value proposition, business models, and governance systems.

The second domain (blue) results from mapping the patterns of digital technology adoption by European family businesses (Chapter 3). Three main patterns of digital maturity are identified: not implemented, rarely implemented, and moderately implemented. This domain highlights the heterogeneity in digital adoption, marked by regional disparities, with greater maturity in Northern and Central Europe and less in Southern and Eastern Europe, and by a tendency to adopt less complex technologies, such as Cloud Computing, to the detriment of advanced technologies, such as Blockchain and Artificial Intelligence. Factors such as company size, turnover and age significantly modulate these patterns.

The third domain (green) integrates the results of the quantitative model (Chapter 4), which tested the impact of internal variables (such as digital skills and infrastructure), external variables (such as support networks and financing) and strategic variables (proactivity or reactivity) on technology adoption. The PLS-SEM analysis confirms that the proactive strategic approach acts as a mediator and amplifier of the influence of internal and external contexts on the adoption of technologies, especially those that are more complex or difficult to implement. This result reinforces the relevance of dynamic capabilities and deliberate strategic orientation, as predicted in the Contingency Model theoretical model, as central mechanisms for the success of digital transformation.

By integrating these three domains, the IDTM4FB model allows us to understand digital transformation as a multidimensional and contingent phenomenon. The model demonstrates that technology adoption in family businesses does not occur in a linear fashion but depends on the interaction between organizational predispositions, institutional contexts, and strategic choices. Thus, the IDTM4FB model contributes to a deeper understanding of the factors that influence digital readiness and provides a theoretical basis for guiding public policies aimed at reducing regional asymmetries and promoting more robust and sustainable business strategies in the face of the digital transition.

5.2 Contributions

5.2.1 Theoretical contributions

This thesis contributes significantly to the advancement of scientific study of digital transformation in family businesses through three distinct fronts.

In Chapter 2, the systematic bibliometric review offers a structured and comprehensive view of the state of the art of digital transformation in family businesses. In this sense, we identify several theoretical contributions. First, a contribution to the existing literature on digital transformation in family businesses. Currently, no known study analyses research trends on digital transformation in family businesses and develops a theoretical framework to help family managers achieve the benefits of digital transformation. Second, new perspectives on management theory and digital innovation. By analyzing the interaction between dynamic capabilities and digital transformation, this study offers new perspectives for management, innovation, and entrepreneurship theories, especially in the context of family businesses. The development of the proposed theoretical framework offers an integrated model that can be used to test new hypotheses related to the adaptation and implementation of emerging technologies in family businesses. Third, the valorisation of sustainability and intergenerational innovation. The importance of intergenerational cooperation and the implementation of sustainable practices as strategies to strengthen digital resilience opens up new possibilities for the study of sustainability and innovation in family businesses. The integration of intergenerational aspects offers an innovative lens for research in family management, addressing how tradition and innovation can coexist strategically.

In Chapter 3, the main theoretical contributions were, first, a contribution to the existing literature on digital transformation in family businesses. Currently, there are no known studies that simultaneously analyze the contributions of seven digital technologies in the digital transformation process in family and non-family businesses. Second, the identification of three patterns of digital maturity present in family businesses in the European Union: digital transformation not implemented, rarely implemented, and moderately implemented. Third, the uneven contribution of different digital technologies in the context of family businesses. The most economical digital technologies are the most widely implemented, while complex digital technologies that require skilled labor and greater investment are the least implemented. In theoretical terms, the study expands knowledge about the different levels of digital maturity and the unequal impact of technologies on family businesses.

Chapter 4 reinforces the Contingency Model by demonstrating that the effectiveness of digital transformation depends on the fit between contextual factors (internal and external) and the strategic structure of the organization (Müller et al., 2024).

Digital transformation is not a uniform process but rather something contingent and highly dependent on the degree of organizational alignment with the challenges of the digital ecosystem (Vrana et al., 2021). This theoretical contribution suggests that the approach to digital technologies acts as a critical variable of organizational alignment, translating internal capabilities and external pressures into concrete technological actions. This broadens the understanding of the mediating mechanisms of digital transformation, a point that is still under-explored in the literature, particularly in the context of family businesses. Furthermore, this study contributes to the advancement of knowledge in the field of organizational strategy in family businesses by demonstrating that family factors - such as a culture of preserving a legacy, risk aversion, and centralization of decisions - directly influence how organizations respond to digital pressures. This highlights the importance of further research in the field of intergenerational dynamics and their impact on digital transformation.

5.2.2 Practical contributions

This thesis also offers relevant contributions to business practice and to the formulation of public policies aimed at accelerating the digital transformation of family businesses.

In Chapter 2, the results of this study allow us to infer several practical implications. First, leadership and organizational change in family businesses. For owners and managers of family businesses, the main practical implication is the need for leadership committed to innovation and capable of promoting cultural and organizational changes that strategically integrate digital technologies. The study highlights the importance of proactive leaders in identifying technological trends and promoting a culture of innovation. Second, digital training and skills development. Digital transformation requires employees to adapt to new processes and technological tools. For family businesses, it is essential to implement training programs that develop digital skills, promote the adoption of emerging technologies and assist in the transition to new ways of working. The adoption of remote working and the use of collaborative tools is suggested. Third, strategic partnerships and collaborative innovation. Family businesses should invest in strategic partnerships, such as collaborations between companies and academic institutions, to accelerate the adoption of technological innovations. This includes the creation of collaborative networks that facilitate the exchange of knowledge and the joint development of digital solutions. Fourth, sustainability as a competitive advantage: The adoption of sustainable digital practices can become a competitive advantage for family businesses, both in terms of operational efficiency and value creation for customers. Investing in technological solutions that reduce waste and

improve environmental and social sustainability can be an important differentiator in attracting conscious customers and improving brand image. Fifth, organizational resilience in times of crisis. Digital transformation can also strengthen organizational resilience, especially in times of global crisis, such as the COVID-19 pandemic. Family businesses can benefit from adopting technologies that enable them to adapt quickly to external changes, ensuring business continuity and the ability to innovate during difficult times.

In Chapter 3, several practical implications can be defined based on the results of this study. First, the implementation of digital technologies in European family businesses is still low. In this sense, government officials have an important role to play, particularly in terms of granting subsidies to strengthen confidence in the use of technologies and increase the competitiveness of family businesses in the European digital market. Second, there is a need to develop organizational capabilities and human resources. The implementation of complex technologies, such as Artificial Intelligence and Blockchain, is mainly due to a lack of skilled labor. In this regard, investment in human resources training programs and partnerships with universities or research centers can help overcome the barrier to implementing more complex technologies, making family businesses in the EU-27 more competitive. Thirdly, newer family businesses with lower turnover in the construction and transport sectors are the least likely to implement digital technologies. It is suggested that these family businesses, before embarking on the intensive process of digitization, adopt easy-to-implement technologies that improve their operational efficiency without changing their organizational structure, such as enterprise resource planning (ERP) software, digital collaboration tools (such as Microsoft Teams or Slack), digital accounting systems or simple e-commerce platforms. This progressive digital development will enable a higher level of technology adoption, making European family businesses more competitive. Policies should not be adopted at the national level, but rather at the regional level, taking into account the heterogeneity in the adoption of digital technologies among family businesses and between countries.

In Chapter 4, the results of this study provide a solid basis for guiding strategic decisions in family businesses, while also supporting the design of more effective public policies. The analysis shows that digital transformation in this type of organization requires coordinated interventions on several fronts: human resources, organizational culture, strategy, and coordination with the institutional environment. First, it is important to invest in the digital skills of employees, since the adoption of more sophisticated digital technologies requires specific and up-to-date technical skills. In this sense, it is essential to promote continuous digital learning processes at all hierarchical levels to build a cognitive and cultural foundation that supports technological transition. This investment favors not only the implementation of digital tools but also the creation of an

organizational environment conducive to learning and innovation. Secondly, it is imperative that family leadership takes an active role in promoting a culture of innovation. Family businesses often face internal resistance to change due to rigid hierarchical structures. In this context, leaders must act as agents of transformation, encouraging digital transition. Strengthening this culture is crucial to reducing barriers to technology adoption and increasing the organization's ability to respond to digital challenges. Thirdly, the results indicate the need for gradual strategies aligned with each company's level of technological maturity. Digital transformation should not be carried out abruptly, especially in family contexts, where financial and emotional risks tend to be perceived more intensely. Building progressive trajectories is a more realistic and sustainable alternative.

In addition, the results reveal that the strategic stance adopted in relation to the external environment is a key factor for the success of digital transformation. Access to institutional resources, such as public policies, tax incentives, and innovation support networks, does not automatically translate into innovation, and companies need to develop specific skills to identify digital opportunities. Active management of the institutional environment and strategic inclusion in innovation ecosystems (such as universities, technology centers, and regional clusters) is a significant competitive advantage, especially for family businesses operating in traditionally less innovative sectors.

5.3 Limitations and Future Lines of Research

As with any scientific research, this thesis has limitations that must be acknowledged in order to ensure an accurate interpretation of the results and guide future lines of research. This section is structured based on the three studies developed throughout Chapters 2, 3, and 4.

Chapter 2, based on a bibliometric review of the literature, was limited to the exclusive use of the Web of Science database. Although this database is recognized for the quality of its records, the exclusion of other relevant databases such as Scopus, EBSCO or Google Scholar may have led to the omission of important studies, especially in emerging or more applied areas (Donthu et al., 2021). In addition, the time frame (1996 to 2023) reflects only academic output published up to the date of collection, not covering possible publications in progress or in the process of acceptance. Another limitation is related to the use of quantitative bibliometric analysis, which does not allow for an in-depth discussion of the theoretical and methodological content of the articles analyzed. Future studies could use a combination of systematic reviews and qualitative meta-analyses to explore the interrelationships between theories, methods and results in

greater depth. We also suggest conducting comparative studies between different types of companies (family vs. non-family) or between different geographical contexts (Europe vs. Latin America, Asia), which could broaden our understanding of the specificities of the phenomenon in terms of cultural and institutional factors.

Chapter 3, which used data from Eurobarometer Flash 486, also has important limitations. First, the sample is restricted to family businesses in the European Union, which limits the generalization of the results to other regions of the world. In addition, the study is cross-sectional in nature, reflecting only a snapshot of the moment of data collection. Longitudinal studies would allow us to capture the evolution of technology adoption patterns over time (Venkatesh et al., 2003). The use of Latent Class Analysis (LCA), although suitable for identifying hidden patterns, depends on the selection of observed variables. Other technologies or indicators not covered in the survey could alter the clusters identified. It is therefore suggested that future studies combine clustering techniques with qualitative analyses, such as in-depth interviews, to empirically validate the profiles generated. Another limitation is that the questionnaire used does not address cultural, emotional, or symbolic aspects of family management, which are central to understanding the relationship between tradition and innovation. Future studies could incorporate these aspects, aligning with approaches such as 'Socioemotional Wealth' (Gómez-Mejía et al., 2007).

Chapter 4 used PLS-SEM modeling to test an integrative theoretical model. Although this technique is robust for exploratory estimates and complex models, it is sensitive to sample size and composition (Hair et al., 2017). The use of data from Flash Eurobarometer 486 restricts the analysis to the European context and family businesses, which limits the extension of the findings to other organizational realities. Furthermore, the model considered only three major groups of variables (internal, external, and strategic), leaving out other relevant constructs, such as resistance to change, organizational learning, or leadership type. These factors could be included in future models to deepen the understanding of the mechanisms underlying digital transformation. It is also suggested that the model be validated in different sectors of economic activity (industry, services, agribusiness) and in companies of different sizes. Longitudinal studies are also recommended to verify the stability of causal relationships over time.

In summary, although the three studies offer valuable contributions, it is recognized that their methodological and contextual limitations pave the way for future more in-depth, interdisciplinary, and comparative investigations capable of broadening the understanding of the role of digital transformation in family businesses in different global contexts.

5.4 Thesis outcomes

The completion of this doctoral thesis resulted not only in the production of original scientific knowledge but also in its enhancement and dissemination through indexed scientific publications and presentations at academic events. The present section aims to systematize the main scientific results generated throughout the research in the form of articles and conference papers (Table 20). These scientific results reflect the ongoing effort to integrate theoretical research and practical application, as well as a commitment to disseminating knowledge within the scientific community. In addition, they reinforce the topicality and relevance of the theme of digital transformation in family businesses, positioning it as a central dimension both in the academic agenda and in contemporary business management practices.

Table 20 - Thesis outcomes.

Submitted chapters				
Chapters	Articles	Journals	Impact factor 2024	Scopus Quartile 2024
2	Digital Transformation Of Family Businesses - Review And Research Agenda	Journal of Family Business Management	3.6	Q1
3	Mapping Digital Transformation in the European Union: Implementation patterns in family businesses	Journal of Knowledge Economy	4	Q2
4	Unlocking Digital Transformation: Environmental Influences on Technology Adoption in Family Enterprises	Journal of Business Research	3,5	Q1
Conferences presentations				
Paper	Conference	Host Entity	Date	Location
Digital Transformation Of Family Businesses - Review And Research Agenda	Workshop Family Firms: Avenues of Research	University of Aveiro	10 th March 2025	Aveiro, Portugal
Mapping Digital Transformation in the European Union: Implementation patterns in family businesses	Workshop Family Firms: Avenues of Research	REMIT - Research on Economics, Management and Information Technologies	17 th July 2025	Porto, Portugal

Source: Own elaboration

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ANNEX I

Table A1 – Items and measures

Construct	Item	Description item	Scale
Environment	Internal environment	Skilled human resources and Infrastructures for companies	1 = very good 2 = good 3 = bad 4 = very bad
	External environment	Strength and performance; Access to public and private financing and Legal and administrative environment	
Approach to Digital Technologies	Low	Although there is a recognized need to adopt digital technologies, the company lacks the necessary competencies and financial resources to implement them	1 = Yes 2 = No
	Medium	Although there is a recognized need to adopt digital technologies, the company is currently considering which one to adopt	
	High	The company is currently adopting digital technologies	
Difficulty implementing Digital Technologies	Low	Cloud computing; Smart devices; High speed infrastructure	1 = Yes 2 = No
	Moderate	Artificial intelligence and Blockchain	
	High	Robotics and Big data	