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The Value of Digital Transformation Initiatives in Manufacturing firms

By Francisco Almeida

Master Thesis

presented as partial requirement for obtaining a Master's Degree in Information Management with a specialization in Information Systems Management

NOVA Information Management School

Instituto Superior de Estatística e Gestão de Informação

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Value of Digital Transformation Initiatives in Manufacturing firms

by

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Master Thesis presented as partial requirement for obtaining a master's degree in information management, with a specialization in Information Systems Management

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Statement of Integrity

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism, any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

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ABSTRACT

Digital Transformation (DT) is a fundamental enabler to value-generation in manufacturing firms, with initiatives leading to improved efficiency, innovation and flexibility in organizations. But despite the various academic research in this field, the factors enabling the successful implementation of these DT initiatives are still at large underexplored, particularly in the context of industrial firms. Thus, this thesis uses the Technology-Organization-Environment (TOE) framework and a mixed-methods approach to explore the key drivers of DT success in manufacturing firms, within a Portuguese context. The findings of this dissertation reveal that some of the proposed model construct items (also referred as enabling factors) like ICT literacy, top management support, integrated systems, and data quality are critical enablers of value creation, while technology complexity and regulation/government intervention may pose as obstacles to the successful implementation of DT initiatives. This TOE-based proposed model also highlights the relationships between technology readiness, organizational agility, and environmental competitiveness as avenues for firms to attain operational efficiency, innovation, and market expansion. Finally, actionable strategies are proposed in this research to managers in manufacturing firms (or other relevant stakeholders), to guide them in their digital transformation journey, in making decisions concerning resource allocation and in setting the right culture that fosters innovation and success. Future research can expand on this work by exploring different sectors or refining the metrics for assessing DT impact.

KEYWORDS

Digital Transformation; Digitalization; Manufacturing Sector; Industrials; TOE Framework; Enabling Factors; Value creation; DSR; Mixed methods

SUSTAINABLE DEVELOPMENT GOALS (SDG):

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

In today's fast-changing world, companies have to continuously adapt and innovate if they want to stay competitive and thrive. When the concept of "digital transformation" (DT) first appeared, it simply referred to the process of moving from paper-based systems to a digital format. However, as the understanding of the relation between technology and Organizations progressed, so did this concept (Plekhanov et al., 2023). Today, it is said to encompass many more dimensions, including changes to the business models, processes, culture, and customer experiences (Kraus et al., 2022).

And with increased complexity, the significance of evaluating and measuring the impact of digital transformation has grown as well. To ensure optimal resource utilization, companies must systematically measure the benefits brought by each initiative they want to implement (Mahboub et al., 2023). However, this has presented some challenges, since researchers and firms alike have found the lack of universal metrics that apply to all enterprises, the absence of consistency in DT initiatives, and the challenge of creating meaningful key performance indicators (KPIs) to be a roadblock in progressing smoothly with their transformation processes (Deloitte Development LLC, 2023).

While there is a growing body of literature on DT, it often falls short in delivering a holistic perspective that accounts for shared needs and strategies among companies operating in the same industries (Nadkarni et al., 2021). Many studies focus on individual case analyses, providing insightful but isolated glimpses into successful Digital Transformation initiatives. But there's a gap in comprehensive, industry-wide studies that synthesize common challenges, overarching strategies and the drivers that lead to the successful implementation of DT initiatives (Verhoef et al., 2021). Additionally, firms find it difficult to transpose the benefits and impact from DT initiatives of other companies to their own, given that the structure of the firms, goals and strategies might not be aligned at all. As such, focusing on a single sector of the economy during research can be an advantage in overcoming this barrier (Reis & Melão, 2023; Verhoef et al., 2021) .

If we look at Small and Medium sized Enterprises (SMEs), we observe that these firms face additional difficulties when implementing digitalization processes, due to their limited resources and capabilities. Research shows us that SMEs do not have dedicated positions or even departments which can be involved in DT projects, instead they are forced to balance their resources between daily activities and transformation efforts (Fliege et al., 2023). Large firms on the other hand, possess more resources and can allocate these to tackle and support DT efforts, however, their size, the complexity of operations, or the inertia of the organization can be obstacles to the implementation of digital initiatives (Kaganer et al., 2023).

With the goal of understanding how firms can generate a positive impact and create value through the implementation of DT initiatives, this research will propose two fundamental questions: First, "What are the main drivers to the successful implementation of digital

transformation initiatives in firms that operate in the Industrial sector?" This question will look for a positive or negative connection between different drivers, or “contexts”, of a firm and the successful implementation of initiatives. Second, "How can we define success and value creation?" If we want to measure impact and quantify success when implementing DT initiatives, it is crucial to define what creation of value entails, and how our drivers relate to it.

Considering that firms find it difficult to organically create a culture of innovation and continuous improvement, making use of drivers as guidelines can serve as a spring to capture value (Haug et al., 2011). As such, the main objective of this thesis can be defined as the development of a Framework to explain the drivers that Industrial firms can use to generate value when implementing DT initiatives.

Regarding Methodology, this research will use Design Science Research (DSR) methodology to explore and adapt the Technology-Organization-Environment framework (TOE) and its different contexts, establishing a connection between the various contexts (or dimensions) and the “successful” implementation of DT initiatives. Also, considering the shared incentives and technological needs among companies operating in the same industries, as highlighted by (C. Matt et al., 2015), the presented framework will use the Industrial/Manufacturing sector as a control point to assess if our developed assumptions hold true equally across firms operating in the same and different industries. These assumptions will be supported and expanded through in-depth qualitative interviews and a quantitative survey conducted with experts in the field. Thus, this research can also serve as a guide to firms on selecting drivers that will contribute to creation and capture of value.

To develop this research, a mixed-methods approach encompassing a comprehensive literature review, framework development, qualitative and quantitative analysis was adopted. The thesis methodology revolves around the TOE framework, but also gains inspiration from previous research on digital transformation and value creation in firms. Additionally, drawing on insights from different academic sources, this study analyses and attempts to judge the challenges and gaps in the current understanding of digital transformation. Finally, the structure of this study is organized into distinct chapters, starting with an introduction, followed by a comprehensive literature review, detailed methodology and results, discussion, and conclusion. This structured approach ensures a rigorous and thorough exploration of the enabling factors to digital transformation initiatives in manufacturing firms, contributing valuable insights to the field.

2. LITERATURE REVIEW

2.1 DIGITAL TRANSFORMATION AS A CONCEPT

Digital transformation (DT) is a dynamic and rapidly evolving concept that has gained significant attention in business and management research. The core elements of digital transformation typically include automation, indicating the mechanized replication of a series of actions through a program; dematerialization, involving the substitution of physical media with computer files; and disintermediation, signifying the elimination of intermediaries (Mahboub et al., 2023).

This is achieved by leveraging technologies to enhance processes, innovate business models, and improve efficiency. Thus, some key components of DT include the adoption of modern tools such as artificial intelligence, machine learning, big data analytics, among others. On top of this, it also involves process optimization that allows business to rethink and redesign processes in order to achieve greater efficiency, agility, and effectiveness through the application of digital tools. Additionally, it includes a customer-centric approach, seeking to enhance customer experiences by integrating digital initiatives that align with evolving needs and expectations. Another crucial aspect of DT is the implementation of flexible and adaptive governance structures, facilitating swift responses to changes in the market and emerging technologies (Plekhanov et al., 2023; Reis & Melão, 2023).

According to Heavin and Power (2018), the primary focus of digital transformation (DT) initially focused on the integration of digital technology across all areas of a business to streamline operations and enhance efficiency (Guha Majumder et al., 2022; Heavin & Power, 2018; Kretschmer et al., 2022). However, in recent years, particularly since the onset of the Covid-19 pandemic, businesses worldwide have recognized the strategic importance of leveraging digital technologies to stay competitive and responsive to evolving market dynamics. Consequently, there has been a noteworthy shift in investments, impacting businesses, consumer needs, and governance, towards digital globalization and transformation (Kretschmer et al., 2022). Respectively, the allocation of resources towards technologies such as cloud computing, artificial intelligence, cybersecurity, and digital communication tools has increased significantly. This shift in investments signifies a strategic recognition that digital transformation is not just a trend but a fundamental necessity for long-term sustainability and growth (Kraus et al., 2022). Additionally, there are more digital natives than ever before (over sixty percent of the world's population being under 30-years-old), hence, companies must recognize the imperative of aligning their strategies with digital advancements to meet the expectations of this growing demographic and remain relevant in the market (Dwivedi et al., 2021). Moreover, research has shown that companies failing to promptly develop and implement DT strategies are unlikely to remain competitive in the evolving digital landscape (Haug et al., 2011; Uren & Edwards, 2023). Consequently, organizations are compelled to continually adapt and digitally transform their operations to thrive in the contemporary business environment (Matt et al., 2016).

2.2 Measuring impact of DT

By measuring the impact of digital transformation, firms can gain additional insights and knowledge into their areas of improvement, as well as optimize their strategies, and ensure a positive return on investment. The current metrics and measurement tools have been noted to struggle to keep up with the rapid pace of the DT, which can be assessed through quantitative measures and qualitative benefits. Additionally, quantitative measures involve analyzing key performance indicators (KPIs) as 1) revenue growth, 2) cost savings, 3) customer acquisition and retention rates, and 4) operational efficiency improvements. In order: 1) Revenue growth occurs when implementing digital strategies to expand the customer base and increase sales; 2) Cost savings are achieved by streamlining processes, automating tasks, and reducing manual labor; 3) Customer acquisition and retention rates are improved by leveraging digital channels and technologies; and lastly 4) Operational efficiency improvements happen by digitizing processes, eliminating bottlenecks, and improving collaboration.
Regarding qualitative measurements, these include improved customer satisfaction, increased employee productivity and satisfaction, enhanced brand reputation, and the ability to adapt quickly to market changes. These qualitative benefits can be achieved by providing employees with digital tools and thus embracing digital capabilities, while simultaneously delivering innovative solutions and contributing to long-term business success.
Measuring the impact of digital transformation is an ongoing process and it is essential to tailor the measurement approach to the specific goals and context of the organization (Deloitte Development LLC, 2023; Mahboub et al., 2023; OECD Publishing, 2019).

2.3 Small and Medium Enterprises (SMEs) and Digital Transformation

SMEs are faced with their own unique challenges when running operations, such as limited human and capital resources or difficulty in expanding market size. And these challenges are only exacerbated, when smaller firms are forced to compete with large corporations that have the advantage of economies of scale in production, name recognition when penetrating into new markets and overall, more resources to compete. However, to level the playing field, SMEs can implement Digital Transformation initiatives to drive efficiency in operations, promote agility and innovation capabilities (Fliege et al., 2023). They also have an advantage in implementation, with a smaller size often being conducive to more flexibility to change.

However, while the implementation of DT initiatives can help close the gap, there are also several challenges in the way of successfully implementation. To start with, the limited resources and capabilities of the firms will constrain the available budget and manpower for transformation projects. Also, since in SMEs there are usually no dedicated departments or personnel to digital transformation, firms have to balance between daily operations and transformation efforts – leading to slower progress. There is also a lack of knowledge in transformation and digital expertise, which leads to external resources being necessary for

successful implementation. Additionally, if firms have old legacy systems and a fragmented data landscape, integrating or switching systems with the help of digital solutions can be costly and complex (since there was an accumulation of knowledge in these systems through time, and the users are also more likely to resist to change). Lastly, there needs to be a shift in the mindset towards innovation, since fostering a culture that embraces digitalization is critical for the success of transformation efforts (Fliege et al., 2023).
With the tools and resources required to implement DT initiatives in place, SMEs will be in an advantaged position to leverage these and generate value in their business.

2.4 Large Enterprises and Digital Transformation

Regarding the implementation of DT in large enterprises, there are both unique advantages and challenges that firms face, when comparing with their smaller competitors. On one hand, having more resources gives them an advantage in terms of access to technology and specialized teams, while on the other, their size and the complexity of operations can difficult the implementation of digital initiatives. If we consider the challenges these firms face - organizational inertia, the cost of updating systems (like ERPs) and cybersecurity risks are often the main enemies to successful DT implementation.

Firstly, with time employees become accustomed to the processes that are in place, and management may struggle to promote the cultural shift necessary for continuous innovation and change. Moreover, large firms have multiple layers of management and decision-making which make aligning all departments to a cohesive digital transformation strategy difficult (Kaganer et al., 2023).

Another important issue is the cost and difficulty in updating or shifting out of legacy systems. Complexity in operations and processes means that tailor-made systems often have to be created, and the cost of switching out of these is always high (since it involves redesigning the processes in the new system). Thus, larger firms often rely on older and outdated technology infrastructure that, while critical to daily operations, is difficult and expensive to replace – both in terms of the time it takes and the financial commitment it requires. In some cases, firms may perceive that the effort required to upgrade these systems is higher than the immediate benefits changing them would bring, forcing them to maintain old technologies along with new ones for extended periods(Furneaux et al., 2022). Another important element is cybersecurity, which poses a significant challenge due to the high digital footprint and large data repositories these firm have, making them prime targets for cyberattacks. Mitigating these risks requires additional investment in cybersecurity infrastructure and expertise, which takes away resources from other digital transformation initiatives (Kretschmer et al., 2022).

Despite these challenges, large enterprises also benefit from several unique advantages in digital transformation. Their financial resources allow them to invest in new technologies and create dedicated R&D or innovation teams tasked with exploring new digital solutions before rolling them out across the enterprise. The ability to test and scale initiatives gives them a strategic advantage, allowing for risks to be mitigated and complex DT initiatives to be better managed (Fliege et al., 2023).

2.5 Industry Classification Standard

Since this research will explore the value generated in SMEs across different Industries, it is important to define exactly what we consider as being the different industry sectors. Thus, the paper will follow the standard proposed in the Global Industry Classification Standard (Standard & Poor's Financial Services LLC, 2018). This classification categorizes companies into different industry groups based on their primary business activities, and defines 11 industries (Energy, Materials, Industrials, Financials, Healthcare, IT, Consumer Discretionary, Consumer Staples, Communication, Utilities, and Real Estate).

Research shows that each industry sector has its own unique digital transformation needs, priorities, and drivers. This implies the possibility of also categorizing DT initiatives based on their sector. Focusing on a single Industry allows studies into Digital Transformation to propose tailored strategies and solutions designed to the common needs of companies in the sector, and also facilitates benchmarking and comparison of DT initiatives outcomes (since companies are more similar) (Plekhanov et al., 2023).

2.6 Digital Transformation in Manufacturing Sector

Firms operating in the industrial sector are faced with high competition, supply chains integrated globally and constant pressure on higher levels of productivity and efficiency. And aside from this focus on productivity and cost-cutting, companies must also pursue high quality standards, foster innovation, and adapt to changing market demands if they aspire to thrive in this sector. This environment cultivates a need for constant transformation in firms, and the successful implementation of different DT initiatives also plays a role in giving firms an edge, and positioning themselves for success and growth in such a competitive environment (Matt et al., 2023)

The constant need for innovation and potential for impact through technological advancements are two of the characteristics that differentiate the industrial sector from others. Additional factors are also the complexity of operations (intricate supply chains, and manufacturing processes) which drives new technologies to increase productivity, and the emphasis on physical assets (DT in industrials involves leveraging technologies like predictive maintenance and asset tracking to maximize the lifespan and performance of assets) and a focus on automation and robotics. This mean that there is a focus on the technology context as a driver for value creation when studying firms in the industrial sector (Jones et al., 2021; Vogelsang et al., 2019).

2.6.1 INDUSTRY 4.0: Digital Transformation in Manufacturing

Advances and shifts in technology have led to what we know today as Industry 4.0, which in the manufacturing sector has been characterized by the integration of digital elements into physical systems like with the Internet of Things (IoT), cloud computing or cognitive computing. It has

brough a new dimension to manufacturing by enabling real-time data exchange across all levels of production, making manufacturing more efficient and flexible. A particular relevant application of these digital dimension has been predictive maintenance, where sensors and trackers are used to evaluate the "wear and tear" of different products and components – making down times in assembly lines less recurrent and maintenance on these more predictable (Lasi et al., 2014). Industry 4.0 has also enhanced supply chain visibility and agility, in turn allowing for firms that operate in this sector to respond better to market shifts (Hermann et al., 2016).

2.7 Digital Transformation Initiatives and value creation

The implementation of transformation initiatives can be challenging for both the financial and human resources of a firm, especially in the case of SMEs. Hence, initiatives need to have their value weighted before implementation, which raises the question of "How can we define success and value creation"? If we consider existing literature, we can define a firm's value creation in four separate measurements already mentioned: 1) revenue growth, 2) cost savings, 3) customer acquisition and retention rates, and 4) operational efficiency improvements (Brynjolfsson & McAfee, 2012; Lindman et al., 2016).

Thus, if a digital transformation initiative has a positive ROI and the outcome leads to the improvement of one or more of these four measurements in a firm, we can consider that it was successfully implemented. However, there are several different paths that can lead to this successful implementation. To condense the different categories of DT initiatives, this research proposes three dimensions to quantify value generation in the developed framework, as well as establish connections between the different TOE contexts. These categories are Efficiency and Productivity improvements, customer & market capture and Innovation and Differentiation.

Efficiency and Productivity improvements can often be associated with the streamline of processes, automation of repetitive tasks, and optimization of resource allocation that are common DT initiatives in firms. These, if implemented properly, may lead to cost reductions. Another way - implementing more efficient processes results in value generation - is through increased agility, which can lead to the acceleration of Time-to-Market of products (product development times) (Bharadwaj et al., 2013).

In relation to customer and market capture, DT initiatives can expand the reach of the business – for instance, through implementation of online platforms or digital marketing. Another point is that initiatives can also be proposed to improve customer or supplier engagement, which often leads to increased satisfaction and strengthening of brand loyalty. Furthermore, DT initiatives can also provide firms with more insights into customer behavior (with AI for example) or into potential new business models that have the potential to lead to additional market capture. This category is mainly associated with the increase in revenues due to volume expansion (Verhoef et al., 2021).

Finally, research shows that transformation initiatives focusing on Innovation and differentiation, contribute to the development of a unique value preposition in firms. Customers are attracted to products that are different from other competition, and this leads to firms being able to command a premium pricing (being "differentiated" means they can be unique in their customer approach, product quality or scarcity, or even in their model of business) (Lindman et al., 2016; Teece, 2018).

2.8 Enabling factors to Digital Transformation

Table 1 contains a summary of the different factors enabling digital transformation. These can serve as a guide to strategic planning, resource allocation or risk management efforts inside a company undergoing DT.

Table 1: Enabling Factor Framework. Retrieved from A Framework of Factors Enabling Digital Transformation, by (Mühlburger et al., 2019)

	Enabling Factor	Referring Sources
Workforce Capabilities	Individual Creativity and Innovation	An individual's capability to think creatively, work creatively with others and implement innovations (Mühlburger et al., 2019)
	ICT Literacy	The individual's capability of "using digital technology to access, manage, integrate, evaluate and create information in order to function in a knowledge society and at its highest level enable innovation, individual transformation, and societal change" (Mühlburger et al., 2019) .
Organizational Values	Agile and Innovative Org Culture	A company culture which fosters innovation and creativity, while embracing change(Nadkarni et al., 2021) .
	Internal and External Collaboration	A value structure that promotes cross-functional collaboration and includes external parties throughout the innovation process, facilitating knowledge sharing and leveraging both internal and external resources (Mühlburger et al., 2019).
	Customer-Centric approach	Focus on enhancing customer experience through digital channels (Reis & Melão, 2023)
Organizational Infrastructure	Digital Platform Infrastructures	Highly integrated infrastructures following investments into technology infrastructure, data, digitized business processes and electronic linkages to external parties(Mühlburger et al., 2019).
	IT-Agility	An IT–function's capability to identify changes within a company's environment and adapting to the changing business needs following these changes (Mühlburger et al., 2019).
Management Capabilities	Strategic Embeddedness	An interwoven digital business strategy which effectively governs the necessary transformational processes within the organization(Mühlburger et al., 2019; Reis & Melão, 2023).
	Digital Leadership	Management board that has reached a mutual understanding to view IT as an asset, recognize its' strategic or turnaround orientation; contains a member fulfilling the role of an IT Orchestrator (Mühlburger et al., 2019; Reis & Melão, 2023).

2.9 Technology-organization-environment (TOE) framework

The TOE framework is a conceptual model developed in 1990 by Tornatzky and Fleischer used in management and organizational studies to assess the factors influencing an organization's

performance and behavior. It is made of three main components: Technology, Organization, and Environment (Tornatzky et al., 1990).

The Technology dimension describes the internal and external technologies relevant to the firm. This includes the equipment and practices the firm possesses, as well as the set of available technologies outside of the firm. The Organizational dimension refers to descriptive measures about the organization such as its scope, size, and managerial structure. Lastly, the environmental dimension is the stage in which a firm conducts its business—its industry, competitors, and relation with the government (Oliveira & Martins, 2011).

By exploring the interactions, dependencies, and performance of these three components, the TOE framework is used in this research with the aim of providing a wide perspective on how value can be captured by firms when implementing DT initiatives, recognizing the importance of both internal and external factors (in the outcome of initiatives). This framework is a useful tool for researchers and practitioners in various fields due to its flexibility and adaptability to different research methods, including qualitative and quantitative approaches (Baker, 2012)

If we consider the study of digital transformation in firms, it is possible to systematically examine the interplay between technology adoption, organizational factors, and the external environment in driving value creation to firms. The TOE framework can identify key drivers or groups of DT initiatives that are most conducive to value creation in firms and provide valuable insights for practitioners and policymakers looking to support firms in their digital transformation journeys. This is supported by the fact that DT today extends beyond technology, encompassing various transformational processes such as changes to business models, procedures, culture, and customer experiences. The TOE framework will this provide us with a holistic approach that can capture the expanding dimensions of DT (Kraus et al., 2022).

3. RESEARCH MODEL

3.1 The Conceptual Model

Through this study, a conceptual model based on the TOE Framework was created to try and ascertain what are the factors (or drivers) that lead to the creation of value when implementing DT initiatives, for firms operating in the Industrial Sector. Many researchers have used the TOE approach as a tool in previous Digital Transformation studies, including when constructing frameworks. Hence, there is reliable support and precedent to such an approach (Nguyen et al., 2022; Yin, 2023). By making use of this framework, this study explores the three dimensions: Technological, Organizational and Environmental, and connects these to value capture in firms implementing DT initiatives.

With digital transformation often being sprung by new technologies, we can connect the technology dimension to capture of value in firms (Broughel & Thierer, 2019). Having a technological advantage leads to not just more efficient processes, but also an added element of differentiation that is beneficial (Vial, 2019). For SMEs in particular, it is acknowledged that in an innovative environment, creativity and experimentation are strengths to be considered and may bring value to firms. As for the Organizational dimension, the buy-in and vision of Management will be crucial for "opening the way" to the implementation of DT initiatives (limited human and capital resources mean that investing time and money into these projects has a much higher "price" for companies – and is crucial in overcoming resistance from employees) (Fliege et al., 2023). Finally, for the Environmental dimension, the competitiveness and rate of innovation of the industry the company operates in, is also a large factor in how much it has to push for new processes and ideas (as well as more efficiency in production) (Hermundsdottir & Aspelund, 2021). Another factor is the improvement of Customer experience, since enhancing customer interactions, satisfaction, and loyalty through digital channels and personalized experiences can have a large impact and generate value by capturing new customers and market share (Rane et al., 2023).

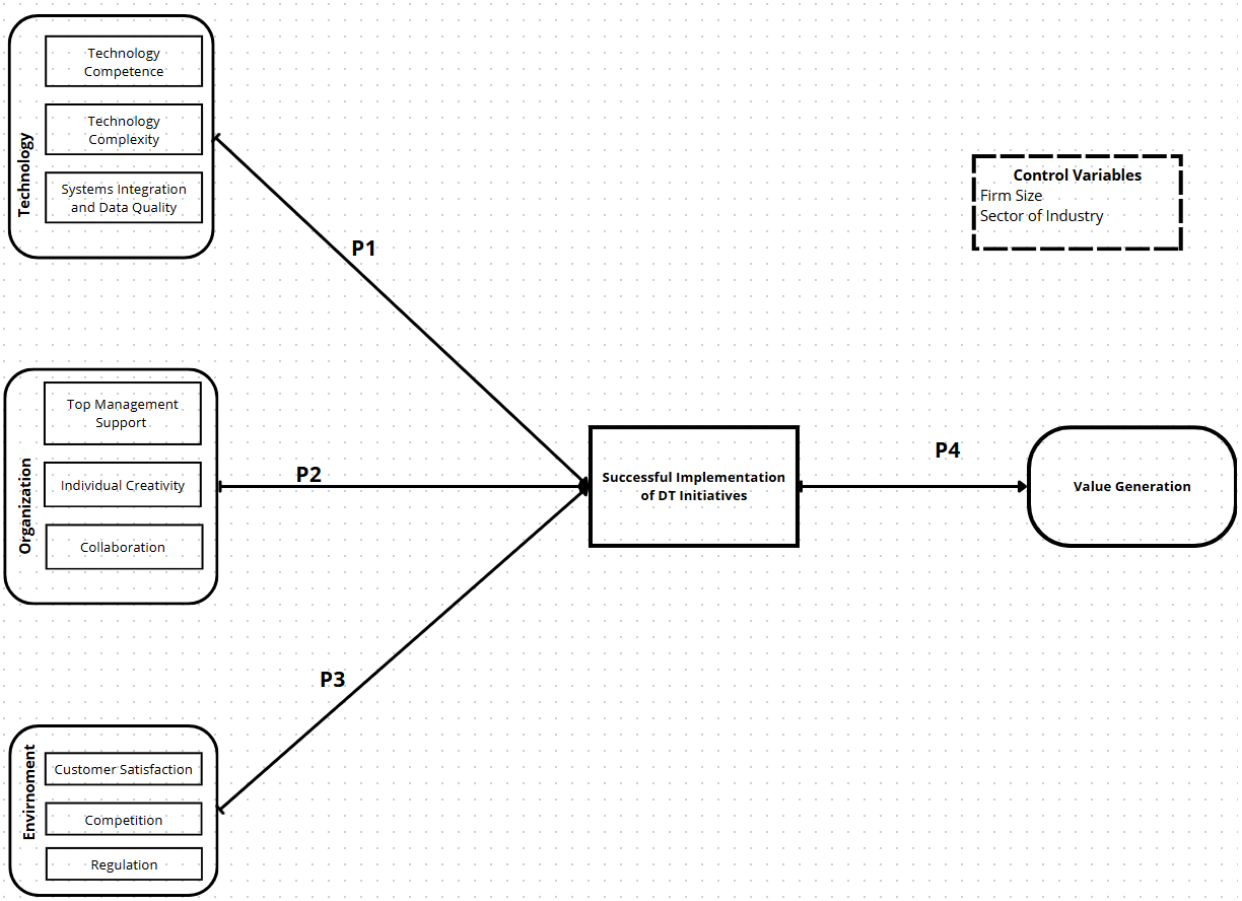

Figure 1: Conceptual Model of Value Creation for DT initiatives.

3.2 Technology Context

In the realm of Digital Transformation subjects, the Technology Context can be formed by the component's technology complexity, technology readiness and Systems Integration, as referred to in Figure 1.

Technology competence refers to the firm's current technological assets, its ability to understand and utilize new technologies (including its employees, and their "ICT Literacy"), and the overall readiness and to integrate these technologies into its operations (Baker, 2012). A firm that knows how to integrate technology in its operations can significantly enhance productivity and facilitate production volume expansion (Angevine et al., 2021). Thus, the ability of a firm to capture and generate value from DT initiatives is influenced by the technologies it has available, as well as the capabilities to use these in different contexts internally (Masoud & Basahel, 2023). Given this is one of the components of the Technology context in the proposed model (in Figure 1), we should consider whether or not Technology Competence has a positive value when implementing DT Initiatives

Technology Complexity denotes the degree to which an innovation is perceived as difficult to understand and use. This perception of difficulty can impact the adoption of technological solutions within organizations. Research shows that in situations where the operators feel they have inadequate skills, adoption will become more difficult (Singh, 1997). Thus, we should also consider if Technology Complexity has a positive value when implementing DT Initiatives propose:

Contributing to the technology context are the systems integration aspects and data quality. IT systems allow for information sharing and transactions being recorded across different functions in an organization. A company with a high capacity of systems integration is capable of extracting, transforming, and loading data from multiple types of sources and suppliers (Genesereth, 2010). Given that the quality of data in a firm and the operability of its systems are critical for the implementation of DT initiatives, we can assume a positive relation between these and Systems Integration/data quality. Thus, we must also ascertain if Systems Integration and data quality have a positive value when implementing DT Initiatives

Once we consider all three components of the Technology context, one proposition that covers all of these previous ones is proposed:

P1 Technology Context has a positive value when implementing DT Initiatives

3.3 Organization Context

The Organizational dimension refers to descriptive measures about the organization such as its scope, size, managerial structure as well as the financial commitments it has (Baker, 2012).

Top management is responsible for allocating resources, setting goals and making decisions, among other things, inside of a firm. As such, management will allocate the necessary resources (financial, human capital) and provide a clear direction for transformation initiatives – thus making support from leadership indispensable in overcoming obstacles and succeeding in the implementation of these initiatives (Vial, 2019). In addition, without the support of top management, DT initiatives are likely to encounter resistance since employees often feel uncertain when facing change and transformation and buy in from the "top" is crucial to overcome this (Fliege et al., 2023). So, we must consider if Top Management Support and Vision has a positive impact when implementing DT Initiatives

For firms, having the agility to respond and adapt to changes in technology and customer needs is critical for success. This flexibility allows them to make adjustments as new opportunities and challenges occur, which can result in gaining an advantage against competition when implementing new technologies or adopting new processes more quickly – such as in the implementation of digital transformation initiatives (Vial, 2019). Additionally, fostering a "flexible and adaptable" culture in an organization can contribute to employees being less resistant to change, and more prone to seeking innovation (Broughel & Thierer, 2019). So, we

can assume a positive relation between agility and adaptability and the implementation of DT initiatives. And so, we have to consider if Agility and adaptability has a positive value when implementing DT Initiatives

Internal collaboration between different departments and teams helps sharing knowledge and aligning the organization's goals and needs (Baker, 2012) . In turn, this makes the implementation of new technologies and transformative project

s smoother, with teams less resistant to change and more integrated in the company overall (Fliege et al., 2023). Externally, engaging with technology or consulting partners, suppliers and even customers is beneficial to firms and can add value to their business, giving them access to new expertise, technology and resources that might not be available in-house (Rane et al., 2023). Thus, collaboration is positive when implementing DT initiatives since it provides new resources and a more integrated approach when adopting technology. Considering this, we must also ascertain if Collaboration (Internal and External) has a positive value when implementing DT Initiatives.

Finally, one proposition that covers all the mentioned components is proposed:

P2 Organizational Context has a positive value when implementing DT Initiatives

3.4 Environment Context

The environment context of the TOE framework contains all the external factors that influence an organization's technology adoption and implementation (Baker, 2012). In the realm of Digital Transformation subjects, this context includes customer and supplier satisfaction, Industry and competitive pressure and Government pressure, as shown in Figure 1.

Regarding customer satisfaction, positive responses to the products or services offered by Enterprise can influence the organization's technology adoption and implementation processes. High levels of customer satisfaction may lead to a greater emphasis on adopting technologies that improve customer experience, while low levels of satisfaction will drive the organization to seek technological innovations and transformation processes to address customer concerns (Jia et al., 2017). Customer experience is a source of competitive advantage since it leads to customer loyalty (Masoud & Basahel, 2023). Thus, we must consider if Customer Satisfaction has a positive value when implementing DT Initiatives.

Industry and competitive pressure refer to the level of pressure perceived by an organization from its competitors in the market. This pressure can impact the organization's decisions regarding the adoption of new technologies and improvement of current processes, in order to respond to the market's demands (Baker, 2012; Nguyen et al., 2022). So, we must examine if Industry and competitive pressure has a positive value when implementing DT Initiatives.

Regulatory frameworks, tax incentives and government initiatives push companies to adopt new technologies and change their operations and processes to adapt to new standards (Nguyen et al., 2022). While regulation may exist to protect consumers (for example with data protection regulations) or to ensure fair competition in the markets, it is also true that it may lead to inefficiencies in organizational processes since additional resources and time will be spent to meet regulations. On the other side, regulation can also compel firms to modernize their systems to meet regulatory requirements (Broughel & Thierer, 2019). Additionally, government subsidies and tax incentives that target innovation and digital transformation can lower the cost of implementing digital solutions and investing in technology for firms. Another important role governments can have is to provide platforms for knowledge sharing, training, and collaboration, giving firms the necessary and resources for successful digital transformation (Masoud & Basahel, 2023). Thus, we must also examine if Government Intervention has a positive value when implementing DT Initiatives.

So, one proposition that covers all the mentioned components of the Environment context is proposed:

P3 Environment Context has a positive value when implementing DT Initiatives

3.5 Successful Implementation of DT Initiatives and Value creation

When discussing what constitutes a successful implementation of a DT initiative, research highlights three different categories: Efficiency and Productivity improvements (Bharadwaj et al., 2013), customer & market capture (Verhoef et al., 2021) and Innovation and Differentiation (Lindman et al., 2016). These three different dimensions serve as important trackers that contribute to the success of a DT initiative and, progress in these areas can enable value creation for firms by driving: 1) revenue growth, 2) cost savings, 3) improved customer acquisition and retention rates, and 4) enhanced operational efficiency.

Thus, one additional proposition must be considered:

P4 The Successful Implementation of DT initiatives has a positive value in generating value for firms

4. METHODOLOGIES AND RESULTS

4.1 Research Design and Measuring

Given the TOE model proposed to explain the factors that lead to value creation in DT initiatives, the methodology chosen was Design Science Research. DSR is an iterative and solution focused methodology that creates and then accesses artifacts and, thus is well suited for studies that propose frameworks and models (Hevner et al., 2004). This methodology follows a cyclical process that includes several steps: problem identification, artifact identification, artifact design, demonstration and evaluation. This can be seen in Figure 2, which represents the DSRP model proposed by (Peffers et al., 2007).

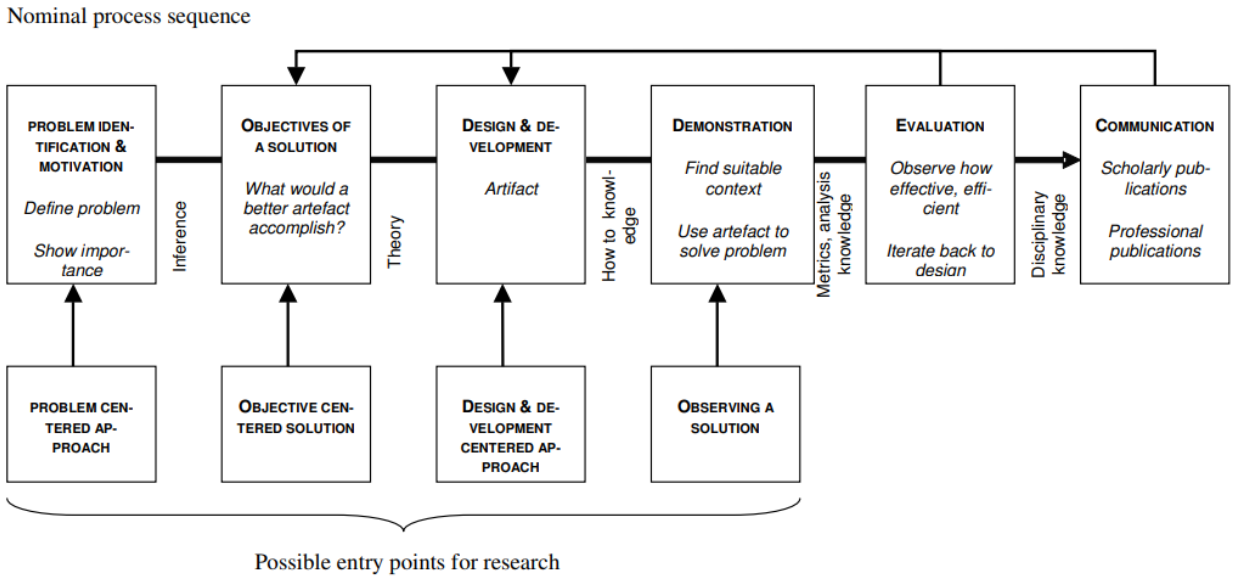

Figure 2: Design science research process (DSRP) model (Peffers et al., 2007)

For this research, the problem identified was the need for a framework or model to guide manufacturing firms in maximizing value creation from digital transformation initiatives; the artifact designed is the revised TOE framework, which is based on previous research and empirical data; the artifact was demonstrated and tested through a mixed-methods approach; and in the final phase the revised TOE framework will be evaluated to ensure its effectiveness and impact, while refining it further based on feedback.

To demonstrate and test the created artifact (TOE framework/model) and the proposed proposition, semi-structured in-depth interviews were conducted with a range of experts. In

addition, a follow up survey at the end of each of the interviews was administered to each of the experts to quantify data and clarify responses given during the interview.

Choosing this approach enables us to delve deeply into the nuances of how the interview subjects perceive digital transformation and its impact on value generation. It also serves to contextualize our proposition and background to the study, while also having the flexibility to explore emerging themes or unexpected insights that develop during the interview and can contribute to the study. And as such, the objective of the interviews is to gather information from different stakeholders and their perspectives on digital transformation - more specifically what their perception of successful transformation is, and the factors that facilitate a positive impact from these initiatives. Considering the scope of the work is focused on firms that operate in the manufacturing sector of the economy, the selection of the interviewees reflects this as well.

The development of the scripts for the interviews and the subsequent survey in this thesis were supported in existing literature and methodologies, with the structure of the proposed model being based in the TOE framework proposed by Tornatzky and Fleischer (Tornatzky et al., 1990), and further developed in additional studies such as Baker, 2012 and Oliveira & Martins, 2011. Additionally, the mixed-methods approach employed in this study follows the DSRP model "guidelines" proposed by Peffers (Peffers et al., 2007), to validate the proposed TOE-based framework through interviews and surveys and ensure the integrity of research.

4.2 Interview Selection

Considering the model proposed had to be reviewed by individuals that had pre-existing knowledge about digital transformation and its implementation in firms, a random selection method was not appropriate for validating the proposed model. As such, a non-probability selection criteria was selected, where the experts to be interviewed had to meet the following criteria for this thesis: first, the expert should work (or have worked) in a company that has undergone DT initiatives implementation; second the expert should be in a position where they have visibility of the processes transformed (and its impact); thirdly the expert should have experience in either managing or participating in DT initiatives; lastly the expert should be able to discuss the factors that lead to a successful implementation of DT initiatives. An additional factor was considered while selecting the interviewees which was the sector of the industry in which they worked. Since this thesis focuses on manufacturing companies, a preference for individuals with experience in this field was taken.

Following Eisenhardt's methodology to select sample sizes (Eisenhardt, 1989), the number of samples (organizations) should be between four and ten. For this thesis, a total of 9 samples were selected.

Table 2: Interview selection

Participant no	*Company Size*	*Industry Sector*	*Industry segment*	*Position*
1	SME	Manufacturing & Industrials	Aviation	COO
2	SME	Manufacturing & Industrials	Parts Assembly & Logistic	CEO
2	SME	Consumer Staples	Distributor and Retail	IT Manager
4	Large	Consumer Staples	Online Retail	Teach Lead (Manager)
5	Large	Manufacturing & Industrials	Automotive	IT Manager (Infrastructures)
6	Large	Manufacturing & Industrials	Automotive	Systems Analyst
7	SME	Manufacturing & Industrials	Food & Beverages Processing	IT Director
8	Large	Manufacturing & Industrials	Textiles	CEO (Managing Director)
9	SME	Manufacturing & Industrials	Food Processing	CEO

4.3 Data Evaluation

The analysis and evaluation of the interviews are aligned with the research questions proposed, which are to explore the main drivers to the successful implementation of digital transformation initiatives in firms that operate in the Industrial sector and to define what creation of value from these initiatives constitutes. The interviews and follow-up survey, together with the literature review will thus provide a basis for the analysis.

Additionally, considering that some of the interviewees were not aware of the maturity state of their firms – an optional digital maturity survey was also conducted before the interview started (please see APPENDIX C). The survey administered is based on the Digital Maturity Assessment Tool from the South Australia government and on the Digital Maturity Assessment Tool of the European Digital Innovation Hub. This survey is not an integral part of the research and had the purpose of giving the interviewees more context and a frame of reference for their firm within a digital maturity scale. Not all interviewees chose to take this optional survey.

Regarding the method chosen for the analysis/demonstration, the research follows a mixed-methods approach, consisting of a quantitative analysis to the follow up survey and qualitative content analysis of the semi-structured interviews (Mayring, n.d.). A descriptive statistical analysis of the survey to the interviewees will be the first step in this analysis so as to identify patterns, trends and correlations within the data, while also giving a general state of the opinions of the interviewees. Considering that 9 semi-structured interviews took place, each with a

duration between 45 minutes and 1 hour (resulting in 35 pages of interview transcripts), text mining was subsequently used as a tool to discover the most frequently mentioned topics during the interviews, and a sentiment analysis was deployed to evaluate in a quantitative manner the emotional tone and attitudes of the interview participants in regards to the proposed construct items (enabling factors of DT). Subsequently, the discussion part of this research will delve deeper into the results of the survey and sentiment analysis, using them to make inferences and uncover the relationship between our constructs and value-generation in firms. Additionally, the content analysis of the semi-structure interviews will serve to support the results of the survey, while delving deeper into nuances and individual's perspectives and opinions. Ultimately, both the statistical analysis and the content analysis will serve as tools to confirm or deny the TOE-based proposed model, as well as to make adjustments to it.

4.4 Model Measurement Items and References

The model's measurement items are components used to evaluate and quantify the constructs within the research model (Wilson, 2023). For this research, items that are based on the various dimensions of the TOE framework and on the enabling factors Framework (in Table 1) will be proposed, with the goal of measuring and exploring how each construct influences the successful implementation of DT initiatives and value creation.

By converting abstract concepts such as "technology competence" into measurable indicators like ICT literacy, this will make it easier for the survey responders (and interviewees) to quantify the impact that each item has on DT initiatives and value creation, while also making the interpretation of the corresponding data more straightforward and reliable. Thus, the Construct Items, Item Descriptions and the base Literature used in the research can be seen in Table 3.

Table 3: Constructs and Construct Items proposed in the Model

Contruct	Construct Item	Construct Item Description	Base Literature
Technology Context (T/C)	T/C 1	ICT Literacy	(Angevine et al., 2021; Fliege et al., 2023; Michael Hammer, 1990; Mühlburger et al., 2019; Van Laar et al., 2017)
	T/C 2	Technical Skills	
	T/C 3	Agility and Adaptability	
	T/C 4	Technology Complexity	
	T/C 5	Data Quality	
	T/C 6	Integrated Systems	
Organization Context (O/C)	O/C 1	Top Management Support / Digital Leadership	(Angevine et al., 2021; Fliege et al., 2023; Mühlburger et al., 2019)
	O/C 2	Individual Creativity	
	O/C 3	Collaboration (Internal & External)	
Environment Context (E/C)	E/C 1	Industry and competitive pressure	(Broughel & Thierer, 2019; Fliege et al., 2023; Masoud & Basahel, 2023; Mühlburger et al., 2019; Nguyen et al., 2022)
	E/C 2	Customer Satisfaction	
	E/C 3	Regulation and Government Interventition	
Successful Implementation Of DT Initiatives (S/I)	S/I 1	Efficiency and Productivity Improvements	(Bharadwaj et al., 2013; Lindman et al., 2016; Teece, 2018; Verhoef et al., 2021)
	S/I 2	Innovation & Differentiation	
	S/I 3	Market Expansion	
Value Generation (V/G)	V/G 1	Revenue Growth	(Brynjolfsson & McAfee, 2012; Lindman et al., 2016)
	V/G 2	Cost Savings	
	V/G 3	Customer Retention and Acquisition rates	
	V/G 4	Operational efficiency improvements	

Figure 3 shows how the different constructs, categorized under the Technology-Organization-Environment contexts, can contribute (or enable) to the successful implementation of Digital

Transformation initiatives. Through this visual representation we can see that successful implementation relies on a combination of the different drivers, and that firms must consider many different aspects to succeed.

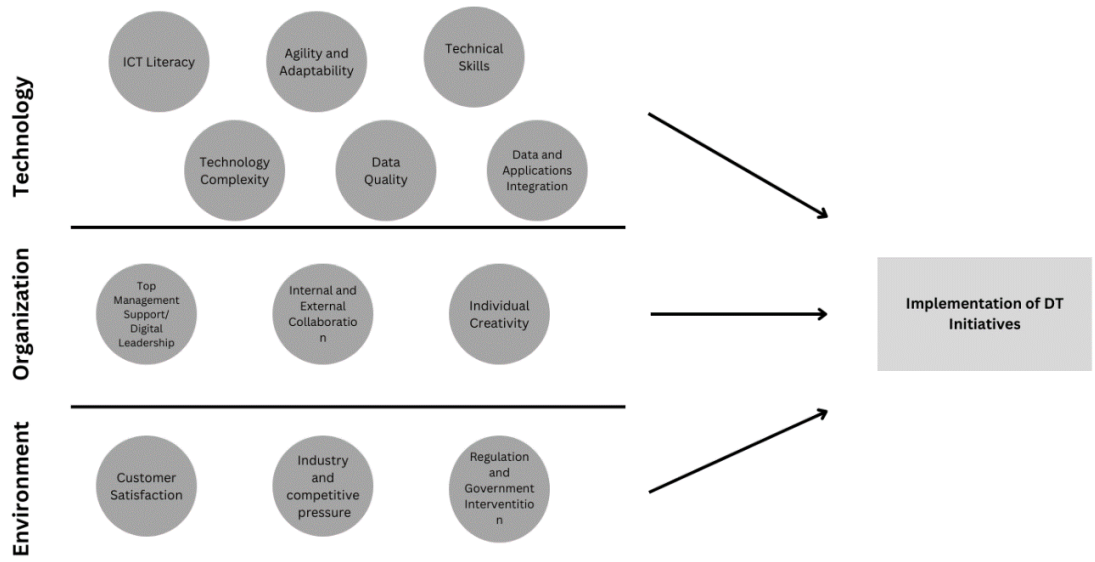

Figure 3: Model Constructs -enabling DT initiatives

4.5 Survey Structure

The survey (in APPENDIX - A and B) will pose to the different participants the same set of questions, each with the intent of quantifying the perceived impact that the construct items have in the research model.

As can be seen in Table 4, the first 14 questions establish a relationship between the Technology-Organization-Environment constructs and the successful implementation of DT initiatives, with two of these questions being auxiliary, and complementary in nature. Following these 14 questions, the survey poses three True or False questions to confirm or deny the research's assumption of what constitutes a successfully implemented DT initiative, related with the "S/I" constructs (Efficiency and Productivity Improvements, Innovation & Differentiation, Market Expansion). Finally, the survey poses five close-ended questions, to ascertain what the respondents consider to be Value Generation in a firm. Thus, the survey will support the validation of the model and quantify how our constructs (enabling factors to DT) contribute to creation of value in firms.

Table 4: Construct Items and Survey Questions

Construct Item	Construct Item Description	Survey Question No
T/C 1	ICT Literacy	Q1
T/C 2	Technical Skills	Q2
T/C 3	Agility and Adaptability	Q3
T/C 4	Technology Complexity	Q4
T/C 5	Data Quality	Q5
T/C 6	Integrated Systems	Q6
O/C 1	Top Management Support / Digital Leadership	Q7
A/C 1	Auxiliary Question – Top Management Support	Q8
O/C 2	Individual Creativity	Q9
O/C 3	Collaboration (Internal & External)	Q10
E/C 1	Industry and competitive pressure	Q11
A/C 2	Auxiliary Question - Customer Satisfaction	Q12
E/C 2	Customer Satisfaction	Q13
E/C 3	Regulation and Government Interventition	Q14
S/I 1	Efficiency and Productivity Improvements	Q15
S/I 2	Innovation & Differentiation	Q16
S/I 3	Market Expansion	Q17
V/G 1	Revenue Growth	Q18
V/G 2	Cost Savings	Q19
V/G 3	Customer Retention and Acquisition rates	Q20
V/G 4	Operational efficiency improvements	Q21
V/G 5	All of the above	Q22

4.6 RESULTS

4.6.1 POST-INTERVIEW SURVEY ANALYSIS

A descriptive statistical analysis was conducted to understand the general position of the interviewees and their position on the validity of the model proposed to explain the factors that lead to a successful implementation of DT initiatives. Additionally, a comparative analysis of the means based on the control variables was also conducted, and correlation between questions assessed.

For the purpose of the survey, questions Q1 to Q14 are rated from 1 to 7 based on favorability (7 is highest, 1 the lowest), while Q15 to Q22 represent True (1) or False (0) questions.

Table 5: Descriptive analysis of post-interview surveys

Question	C. Item	Construct Item Description	Count	Mean	σ	Min	25%	50%	75%	Max
Q1	T/C 1	ICT Literacy	9	5.0	1.4	3	4	5	6	7
Q2	T/C 2	Technical Skills	9	5.8	1.2	4	5	6	7	7
Q3	T/C 3	Agility and Adaptability	9	5.0	2.2	1	5	5	7	7
Q4	T/C 4	Technology Complexity	9	3.8	1.4	2	3	4	5	6
Q5	T/C 5	Data Quality	9	6.6	0.5	6	6	7	7	7
Q6	T/C 6	Integrated Systems	9	6.6	0.5	6	6	7	7	7
Q7	O/C 1	Top Management Support / Digital Leadership	9	6.6	1.0	4	7	7	7	7
Q8	A/C 1	Auxiliary Question - Top Management Support	9	4.0	1.6	2	3	3	6	6
Q9	O/C 2	Individual Creativity	9	4.4	1.2	3	4	4	6	6
Q10	O/C 3	Collaboration (Internal & External)	9	5.6	1.6	2	6	6	6	7
Q11	E/C 1	Industry and competitive pressure	9	4.8	1.8	2	3	5	6	7
Q12	A/C 2	Aux Q - Customer Satisfaction	9	4.1	1.1	3	3	4	5	6
Q13	E/C 2	Customer Satisfaction	9	4.8	1.6	2	4	5	6	7
Q14	E/C 3	Regulation and Government Intervention	9	3.4	1.2	1	3	3	4	5
Q15	S/I 1	Efficiency and Productivity Improvements	9	1.0	-	1	1	1	1	1
Q16	S/I 2	Innovation & Differentiation	9	1.0	-	1	1	1	1	1
Q17	S/I 3	Market Expansion	9	1.0	-	1	1	1	1	1
Q18	V/G 1	Revenue Growth	9	0.9	0.3	0	1	1	1	1
Q19	V/G 2	Cost Savings	9	1.0	-	1	1	1	1	1
Q20	V/G 3	Customer Retention and Acquisition rates	9	1.0	-	1	1	1	1	1
Q21	V/G 4	Operational efficiency improvements	9	1.0	-	1	1	1	1	1
Q22	V/G 5	All of the above	9	1.0	-	1	1	1	1	1

Table 6: Q1-Q14 Descriptive statistics of total answers

Total_Count	Total_Mean	Total_Std_Dev	25th_Percentile	Median	75th_Percentile
126	5.02381	1.651493	4	5	6

Table 7: Q5-Q22 Descriptive statistics of total answers

Total_Count	Total_Mean	Total_Std_Dev	25th_Percentile	Median	75th_Percentile
72	0.986111	0.117851	1	1	1

Observing Table 5 we can see that for Questions 1 to 14, the Construct Items for which participants had less favorability were Q4 (Technology complexity), Q9 (Individual Creativity), Q11 (Industry and competitive pressure) and Q14 (Regulation and Government Intervention) – the small favorability indicating that these items could potentially be removed from the proposed model. Additionally, we can single out questions Q5 (Data Quality), Q6 (Integrated Systems) and Q7 (Top Management Support) for the largest favorability perceived by interviewees, with the average mean response for each of these above 6.4 (high favorability), and standard deviation low, bellow 1 (strong agreement between participants) – meaning participants overall consider these the "most relevant".

Looking at table 6 we can also see that the average mean response for Questions 1 to 14 was 5.02, signifying a generally favorable view among respondents for all of our model constructs, since the values are above the neutral point of 4. Additionally, the standard deviation is 1.65, which denotes that there was some variation in responses

As for Q15 to Q22, the results in Table 5 and Table 7 reveal an average mean of 0.98 (1 represents agreement, "True") across all questions, showing a strong consensus for the interviewees that both operational improvements and financial metrics are crucial indicators of successful digital transformation. Thus, we can conclude that the survey participants agree that productivity gains, innovation, and market expansion are related positively with successful DT initiatives implementation, while financial outcomes such as revenue growth, cost savings, and customer retention are seen as essential metrics for assessing the impact (and value generation).

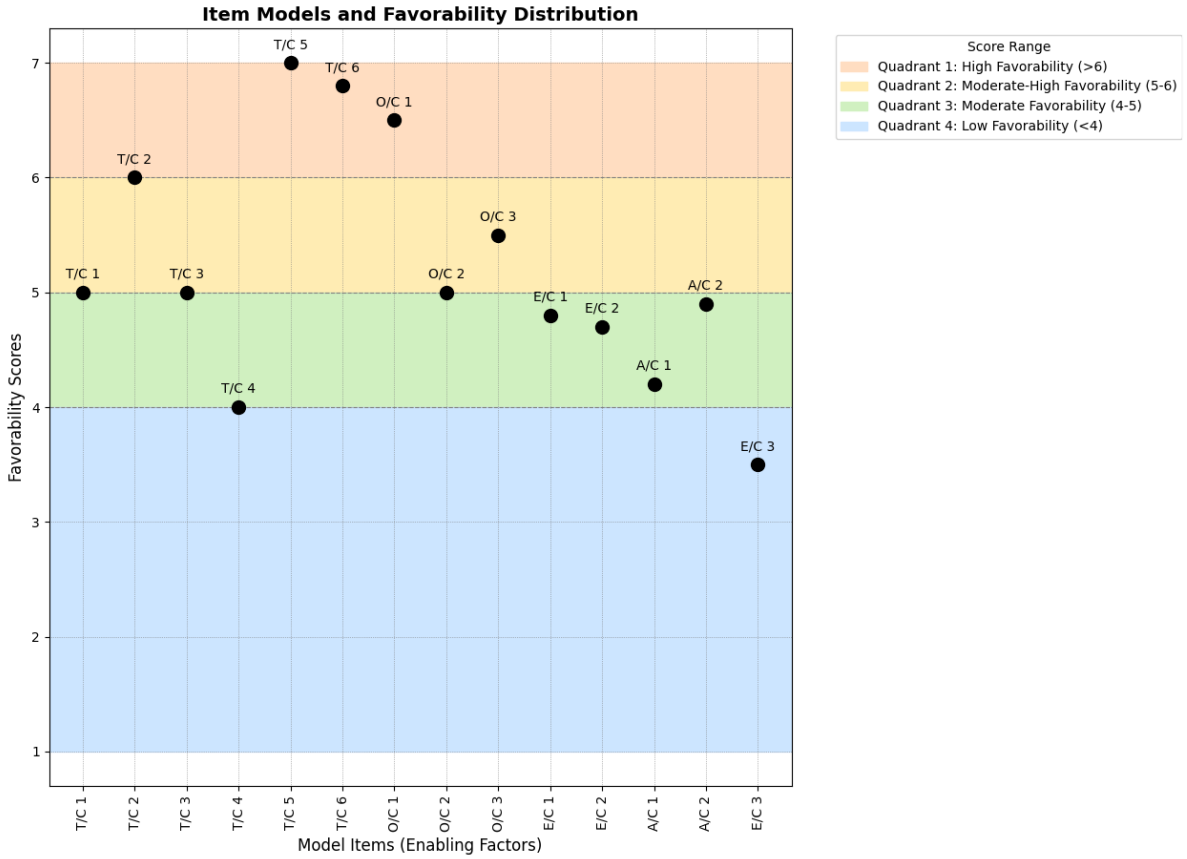

Figure 4: Favorability Distribution of Construct Items T/C, O/C and E/C– the four Quadrants

To categorize the TOE enabling factors based on the favorability shown by the participants of the interviews and survey towards them, this research proposes a matrix made of four Quadrants - represented in Figure 4 "Favorability Distribution of Construct Items T/C, O/C and E/C– the four Quadrants", where each quadrant represents a different interval of favorability. Quadrant 1 (in light red) includes the enabling factors with mean results above 6, which express high favorability and the construct items are seen as critical for DT; Quadrant 2 (yellow) is an interval between 5 and 6, moderate-high favorability for DT; Quadrant 3 (green) represents scores between 4 (which is neutral point of favorability) and 5 which have positive favorability but are perceived as secondary drivers; and lastly Quadrant 4 (light blue) represents scores bellow 4, which have negative favorability towards the enabling factor and are viewed as less critical by the participants.

Table 8: Comparative Analysis - Mean responses based on firm size

FIRM SIZE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	TOTAL
LARGE FIRMS	5.4	6.0	5.0	3.8	6.6	6.6	6.4	3.6	3.8	5.6	5.2	4.4	5.2	3.6	5.1
SMALL & MEDIUM FIRMS	4.5	5.5	5.0	3.8	6.5	6.5	6.8	4.5	5.3	5.5	4.3	3.8	4.3	3.3	4.9

Table 9: Comparative Analysis - Mean responses based on sector of industry

INDUSTRY SECTOR	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	TOTAL
CONSUMER STAPLES	5.0	5.5	6.0	4.5	6.5	6.0	5.0	4.5	5.0	6.0	4.0	3.5	5.5	3.5	5.0
INDUSTRIALS	5.0	5.9	4.7	3.6	6.6	6.7	7.0	3.9	4.3	5.4	5.0	4.3	4.6	3.4	5.0

If we look at our control variables and the comparative analysis in Table 8 and 9, we can observe that the mean answer for all questions 1 to 14 is higher in Large firms than in SMEs (indicating that the proposed model resonates more with this interviewees); while Industrial companies have a similar mean comparing to Consumer staples.

In relation to Table 8, we can also observe that participant from SMEs rate higher on Q8 (Top Management; Initiatives from bottom) and Q9 (Individual Creativity), which shows a reliance on innovation and bottom-up contributions of workers. Large Firms on the other hand, have higher favorability on Q6 (Integrated Systems) and Q10 (Collaboration - Internal & External), indicating a focus on integration and teamwork due to their complex structures. As for Table 9, participants from Industrials emphasize Q6 (Integrated Systems) and Q7 (Top Management Support), highlighting the need for strong systems and leadership, while Consumer Staples prioritize Q3 (Agility) and Q13 (Customer Satisfaction), focusing on flexibility and customer needs, which are necessary to remain competitive and build customer loyalty.

Table 10: Correlation table

	Q1	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*	*Q11*	*Q12*	*Q13*	*Q14*
Q1	1.00	-0.26	0.83	0.76	0.24	-0.41	-0.49	-0.14	0.12	0.59	-0.14	0.36	0.84	0.11
Q2		1.00	-0.49	-0.32	0.17	0.14	0.05	0.25	0.33	0.17	0.16	0.10	-0.34	-0.41
Q3			1.00	0.55	0.12	-0.45	-0.40	-0.33	-0.11	0.41	0.28	0.02	0.85	0.10
Q4				1.00	-0.35	-0.09	-0.44	-0.18	-0.34	0.52	0.78	-0.83	0.69	0.58
Q5					1.00	-0.64	-0.49	-0.04	0.31	-0.25	0.78	-0.86	0.49	0.51
Q6						1.00	0.09	-0.12	-0.34	0.15	-0.09	0.06	-0.05	0.06
Q7							1.00	0.30	0.32	-0.08	0.00	0.25	-0.40	0.08
Q8								1.00	-0.12	0.08	0.78	-0.83	0.22	0.34
Q9									1.00	0.27	0.28	0.02	-0.02	-0.15
Q10										1.00	0.62	-0.75	0.90	0.29
Q11											1.00	-0.86	0.63	-0.12
Q12												1.00	-0.75	0.14
Q13													1.00	0.51
Q14														1.00

Table 10 shows strong positive correlations between some of the model construct items, such as ICT Literacy (Q1) and Agility (Q3) with a correlation of 0.83, as well as Data Quality (Q5) and Industry Pressure (Q11) with 0.78. This shows a relation between firms with higher technological competence and their need to prioritize flexibility and reliable data to navigate competitive environments. We can also observe negative correlations, such as between Data Quality (Q5) and Customer Satisfaction (Q13), correlation -0.86, which suggests that firms emphasizing data quality may not believe customer satisfaction alone guarantees success. Overall, Table 10 allows us to observe the correlation between different items in the model, however we cannot establish causality from this or draw any conclusions that are not further supported.

4.6.2 Interview Text Mining and Content Analysis

While the survey analysis provides a good initial description of the general favorability of the participants towards our model and constructs, word frequency and sentiment analysis were also conducted on the interview transcripts. This analysis has the goal of identifying themes spoken during the interviews, interpreting general sentiments and trends during the interviews and also understanding the emotional (sentiment) context around constructs in digital transformation. As discussed by Klaus Krippendorff (2019), text mining and sentiment analysis are tools that allow for an efficient and objective approach to identifying main topics and the emotional tones associated with them in written content.

Figure 5: Interviews Word Cloud

Figure 5 shows the word cloud generated from the interview transcripts with the nine participants, and it highlights the most frequently mentioned terms across all interview

responses about digital transformation. The word cloud was generated in R (see code in APPENDIX D - R AND PYTHON CODE), where each of the interview's transcript was processed to remove common stop words (e.g., "the," "and") and custom stop words (like participant names and irrelevant terms such as "firm," "company," etc.) - allowing for a clearer focus on the words directly relevant to the content of the interviews.

To explore the transcript's data further, a sentiment analysis was also performed on statements that are related to each of the proposed model's enabling factors. This analysis was done using the *syuzhet* package in R (used code is in APPENDIX- "R code for Text Mining and Sentiment Analysis") - where the sentiment of each construct was evaluated by extracting sentences containing keywords associated with each factor (e.g., "ICT" for ICT Literacy, "agility" for Agility and Adaptability). The extracted text was analyzed to assign an average sentiment score for each construct, where higher scores (above 0) indicate more positive sentiment, scores below 0 indicate negative sentiment and close to zero indicate neutrality.

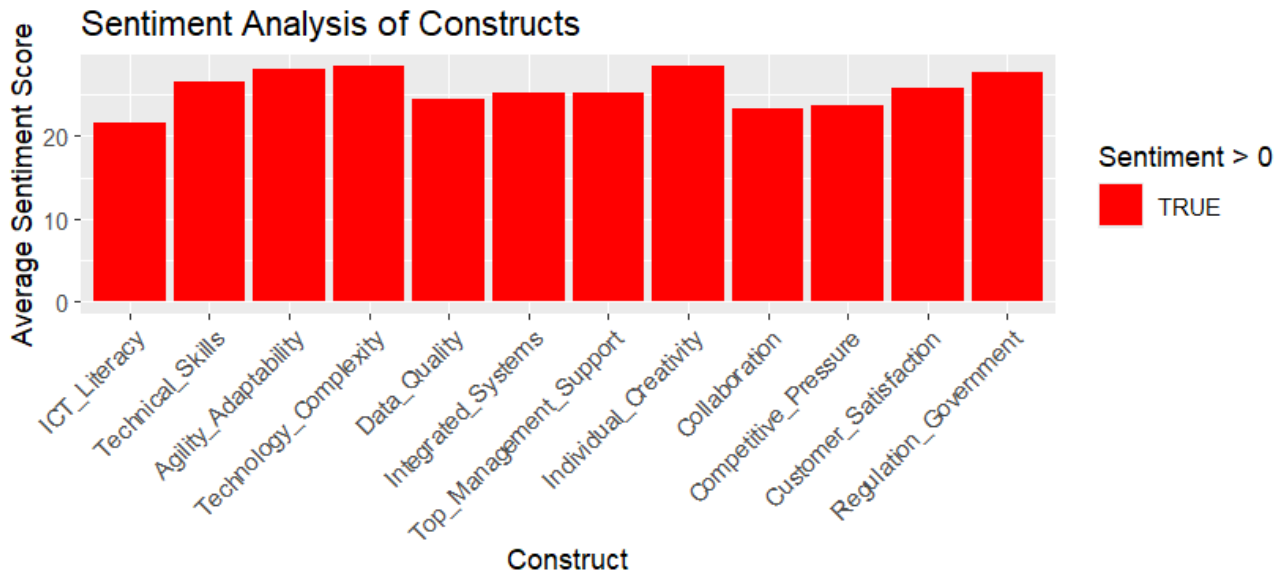

Figure 6: Sentiment Analysis of Constructs

Figure 6 shows the results of the sentiment analysis conducted on the interview transcripts in a bar chart, displaying the sentiment scores for the different constructs. Enabling factors such as Agility and Adaptability, Individual Creativity, and Integrated Systems have higher sentiment scores, suggesting the participants had a more optimistic view when discussing these topics; on the other hand, ICT Literacy, Competitive Pressure, and Data Quality display relatively lower sentiment scores, which are associated with a more neutral stance or less favorable perceptions of participants regarding these topics.

Curiously, the sentiment scores do not always align with the favorability results from the surveys. For example, "ICT Literacy" and "Data Quality" were rated highly in the survey (with 6.6 and 5 favorability), but their respective sentiment scores are low. Lastly, another aspect to take into account is the open-ended nature of interviews, which allows the participants to express nuanced views, including frustrations or limitations, that may subsequently affect sentiment scoring.

5. DISCUSSION

In this discussion, the study's key findings are contextualized and analyzed in depth. The discussion begins with an overview of the survey results, which highlights trends and patterns. This is followed by a detailed content analysis of the interviews conducted, to better understand the participants' perspectives and their emotional context regarding DT factors. Next, a contextualization of the qualitative and sentiment findings of the interviews is provided; as well as the managerial implications of the findings. Lastly, a critical assessment of the study's limitations and potential prospects for future research is given.

5.1 Overview of Survey Results

Through the results of the survey conducted (in APPENDIX B), patterns can be identified and used to determine the impact of drivers in the successful implementation of digital transformation (DT) initiatives.

Regarding the methodology employed to analyze the survey, the first step is to examine the mean values and distribution of the construct items (in Table 5), identifying the factors with the highest and lowest favorability to understand which are perceived as the most and least crucial for successful DT. The highest-rated factors point to the main enablers of value creation, while the lowest-rated ones may indicate areas that can be deprioritized or excluded from our model. The use of descriptive statistics serves to summarize the survey data in the form of mean and distribution patterns, as discussed by Ali & Bhaskar (2016). Respectively, the analysis of mean values allowed for the differentiation of key trends and priorities among survey participants, while the analysis of distribution patterns provided insights into the diversity of answers and perspectives on the factors that contribute to DT initiatives success.

"Data Quality", "Integrated Systems" and "Top Management Support" are the enabling factors, shown in Table 5, for which the interviewees showed the largest perceived favorability, with the average mean response above 6.5 and standard deviation being low, below 1. The first two factors/items mentioned tie to Proposition 1 of the proposed model (technology context), which serves to support the claim that "Systems Integration and data quality have a positive value when implementing DT Initiatives". As for Top Management Support, this enabling factor ties to Proposition 2 (Organizational Context), and supports the claim that "Top Management Support and Vision has a positive impact when implementing DT Initiatives". Additionally, the auxiliary question to the Top Management Support factor, Q8, shows low favorability by the interviewees, indicating that participants disagree with the statement "Transformation should start from the bottom".

Conversely, "Technology Complexity" and "Regulation and Government Intervention" are the driving factors with lowest favorability, the average mean being below 4 ("neutral point") and standard deviation being relatively high (1.2 to 1.4), indicating variation in responses. The first factor is tied to the Technology Context and the model's Proposition 1, and the low favorability by the participants in opposite to the claim "Technology Complexity has a positive value when

implementing DT Initiatives". The second is related to Environment context and Proposition 3 and is opposite to "Government Intervention has a positive value when implementing DT Initiatives". Considering the low favorability of both factors, they can potentially be excluded from our model.

All other enabling factors (construct items) in Table 5 show a positive favorability by the participants - above 4. However, we can categorize them further between those who have a mean average favorability below or above the total mean for Q1-Q14 (which is 5.0, as shown in Table 6), in order to create a scale that reflects the impact of factors in the successful implementation of DT initiatives – this is reflected by the four quadrants shown in Figure 3. Below the Mean are the items "Individual creativity", "Industry and competitive pressure" and "Customer satisfaction" while above it is "ICT Literacy, Technical Skills, "Agility" and "Adaptability" and "Collaboration".

As previously mentioned, for Q15 to Q22, the results in Table 7 reveal an average mean of 0.98 (1 represents agreement, "True") across all questions, showing a strong consensus for the interviewees that both operational improvements and financial metrics are crucial indicators of successful digital transformation.

In addition to the descriptive analysis, Table 8 and Table 9 and Table 10 show a comparative analysis to assess trends based on the participants' firm size (6) and the industry (7) in which their firms operate. This comparative analysis is relevant since the participant's firm size and industry will influence their perspectives and responses as demonstrated by Wu et al., (2024). Hence, by segmenting the results based on such variables, insights can be gained into how the organizational context affects the perceptions on digital transformation (DT) enablers. Results in Table 8 show that large firms have a higher total mean score than SMEs, with "Data Quality" and "Integrated Systems" having the highest favorability, suited for managing the complexity in such firms. In addition, we can see that SMEs, which have a lower total mean, focus more on Bottom-Up Initiatives and Individual Creativity for flexibility in comparison. As for Industry, results in Table 9 show that Industrials prioritize "Integrated Systems" and "Top Management Support" (linked to operational efficiency), while Consumer Staples emphasize "Agility" and "Customer Satisfaction" (market and customer demands). Despite these differences, the total mean scores for both groups are similar across both industry groups, at 5, suggesting a shared overall favorability toward the DT enablers in the model.

Thus, the survey results provide an important quantitative analysis of the participants' favorability toward the enabling factors proposed in the model, allowing us to validate it while assessing their preferences. However, to explore a deeper level of their perspectives and uncover suggestions and further opinions on digital transformation, a qualitative analysis of the interviews should also be conducted.

5.2 Content Analysis of Interviews

In addition to the survey results, a content analysis in R of the interviews was conducted (see in section 3.6.2), to provide a deeper understanding of the participants perspectives and their emotional context when discussing the DT factors proposed in the TOE model. As supported by Benchimol et al. (2022) and Klaus Krippendorff (2019), text mining techniques such as word cloud generation and sentiment analysis can be useful tools to explore the most frequently discussed topics in a text script and the emotional context that surrounds them. Thus, for this research a word cloud (in Figure 5) and sentiment analysis (Figure 6) were deployed to extract insights from the semi-structured interviews.

Firstly, using text mining, a word cloud was generated to highlight the key themes discussed across the different interviews. Figure 5 reveals that terms like “digital,” “processes,” “data,” “quality,” “team,” and “implementation” are the most prominent themes, suggesting that participants link digital transformation with data management, process optimization, and team collaboration. Additionally, the prominence of the words “team” and “people”, may indicate a strong focus on the human aspect of transformation, which emphasizes the need for collaboration and employee engagement when driving digital initiatives.

A sentiment analysis was also performed, to explore the emotional tones associated with each of the enabling factors in the model. The results of this analysis, shown in Figure 6, indicate that the constructs Agility and Adaptability, Individual Creativity, and Integrated Systems evoke the most positive sentiments from the participants, suggesting that interviewees might associate these with successful DT outcomes. On the other hand, ICT Literacy, Competitive Pressure, and Data Quality have lower sentiment scores, reflecting a more neutral or indifferent attitude towards the factors. However, overall, the results of the sentiment analysis show a positive result for all enabling factors, indicating a positive underlying tone of the participants when discussing the model constructs. This analysis can serve a complementary role to the survey findings by exposing the emotional tones of the participants, that are not discernible through quantitative measures alone.

While comparing the favorability results in the survey and the results from the sentiment analysis, it is interesting to note that there are discrepancies in the scores. As previously noted in section 3.6.2, ICT Literacy and Data Quality were highly rated in the survey (5 and 6.6 favorability score respectively) but received lower sentiment scores in comparison. Such a difference can be attributed to the different aspects that the sentiment analysis and survey are measuring, for example, results show interviewees have high favorability towards Data Quality but low sentiment scores, which indicates they might consider it challenging and difficult to guarantee high data quality in their firm, despite this being a critical enabler to DT - and thus, this “negative” attitude is denoted in sentiment analysis. This distinction between sentiment and relevance has also been noted by Klaus Krippendorff (2019) in his study, in which the author describes that emotional tones often reflect personal experiences and subjective attitudes rather than objective assessments of values. And this contrast is important, since it reflects an

area, Data quality, where firms might need to provide additional resources to address challenges and improve DT initiatives success.

Thus, using sentiment analysis as a complementary tool to quantitative methods provides for a more nuanced understanding of the participants perceptions – uncovering their underlying sentiments that the structured survey did not capture. And this is supported by Wankhade et al. (2022), that defends the use of sentiment analysis methods and a mixed-methods approach in research to paint a more holistic view of the data, balancing the objective importance of constructs with the emotional and subjective experiences of the participants.

5.3 Qualitative Insights from Semi-Structured Interviews and Literature Review

Semi-structured interviews were conducted with the participants to explore their views on the various digital transformation enablers that are proposed in the research model, and to gain a deeper understanding of the favorability and perceived importance of each of these factors. By examining the interviewees' standpoints on each construct item, this chapter contextualizes the quantitative and sentiment findings with the discussed perspectives and thoughts of interviewees, helping to identify specific drivers, challenges, and contextual nuances in DT implementation. Each item in the model will be reviewed with detailed reflections drawn from the participants' experiences, offering valuable qualitative support to the broader analysis of DT success factors.

Concerning the Technological context of the model, the first construct item considered is "ICT Literacy" (T/C 1). For this factor, the survey shows that participants have a positive favorability towards it, meaning they consider that ICT Literacy has a positive impact when implementing DT initiatives. According to Fliege et al., 2023, prioritizing ICT skill development can help firms leverage internal capabilities without having to use external investments. This is evidenced by Participant 1, who mentioned that *"We have had situations in the company when we found out that workers that are - for example maintenance or radar technicians - also have IT skills and know how to program– and that meant that for certain projects we can bring them in for help."*, highlighting the role ICT Literacy has in preparing employees to be active members in transformation initiatives. Additionally, research by Van Laar et al. (2017) contextualizes ICT in modern times as more than just technical skills, encompassing critical thinking, information management, and digital communication - which are skills that support continuous improvement and adaptability. This aligns with Participant 2's view that *"ICT Literacy plays a fundamental role in continuous improvement and digital transformation."*. Thus, both the insights from the interviews and research support that ICT Literacy equips employees to contribute positively to DT initiatives implementation and generate value for a firm.

Another Technological factor are technical skills (T/C 2), for which the participants showed very high favorability towards. Technical skills allow employees to implement and operate digital

systems, which are critical in DT initiatives implementation. This is supported by Mühlburger et al. (2019), who highlights the importance of these skills in

The third item is Agility and Adaptability (T/C 2), which also has a positive favorability in the survey, being placed in the 3rd quadrant. Participant 8 mentioned regarding Agility *"in our company we have a great philosophy in terms of continuous improvement, which is a form of strategy. When people have access to tools and the freedom to improve processes, that makes it easier for them to carry out their work, and they tend to be more board with change and transformation – so we don't have any obstacles in this regard."*, which refers to the importance of having an agile culture in a firm, so that people adapt to change and embrace it. This is supported by Fliege, who emphasizes in his paper the importance of agility in industrial firms, especially SMEs, since it enables fast responses to change within limited resources.

As for Technology complexity (T/C4), this is one of the constructs that the survey places in the fourth quadrant, due to the negative favorability shown by participants. Despite this, participant 2 mentioned that *"There are processes with a lot of "complexity" that can have a very smooth implementation due to a solid design and launch phase … they have to be approached in a different way, there has to be another level of involvement… with a longer implementation time, but the results have been quite positive"*, which explains why some participants might consider that more complexity can lead to positive DT initiatives implementation. However, most interviewees expressed the opposite opinion, such as Participant 5 *"- I would say of course complexity can impact and delay the implementation of measures."*. This is in line with Fliege, who argues that complexity can hinder resource-limited firms in adapting to digital change. Additionally, Angevine et al. (2021) emphasizes that decreasing complexity in processes and tasks enables more efficient transformations, particularly in industrial contexts. Thus, both literature and the results from interviews suggest that even though complexity can at times lead to positive results, its influence is generally seen as an obstacle in DT initiatives.

For the fifth construct item, Data Quality (T/C 5), interviewees showed strong positive favorability, and this factor is in the first quadrant. In interview 7, the participant referred that *"Data quality is the most critical point of information. So that's why we tried to culturally hit that key from the beginning"*, while Participant 2 also referred to that *"Data quality is key. Without reliable data, we speak on the basis of things that are not concrete. The quality of decisions will clearly be affected",* thus explaining how crucial data is for decision making and the functioning of firms. This is supported by Chris Angevine, who refers that "data related issues should be considered in strategic roadmaps" and also that data allows for strategic insights – underscoring the importance of data as an enabler of transformation.

The 6th factor is Integrated Systems (T/C 6), which also has strong positive favorability and is in the first quadrant. Regarding the importance of Integrated Systems when implementing DT initiatives and if their existence was favorable towards this, Participant 7 mentioned *"Yes Absolutely … if the infrastructure is lacking and the systems you have are not secure, or they are inefficient at managing data– that will impact the roll-out of a lot of projects".* Michael Hammer's paper on Business Process Reengineering (Michael Hammer, 1990) supports this by arguing

that integrated systems simplify the flow of information and reduce inefficiencies which are obstacles to successful transformation. Additionally, Chris Angevine also outlines the importance of connected systems in industrial firms, for a smooth flow of data, automation and streamlined operations.

As for the Organizational factors, one of the enablers proposed to the interviewees was Top Management Support (O/C 1). For this organizational enabler, all interviewees showed very high favorability overall and expressed that support from management is critical to successful transformation – whether it be in transformation initiatives started from the Top-Management teams (top down), or from initiatives coming from employees (bottom-up). This is supported by both Mühlburger et al. (2019) and Angevine et al. (2021), who explain that effective leadership empowers initiatives inside departments and for the whole firm, fostering an environment of transformation. And when discussing whether processes usually started from "bottom up" or "top down" in their firm, Participant 4 mentioned *"It's both. We have the strategic guidelines for our administration. One of the guidelines we have is to promote continuous improvement and promote Kaizen processes (…) We have other small and parallel processes that are triggered by the various departments. So, to sum it up, it's not always from above or below. I think it goes both ways."*. These comments reflect the low favorability shown by participants toward the auxiliary construct 1 (A/C 1), which proposed that DT initiatives should start from the bottom only (instead of "both ways".

The second organizational construct is Individual creativity (O/C 2), for which participants showed positive favorability but didn't seem to prioritize over other factors. Several of the interviewees expressed that collaboration and a "culture of innovation" and agility was more important over specific individual's creativity when implementing transformation in a firm - which is in line with (Fliege's et al. (2023) emphasis on creating an innovative organizational culture that supports team-driven problem-solving.

Thus, interviewees showed strong favorability towards Collaboration (O/C 3), placing it in the third quadrant. When discussing the implementation of digital projects, Participant 2 highlighted that *"There has to be teamwork, it's not a one-man job", while participant 9 referred that "(…) it's increasingly necessary to collaborate this way, through partnerships. We try to do it internally, for example, between the continuous improvement and engineering teams, who work very closely together. And also, with suppliers (…)"*. The participants overall defended that collaboration, both within the company with internal resources and with external parties, played an important role in the success of transformation – and this is also highlighted by Muehlburger's (2019) framework, which identifies collaboration as an important building block for digital transformation, particularly in empowering knowledge-sharing and fostering alignment across departments.

As for the Environmental context, the survey and interviews both pointed out that the participants saw Competition, or competitive pressure (E/C 1) as a positive enabler, in the third quadrant. Based on the responses of participants there were two different perspectives on the role of this enabling factor: some interviewees shared that digital transformation started from

within the firm and not from market pressures, while others considered that changes in the market and competition forced the transformation of the firm itself – sometimes in order to keep up, others to innovate. This difference in opinion is shown in Participant 1 comments *"I would say that our transformation processes are not really triggered by competition – but from our internal needs and also the "state" we want to be in the future.",* which differ from Participant 2 *"We have to be mindful of our place in the market, because when we stop being competitive, the business dies.* The positive favorability shown by participants towards competition as an enabling factor, despite their difference in opinions, is supported by (Nguyen et al., 2022) who expands in her research into Vietnamese firms that competitive pressure can drive firms to adopt digital innovations with the goal of staying relevant, which suggests that even when transformation is internally motivated, competition can accelerate these efforts.

The second Environmental factor discussed with the participants was Customer Satisfaction (E/C 2), which similarly to competition had slightly positive favorability with participants, and for which different opinions were discussed. Some participants considered that customer satisfaction is not a driver for implementing DT initiatives successfully since customers are only concerned about the end product and not with the processes of the firm - as mentioned by Participant 3 (firm is industrial) *"In our case the customers are usually not very demanding. As long as the client has the final information, he is satisfied – so our internal processes are not seen on their side.".* However, other participants viewed customer satisfaction as a trigger for the start of digital transformation, like Participant 4 (Consumer staples firm) *"…in addition to the competitors, transformation starts often due to the customers. Because customers have certain requirements that, if we want to work with them, we have to fulfill. And most of the time, I would say those are our main driver to pursue innovation and digitalization…".* As referred when discussing Table 5b (Comparative Analysis - Mean responses based on sector of industry), the participants whose firms belonged to the industrial sector seemed to favor this construct much less than the interviewees connected to the Consumer Staples Industry, perhaps due to the focus of this industry in customer needs and loyalty. And this is supported by (Masoud & Basahel, 2023) paper, that dives into the importance of consumer experience and satisfaction in Digital Transformation for sectors that are consumer-facing, since it gives firms a competitive advantage. However, since most firms in this study are industrial/manufacturing, there is less of an importance on this factor.

The final construct discussed is Regulation and Government Intervention, for which participants showed negative favorability. Broughel & Thierer, (2019) research discusses that while regulation may have the goal of standardizing and protecting firms in the market, it can also be an obstacle to technological innovation and flexibility - slowing their ability to digitally transform due to enforced compliance measures. When discussing this topic, most participants reflected that the Government either had no impact as a driver for transformation, or actually hurt the bottom line, as shared by participant 1 *"We had a software that gave us full openness in terms of maintenance control, quality control … everything integrated in just one system. But since the Portuguese state has mandated that we can only use another software (sponsored by public administration) to invoice and carry out stock management, we had to implement this additional*

system. We were forced to do a digital downgrade, … So, I do not feel regulation has a positive effect in driving digitalization." It is important to note that regulation differs greatly based on the industry firms operate, as well as the legislation these companies are subject to - which in this study, is Portuguese legislation and regulation mostly.

As for the constructs related to value generation and the different dimensions of DT implementation, all participants showed very strong agreement both in the interviews and survey, confirming the relevance of the proposed constructs in guiding effective DT implementation and measurement of value generation. And this is supported by the literature review present in Section 1.7 "Digital Transformation Initiatives and Value Creation", which highlights that measurements such as efficiency and productivity improvements, customer engagement and innovation/differentiation play an important role in quantifying the impact of DT initiatives- while revenue growth, cost savings, customer acquisition rates and operational efficiency improvements are good trackers for value generation in a firm.

These insights gained from the semi-structured interviews reflect the alignment between the participant's perspectives and the proposed TOE-based framework, highlighting the role of the construct items as drivers of value-generation from DT initiatives, as well as in enablers of the firm's goals. Thus, it is important that these insights are translated into actionable strategies for firms to apply and maximize their success in DT initiatives.

5.4 Managerial Implications

This thesis explores through literature review and a mixed methods scientific approach the enabling factors to digital transformation in manufacturing firms and, as such, the results from it can serve as a tool for managers and decision makers looking to implement DT initiatives successfully. Thus, based on the survey and interview's findings, organizations can use the discussed insights and key identified drivers to shape their strategy and focus their resources in areas that have the most potential for driving value-creation and impact.

One of the most important findings of this study is that certain enabling factors should be prioritized over others, if firms want to maximize their investments in digital initiatives. To this end, Data Quality (T/C 5) is highlighted as a crucial enabler, and firms should invest in data management practices and quality assurance frameworks to ensure that decision-making inside their organizations doesn't become unreliable, and DT initiatives fail. This factor was singled out during the interviewees and literature review as a fundamental enabler of decision-making and strategy in firms and thus, should be considered as a key driver and prioritized over others.

Another key enabling factor identified was Integrated Systems (T/C 6), and managers should allocate resources to integrate their systems (ERPs, CRMs, etc.) if they want to streamline operations (in factory and admin processes), improve data flows, and open the doors to process automation and efficiency gains. Organizations should also consider that while integrating systems, IT and the business departments ought to collaborate together to align requirements,

operational needs and the overarching strategy of the firm. Finally, Top Management support (O/C 1) also emerged as a pivotal factor in driving DT, with Management being responsible for championing a culture that promotes innovation and risk taking, while also managing the allocation of the necessary resources and direction of employees during the implementation of initiatives. The study also revealed that there should be a dual approach when it comes to the pipeline of DT initiatives, where some should come from the management and cascade down (top-down), while others should start from employees and then be supported by management (bottoms-up), if organizations want to have the full buy-in of employees and foster culture of innovation.

And while some factors were identified as critical, others such as Technology Complexity (T/C 4) and Government Intervention (E/C 3) were singled out for being perceived as barriers to the successful implementation of DT initiatives– and so, organizations should attempt to mitigate the impact of these obstacles. Regarding complex technological processes, firms can try to simplify their implementation by investing in user-friendly systems, training their employees or employing external consultants to guide large transformation efforts. As for regulation and government intervention, organizations can attempt to form partnerships with regulatory bodies to gain insights into government actions, they can advocate for regulatory developments in their favor, and also invest in technology that helps them navigate regulatory compliance more efficiently (like ERPs). However, overcoming these barriers can be difficult, especially for SMEs that do not have large resources for investing in such countermeasures.

In addition, organizations should also focus on promoting Agility and Adaptability (T/C 3) within their workforce and processes (continuous improvement culture), by establishing agile project-management methodologies, creating cross-department teams focused on innovation and process excellence, and maintaining flexible structures that can be reshaped and adapted to market demands. At the same time, this study highlights the importance of a human-centric approach to transformation, where firms should prioritize Collaboration (O/C 3) and employee engagement during DT initiatives by promoting teamwork, knowledge-sharing and cross-department collaboration. Furthermore, if resistance from employees exists during transformation efforts, firms should invest in change management programs (to address concerns of employees), provide training, and reward employees based on successful outcomes of transformation - since these actions can contribute to creating a more innovative and driven culture inside in teams, that prepares them to deal with DT.

Through the comparative analysis shown in Tables 8 and 9 and existing literature, this study also discusses that the perception of DT enablers varies based on both firm size and the industry sector where it operates. Thus, large firms might have to focus more on system integration and operational efficiency, while SMEs should promote flexibility and employee-driven DT initiatives; additionally, industrial firms should focus on process optimization and data quality while consumer-driven organizations should emphasize customer-centric digital solutions. By considering these factors and using tailor-made DT strategies, managers can ensure that their initiatives are more aligned with the needs of the firm.

At last, through the interviews and survey conducted in this research, participants showed a strong consensus on the importance of financial metrics and operational improvements as indicators of success when implementing DT initiatives – underscoring the importance of having mechanisms for tracking and displaying the impact of DT initiatives. To this effect, KPIs like cost savings, productivity improvements or customer satisfaction metrics should be put in place and regularly reviewed, to generate support and understanding for transformation efforts and their consequences.

5.5 Limitations and Future Research

This thesis, focused on digital transformation and the enabling factors that lead to the success of DT initiatives in industrial firms, draws valuable insights from both Literature Review and a set of interviews and surveys undertaken with industry experts and leaders. However, it is important to note that there are several limitations that should be acknowledged, and that shaped the content of this thesis.

Firstly, the sample of interviews is relatively small, with nine interviews being conducted. Thus, the perspectives of participants do not fully represent the diversity of experiences and perspectives related to DT initiatives in Industrial companies, and a larger and more varied sample could lead to different insights and strengthen the findings. Additionally, the North American Industry Classification system categorizes the Manufacturing sector in thirty different segments, ranging from food manufacturing, textiles, chemical manufacturing, metal manufacturing, computer & electronic parts, among others (Murphy, 1998); and the sample of interviewees is this research does not capture this diversity of segments. A larger and more varied sample of participants could potentially lead to different insights and strengthen the generalizability of the findings.

It is also important to note that this thesis focuses on Manufacturing and Industrial firms, and that future research could be done on other Industry sectors.

Moreover, the scope of research is also limited by the geography and location of the interview participants, who are mostly from Portugal-based firms. Since eight of the nine interviewees are currently located out of Portugal, this geographical focus means that findings are mostly applicable to the Portuguese context, where economic, regulatory and cultural factors can influence the views and implementation of DT when comparing to other regions. Thus, future studies could focus on different regions to see if different cultural and economic environments impact the perspective of participants on DT and enabling factors. Also, the scope of the study could be more diverse, with interviewees from different regions participating.

Another limitation relates to the qualitative nature of the interviews data. As discussed by Klaus Krippendorff (2019), while interviews allow for the explorations of nuanced insights into the views of participants, they are also subjective, and their interpretation can be influenced by the biases of the researchers. This research intended to mitigate the bias risk by integrating a survey

as a quantitative method, but future research could employ more robust methods to validate the findings. Additionally, the sentiment analysis that was conducted (in section 3.6.1) captures the emotional tones of the interviews, but these tones can also be misinterpreted since this method overlooks context or nuances in the language used. To mitigate this risk, section 4.3 delves into these nuances and perspectives of the participants; however future research could use more advanced natural language processing techniques to improve the accuracy of the sentiment analysis.

Finally, the study focuses solely on the TOE constructs that are proposed in the model, and then validated thorough a survey and interview data. The limited scope of the TOE model means that enabling factors outside of it are overlooked, and future research could explore the impact of other emerging technologies and trends like AI and blockchain as enabling factors to DT. For example, several of the participants mentioned that company culture was instrumental in driving DT initiatives and the engagement of employes inside of their firms (building "a culture conducive" to transformation); others referred to the role AI was starting to play and would have in their digital future. Both factors are not currently included in the proposed TOE model and could be explored in future research.

In summary, while this research provides important insights into DT enablers in Portuguese manufacturing firms, future research could change or expand the geographical scope, increase the participant sample size, improve the sentiment analysis methods deployed, or explore additional constructs that can improve the overall picture of DT implementation for both academia and industry.

6. CONCLUSION

With the Technology-Organization-Environment framework as a base, this thesis focuses on exploring the enabling factors that contribute to the successful implementation of Digital Transformation initiatives in Portuguese firms operating within the industrial/manufacturing sector. Thus, two fundamental research questions were posed as a starting point to guide this study; the first being “What are the main drivers to the successful implementation of digital transformation initiatives in firms that operate in the industrial sector?” and the second “How can we define success and value creation in digital transformation initiatives?”.

The chosen methodology to tackle these questions was DSRP and, through a revision of the Technology-Organization-Environment framework and the enabling factors extrapolated from it, a mixed-methods approach was employed to analyze how DT can be managed by firms to drive value-creation and positive organizational outcomes. In this mixed-methods approach, both a survey and semi-structured interviews were conducted with nine industry experts to discuss the proposed TOE model and the enabling factors to success in DT. The results from both interviews and survey suggest that certain enabling factors are more impactful in the success of DT than others, with “Data Quality”, "Integrated Systems," and "Top Management Support" being highlighted, underscoring the need for reliable data and well-integrated systems, and strong leadership to drive digital change in manufacturing firms. On the other hand, "Technology Complexity" and "Regulation and Government Intervention" were perceived less favorably by participants, indicating that these could pose as obstacles during transformation initiatives.

Additionally, the interviews explored important themes such as the role of agility in production processes, the impact of systems and data integration in managing dataflows and improving efficiency, and the cultural shifts required to foster continuous improvement and innovation in firms. A sentiment analysis was also conducted on the interview transcripts, unveiling mixed sentiments from participants when discussing some of the themes, such as ICT Literacy, Data Quality and Collaboration – and upon exploring these topics in more detail, it is evident this duality in sentiment is reflective of the importance these factors play as drivers of transformation, while also being “pain” points for firms in terms of the difficulty in guaranteeing them (eg: ensuring high quality data in a firm can be difficult, as well as increasing ICT literacy of employees). And this complexity associated with some DT initiatives also highlights the nuanced and multifaceted nature of Digital Transformation.

Despite these important contributions, there are also some limitations and future considerations that future research could explore on this topic. The focus on manufacturing firms of this thesis can limit the generalizability of the findings to other sectors, and the geographical and cultural scope (Portugal) can also condition the perception of the study’s participants toward the proposed model construct items. Thus, future research can be done focusing on different sectors of industry, or with a different cultural and geographical focus.

In conclusion, this thesis discusses the importance for manufacturing firms in having a strategic and focused approach when implementing digital transformation initiatives, while also highlighting the different degrees of impact that each of the enabling factors (model construct items) proposed in the TOE framework have in driving the successful implementation of DT initiatives. Ultimately, suggestions are made for organizations to prioritize investments in areas that maximize value-creation - such as data quality, system integration, and digital leadership – and other insights are also proposed to help firms in making informed decisions to improve their success when undergoing transformation efforts.

BIBLIOGRAPHICAL REFERENCES

Ali, Z., & Bhaskar, Sb. (2016). Basic statistical tools in research and data analysis. *Indian Journal of Anaesthesia*, *60*(9), 662. https://doi.org/10.4103/0019-5049.190623

Angevine, C., Keomany, J., Thomsen, J., & Zemmel, R. (2021). *Implementing a digital transformation at industrial companies*. Mckinsey & Company. https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/implementing-a-digital-transformation-at-industrial-companies

Baker, J. (2012). The Technology–Organization–Environment Framework. In Y. Dwivedi, M. Wade, & S. Schneberger (Eds.), *Information Systems Theory. Integrated Series in Information Systems* (Vol. 28, pp. 231–245). Springer, New York, NY. https://doi.org/10.1007/978-1-4419-6108-2_12

Benchimol, J., Kazinnik, S., & Saadon, Y. (2022). Text mining methodologies with R: An application to central bank texts. *Machine Learning with Applications*, *8*, 100286. https://doi.org/10.1016/J.MLWA.2022.100286

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. V. (2013). Digital Business Strategy: Toward a Next Generation of Insights. In *MIS Quarterly* (Vol. 37, Issue 2, pp. 471–482). https://papers.ssrn.com/abstract=2742300

Broughel, J., & Thierer, A. D. (2019). Technological Innovation and Economic Growth: A Brief Report on the Evidence. *SSRN Electronic Journal*. https://doi.org/10.2139/SSRN.3346495

Brynjolfsson, E., & McAfee, A. (2012). *Big Data: The Management Revolution*. Harvard Business Review. https://hbr.org/2012/10/big-data-the-management-revolution

Deloitte Development LLC. (2023). *Mapping Digital Transformation Value - The Metrics that Matter*. https://www.deloitte.com/content/dam/assets-shared/docs/collections/2024/mapping-digital-transformation-value-metrics-that-matter.pdf

Dwivedi, Y. K., Ismagilova, E., Hughes, D. L., Carlson, J., Filieri, R., Jacobson, J., Jain, V., Karjaluoto, H., Kefi, H., Krishen, A. S., Kumar, V., Rahman, M. M., Raman, R., Rauschnabel, P. A., Rowley, J., Salo, J., Tran, G. A., & Wang, Y. (2021). Setting the future of digital and social media marketing research: Perspectives and research propositions. *International Journal of Information Management*, *59*, 102168. https://doi.org/10.1016/j.ijinfomgt.2020.102168

Eisenhardt, K. M. (1989). Agency Theory: An Assessment and Review. *The Academy of Management Review*, *14*(1), 57. https://doi.org/10.2307/258191

Fliege, L., Fliege, K., Lehmann, C., Kanbach, D. K., & Kraus, S. (2023). A Taxonomy on Influencing Factors Towards Digital Transformation in SMEs. *Journal of Small Business Strategy*, *33*(1), 53–69. https://doi.org/10.53703/001C.66283

Furneaux, B., Mannina, S., & Rieser, L. (2022). Responding to Information System Obsolescence: Should We Upgrade or Replace? *Journal of Computer Information Systems*, *62*(2), 372–383. https://doi.org/10.1080/08874417.2020.1830006

Genesereth, M. (2010). Data Integration: The Relational Logic Approach. In *Data Integration* (1st ed.). Springer Cham. https://doi.org/10.1007/978-3-031-01550-2

Guha Majumder, M., Dutta Gupta, S., & Paul, J. (2022). Perceived usefulness of online customer reviews: A review mining approach using machine learning & exploratory data analysis. *Journal of Business Research*, *150*, 147–164. https://doi.org/10.1016/J.JBUSRES.2022.06.012

Haug, A., Graungaard Pedersen, S., & Stentoft Arlbj⃝rn, J. (2011). IT readiness in small and medium-sized enterprises. *Industrial Management & Data Systems*, *111*(4), 490–508. https://doi.org/10.1108/02635571111133515

Heavin, C., & Power, D. J. (2018). Challenges for digital transformation–towards a conceptual decision support guide for managers. *Journal of Decision Systems*, *27*, 38–45. https://doi.org/10.1080/12460125.2018.1468697

Hermann, M., Pentek, T., & Otto, B. (2016). Design Principles for Industrie 4.0 Scenarios. *2016 49th Hawaii International Conference on System Sciences (HICSS)*, *2016-March*, 3928–3937. https://doi.org/10.1109/HICSS.2016.488

Hermundsdottir, F., & Aspelund, A. (2021). Sustainability innovations and firm competitiveness: A review. *Journal of Cleaner Production*, *280*, 124715. https://doi.org/10.1016/J.JCLEPRO.2020.124715

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly: Management Information Systems*, *28*(1), 75–105. https://doi.org/10.2307/25148625

Jia, Q., Guo, Y., & Barnes, S. J. (2017). Enterprise 2.0 post-adoption: Extending the information system continuance model based on the technology-Organization-environment framework. *Computers in Human Behavior*, *67*, 95–105. https://doi.org/10.1016/J.CHB.2016.10.022

Jones, M. D., Hutcheson, S., & Camba, J. D. (2021). Past, present, and future barriers to digital transformation in manufacturing: A review. *Journal of Manufacturing Systems*, *60*, 936–948. https://doi.org/10.1016/J.JMSY.2021.03.006

Kaganer, E., Gregory, R. W., & Sarker, S. (2023). A Process for Managing Digital Transformation: An Organizational Inertia Perspective. *Journal of the Association for Information Systems*, *24*(4), 1005–1030. https://doi.org/10.17705/1jais.00819

Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management*, *63*, 102466. https://doi.org/10.1016/J.IJINFOMGT.2021.102466

Kretschmer, T., Leiponen, A., Schilling, M., & Vasudeva, G. (2022). Platform ecosystems as meta-organizations: Implications for platform strategies. *Strategic Management Journal*, *43*(3), 405–424. https://doi.org/10.1002/SMJ.3250

Krippendorff, K. (2019). Content Analysis: An Introduction to Its Methodology. In *SAGE Publications* (4th ed.). SAGE Publications, Inc. https://doi.org/10.4135/9781071878781

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business and Information Systems Engineering*, *6*(4), 239–242. https://doi.org/10.1007/S12599-014-0334-4/METRICS

Lindman, M., Pennanen, K., Rothenstein, J., Scozzi, B., & Vincze, Z. (2016). The value space: how firms facilitate value creation. *Business Process Management Journal*, *22*(4), 736–762. https://doi.org/10.1108/BPMJ-09-2015-0126/FULL/XML

Mahboub, H., Sadok, H., Chehri, A., & Saadane, R. (2023). Measuring the Digital Transformation: A Key Performance Indicators Literature Review. *Procedia Computer Science*, *225*, 4570–4579. https://doi.org/10.1016/j.procs.2023.10.455

Masoud, R., & Basahel, S. (2023). The Effects of Digital Transformation on Firm Performance: The Role of Customer Experience and IT Innovation. *Digital 2023, Vol. 3, Pages 109-126*, *3*(2), 109–126. https://doi.org/10.3390/DIGITAL3020008

Matt, C., Hess, T., & Benlian, A. (2015). Digital Transformation Strategies. *Business and Information Systems Engineering*, *57*(5), 339–343. https://doi.org/10.1007/s12599-015-0401-5

Matt, C., Hess, T., Benlian, A., & Wiesbock, F. (2016). Options for Formulating a Digital Transformation Strategy. *MIS Quarterly Executive*, *15*(2). https://aisel.aisnet.org/misqe/vol15/iss2/6

Matt, D. T., Pedrini, G., Bonfanti, A., & Orzes, G. (2023). Industrial digitalization. A systematic literature review and research agenda. *European Management Journal*, *41*(1), 47–78. https://doi.org/10.1016/J.EMJ.2022.01.001

Mayring, P. (2014). *Qualitative Content Analysis Theoretical Foundation, Basic Procedures and Software Solution*. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173

Michael Hammer. (1990). *Reengineering Work: Don't Automate, Obliterate*. Harvard Business Review. https://hbr.org/1990/07/reengineering-work-dont-automate-obliterate

Mühlburger, M., Rueckel, D., & Koch, S. (2019). *A framework of factors enabling digital transformation*. 1–10. https://web.archive.org/web/20210812031133id_/https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1133&context=amcis2019

Murphy, J. B. (1998). Introducing the North American Industry Classification System. *Monthly Labor Review*, *121*. https://heinonline.org/HOL/Page?handle=hein.journals/month121&id=711&div=&collection=

Nadkarni, S., Prügl, · Reinhard, Prügl, R., Nadkarni, S., & Prügl, R. (2021). Digital transformation: a review, synthesis and opportunities for future research. *Management Review Quarterly*, *71*, 233–341. https://doi.org/10.1007/s11301-020-00185-7

Nguyen, T. H., Le, X. C., & Vu, T. H. L. (2022). An Extended Technology-Organization-Environment (TOE) Framework for Online Retailing Utilization in Digital Transformation: Empirical Evidence from Vietnam. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 200. https://doi.org/10.3390/JOITMC8040200

OECD Publishing, P. (2019). *Measuring the Digital Transformation*. OECD. https://doi.org/10.1787/9789264311992-en

Oliveira, T., & Martins, M. F. (2011). Literature Review of Information Technology Adoption Models at Firm Level. *Electronic Journal of Information Systems Evaluation*, *14*(1), pp110-121-pp110-121. https://academic-publishing.org/index.php/ejise/article/view/389

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

Plekhanov, D., Franke, H., & Netland, T. H. (2023). Digital transformation: A review and research agenda. *European Management Journal*, *41*(6), 821–844. https://doi.org/10.1016/J.EMJ.2022.09.007

Rane, N. L., Achari, A., & Choudhary, S. P. (2023). Enhancing customer loyalty through quality of service: effective strategies to improve customer satisfaction, experience, relationship, and engagement. *International Research Journal of Modernization in Engineering Technology and Science*. https://doi.org/10.56726/IRJMETS38104

Reis, J., & Melão, N. (2023). Digital transformation: A meta-review and guidelines for future research. *Heliyon*, *9*(1), e12834. https://doi.org/10.1016/J.HELIYON.2023.E12834

Singh, K. (1997). The impact of technological complexity and interfirm cooperation on business survival. *Academy of Management Journal*, *40*(2), 339–367. https://doi.org/10.2307/256886

Standard & Poor's Financial Services LLC. (2018). *GICS ® Global Industry Classification Standard 2 S&P Global Market Intelligence | MSCI Global Industry Classification Standard 3*. www.spglobal.com/marketintelligence.

Teece, D. J. (2018). Business models and dynamic capabilities. *Long Range Planning*, *51*(1), 40–49. https://doi.org/10.1016/J.LRP.2017.06.007

Tornatzky, L., Fleischer, M., & Chakrabarti, A. (1990). processes of technological innovation. *The Journal of Technology Transfer*, *16*(1), 45–46. https://doi.org/10.1007/BF02371446

Uren, V., & Edwards, J. S. (2023). Technology readiness and the organizational journey towards AI adoption: An empirical study. *International Journal of Information Management*, *68*, 102588. https://doi.org/10.1016/J.IJINFOMGT.2022.102588

Van Laar, E., Van Deursen, A. J. A. M., Van Dijk, J. A. G. M., & De Haan, J. (2017). *The relation between 21st-century skills and digital skills: A systematic literature review*. https://doi.org/10.1016/j.chb.2017.03.010

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, *122*, 889–901. https://doi.org/10.1016/J.JBUSRES.2019.09.022

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144. https://doi.org/10.1016/J.JSIS.2019.01.003

Vogelsang, K., Liere-Netheler, K., Packmohr, S., & Hoppe, U. (2019). Barriers to Digital Transformation in Manufacturing: Development of a Research Agenda. *Hawaii International Conference on System Sciences 2019 (HICSS-52)*. https://aisel.aisnet.org/hicss-52/in/digital_transformation/3

Wankhade, M., Rao, A. C. S., & Kulkarni, C. (2022). A survey on sentiment analysis methods, applications, and challenges. *Artificial Intelligence Review*, *55*(7), 5731–5780. https://doi.org/10.1007/s10462-022-10144-1

Wilson, M. (2023). The Items Design. In *Constructing Measures: An Item Response Modeling Approach* (2nd ed., pp. 1–364). Routledge. https://doi.org/10.4324/9781003286929

Wu, C.-H., Chou, C.-W., Chien, C.-F., & Lin, Y.-S. (2024). Digital transformation in manufacturing industries: Effects of firm size, product innovation, and production type. *Technological Forecasting and Social Change*, *207*, 123624. https://doi.org/10.1016/j.techfore.2024.123624

Yin, W. (2023). Does digital transformation matter to green innovation: based on TOE framework and configuration perspective. *Environmental Science and Pollution Research*, *30*(44), 100046–100057. https://doi.org/10.1007/S11356-023-29438-0/METRICS

APPENDIX

APPENDIX A –INTERVIEW SCRIPT FOR SEMI-STRUCTURED INTERVIEWS

NOTE: Due to the large size of transcript of interviews (>35 pages), they have not been included in the Appendix. However, please refer to the author (Francisco Almeida) in case you wish to consult them

Interview Preparation	
Objective	Collect stakeholder perspectives on digital transformation, focusing on their views of successful transformation and the factors that enable a positive impact
Timeline	March -September 2024
Logistics	Video calls through teams/Zoom and In Person.
Language	Portuguese
Duration	Between 30 and 45 minutes
Scheduling	By email or Phone

Introduction:
Greetings, and request consent to record the audio of the interview.
Presentation of the study and the interview format.

Warm-Up questions:

1. Could you provide a brief overview of your role and responsibilities within your organization?
2. What is the size and industry of the company?
3. When thinking about digital transformation at [company], what types of activities have it been focused on? More administrative (moving processes to computers) or also in operations – as in production?
4. Do you consider investing in digitalization projects a necessity for your company or just a tool to implement improvements?

Main Interview Questions

Technological Context:

5. How does the knowledge and technological skillset (technological literacy) of employees influence the projects you mentioned? (T/C 1: Technological Knowledge and Skills (ICT Literacy))
6. How important are agility and adaptability in your company's approach to digital transformation? For example, in terms of adapting to changes (O/C 2: Agility and Adaptability)
7. Does the existing technological infrastructure, like servers or billing systems or ERP, play a role in facilitating the success of these initiatives? (T/C 3: Technological Infrastructure)
8. If we consider cases where the technology in question is complex (e.g., robots or sensors added to the production line), do you believe the implementation of digital transformation initiatives is more or less successful?
9. What is the effect of data quality on your company? And on your decision-making?

Organizational Context:

10. Who typically initiates transformation measures within the company? Are they employees or the leadership team (directors and managers)? (O/C 1: Top Management Support)
11. How important is the support and participation of Top Management for these projects to be implemented?

12. When implementing a digitalization project, is there a team within the company responsible for carrying out Digital Transformation initiatives, or is a temporary team created as needed (functional)?
13. In what ways does individual creativity contribute to the success of digital transformation initiatives within your organization? - Are projects often initiated by an individual employee who has an idea or need? (O/C 3: Individual Creativity)
14. Do you believe collaboration is necessary to implement transformation within the company? Whether it is by bringing in an external team or facilitating collaboration within the company? (O/C 4: Collaboration - Internal and External)

Environmental Context:

15. Do you feel that competition and rivalry within the industry drive certain measures to be taken? For example, if a competitor implements a new process or buys new machinery?
16. Have you implemented projects where the main objective was to satisfy or improve customer satisfaction? And was the response positive?
17. Are there any regulations that require the company to adopt certain IT systems? For instance, in quality control?

Successful Implementation (Digital Transformation Initiatives):

In my study, I am considering that for a digital transformation measure to be successful, it must create value for the company. I define value as an increase in revenue, cost reduction, customer retention or acquisition, and also operational improvements (such as investing in a new space to increase production capacity).

18. Do you agree with this, or in your perspective, is there any other component that should be considered as value creation?

APPENDIX B –ONLINE SURVEY – DIGITAL TRANSFORMATION INITIATIVES AND CONSTRUCT VALIDATION(QUALTRICS)

Control Variables:

What is your firm's size?

○ Small Firm (< 50 employees)	○ Medium-Sized Firm (50 to 250 employees)	○ Large Firm (> 250 employees)

In which Industry does your firm operate?

- ○ Energy
- ○ Materials (Respirce extractions)
- ○ Industrials (Manufacturing)
- ○ Financials
- ○ Healthcare
- ○ IT
- ○ Consumer discretionary (non-essential goods)
- ○ Consumer Staples (household goods – food and beverages)
- ○ Communication
- ○ Utilities
- ○ Real Estate

In which "Digital maturity State" is your firm?

○ 1	○ 2	○ 3	○ 4	○ 5
Minimal	Informal & reactive	Transitional	Customer-driven	Transformed

Ratings:

Q1 The technical skills of staff (either industry knowledge, experience, etc.) are positive in the implementation of Digital Transformation initiatives

○ 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q2 ICT Literacy (Individual's capability of using digital technology) has a positive value when implementing DT Initiatives

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q3 Agility and the ability to adapt to changes in business needs are positive when implementing Digital Transformation initiatives

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q4 Technology complexity is positive during implementation of initiatives (the more complex the transformation effort, more successful the initiative outcome will be)1 (Completely Disagree)

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q5 Good quality data is necessary when implementing DT initiatives

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q6 An integrated systems landscape (or applications) is positive when implementing DT initiatives

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q7 Top Management support is necessary to successfully implement Digital Transformation Initiatives

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**
Completely Agree						Completely Agree

Q8 Transformation should start from the bottom (Technical and Admin employees in a company that are "first line")

O 1	**O 2**	**O 3**	**O 4**	**O 5**	**O 6**	**O 7**

Completely Agree — Completely Agree

Q9 Individual collaborator creativity drives DT initiatives (as opposed to "group creativity")

1	2	3	4	5	6	7
Completely Agree						Completely Agree

Q10 Collaboration (internal and external) is the cornerstone to the successful development of DT initiatives

1	2	3	4	5	6	7
Completely Agree						Completely Agree

Q11 Competitive pressures and Industry Standards force the Organization to change and implement DT initiatives

1	2	3	4	5	6	7
Completely Agree						Completely Agree

Q12 Customer satisfaction is sufficient to guarantee the successful implementation of a Digital Transformation Initiative

1	2	3	4	5	6	7
Completely Agree						Completely Agree

Q13 Customer satisfaction is positive when implementing Digital Transformation initiatives

1	2	3	4	5	6	7
Completely Agree						Completely Agree

Q14 Regulation and Government requirements have a positive impact in "Digital" state of the company)

1	2	3	4	5	6	7
Completely Agree						Completely Agree

Q15 A Digital Transformation (DT) Initiative that has an outcome of increasing efficiency and productivity of a process or task, is considered successful (All other things constant)

True **False**

Q16 A Digital Transformation (DT) Initiative with the outcome of fostering innovation or promoting a firm's differentiation against its competitors, is considered successful (All other things constant)

True **False**

Q17 A Digital Transformation (DT) Initiative with the outcome of expanding market share, is considered successful (All other things constant)

True **False**

Within the context of Digital Transformation, do you consider the following measurements define Value generation in a firm?

	True	False
Q18 Revenue Growth	○	○
Q19 Cost Savings	○	○
Q20 Customer Retention and Acquisition rates	○	○
Q21 Operational Efficiency Improvements	○	○
Q22 All of the above	○	○

APPENDIX C –ONLINE SURVEY DIGITAL MATURITY ASSESSMENT SURVEY (OPTIONAL)

Start of Block: Block 1

Q3 **Digital Maturity Assessment Tool**

Dear Participant - Welcome to my Digital Maturity Assessment tool. My name is Francisco Almeida and I am developing my dissertation for my Masters Degree in Information Systems Management at Nova Information Management School.

This is a tool to better understand the digital state of your firm, identify what you are doing well and what are the improvements that can be made.

The tool has five pillars of digital maturity (Governance and leadership, People and Culture, Capacity and capability, Innovation and Technology) - and divides each pillar into **5 levels of maturity - Minimal to transformed**

End of Block: Block 1

Start of Block: Default Question Block

Control Variables What is your firm's size?

- ○ Small Firm (< 50 employees) (1)
- ○ Medium-Sized Firm (50 to 250 employees) (2)
- ○ Large Firm (> 250 employees) (3)

Control Variables In which Industry does your firm operate?

▼ Energy (1) ... Real Estate (11)

---

1 **Governance and Leadership** (The executive support, reporting and detailling of roles and responsibilities) Please rate the following statements from 1 to 5 (Completely Untrue to Completely True)

Q1 **Governance and Leadership** (The executive support, reporting and detailling of roles and responsabilities) Please rate the following statements from 1 to 5 (Completely Untrue to Completely True)	1 (Completely Untrue) (1)	2 (2)	3 (3)	4 (4)	5 (Completely True) (5)
Organization has a Digital strategy that is aligned with business goals (1)	○	○	○	○	○
Top-Management fully embraces digital channels and digital transformation - and leads by example (2)	○	○	○	○	○
There is an active effort to reengineer all non-digital products and processes to digital (when possible) (3)	○	○	○	○	○
Organizational reporting is done though digital channels (eg: Organizational structure changes, financial reporting or quality reporting) (4)	○	○	○	○	○
Collected data is systematically analysed and reported for decision-making (5)	○	○	○	○	○

Q2 **People and Culture** (Orgs culture, including customer focus or attention to change) Please rate the following statements from 1 to 5 (Completely Untrue to Completely True)

	1 (Completely Untrue) (1)	2 (2)	3 (3)	4 (4)	5 (Completely True) (5)
All staff are digitally savvy and aware (1)	○	○	○	○	○
Feedback from customers and staff is encouraged, made public, and lessons learned are applied (2)	○	○	○	○	○
Firm performs staff skill assessment to identify the skills gaps (digital) (3)	○	○	○	○	○
Staff proactively explore ways to improve digital infrastructure and internal productivity via digital solutions (4)	○	○	○	○	○

Q3 **Capacity and Capability** (Resources, trainning plan, supporting policies and procedures)
Please rate the following statements from 1 to 5 (Completely Untrue to Completely True)

	1 (Completely Untrue) (1)	2 (2)	3 (3)	4 (4)	5 (Completely True) (5)
Policies and procedures are constantly reviewed and optimised (1)	○	○	○	○	○
Staff have the resources to anticipate and respond to new technologies and digital innovation (2)	○	○	○	○	○
There is a trainning plan in place to upskill employees (3)	○	○	○	○	○
Resources and budgets are appropriate for supporting the digital channels and transformation activities (4)	○	○	○	○	○

Q4 **Innovation**

Please rate the following statements from 1 to 5 (Completely Untrue to Completely True)

	1 (Completely Untrue) (1)	2 (2)	3 (3)	4 (4)	5 (Completely True) (5)
Experimentation is encouraged across the entire firm (1)	○	○	○	○	○
Innovation is rewarded (2)	○	○	○	○	○
There is a focus on developing new products and processes (3)	○	○	○	○	○

Q11 **Tecnology**

Please rate the following statements from 1 to 5 (Completely Untrue to Completely True)

	1 (Completely Untrue) (1)	2 (2)	3 (3)	4 (4)	5 (Completely True) (5)
Business processes and IT systems are driven by the customers' needs and digital channels (1)	○	○	○	○	○
IT infrastructures are ready to support digitalisation plans (Servers, Operating systems,etc) (2)	○	○	○	○	○
Data is properly integrated (e.g. through interoperable systems, application programming interfaces) even when it is distributed amongst different system (3)	○	○	○	○	○
A business continuity plan is in place in case of catastrophic failures (e.g. all data locked by a ransomware attack or physical damage to the IT infrastructure) (4)	○	○	○	○	○
Staff is regularly informed and trained on cybersecurity and data protection issues/risks (5)	○	○	○	○	○

APPENDIX D - R AND PYTHON CODE

R CODE – DESCRIPTIVE ANALYTICS

```
# Load necessary libraries

library(dplyr)

library(ggplot2)

library(corrplot)

library(tidyr)

# Load the dataset (update the file path with the correct location of your CSV file)

survey_data <- read.csv("C:/Users/franc/Downloads/Data Survey.csv")

# Group Small and Medium firms together

survey_data$Var_Firm_Size <- ifelse(survey_data$Var_Firm_Size %in% c("Small Firm (< 50 employees)", "Medium-Sized Firm (50 to 250 employees)"),

                                    "Small & Medium Firms",

                                    survey_data$Var_Firm_Size)

# 1. Comparative Statistics for Firm Size, Industry, and Maturity State (Q1 to Q14)

# Create a function to calculate the mean and total mean for Q1-Q14

calc_means <- function(df, group_var) {

  df %>%

    group_by({{ group_var }}) %>%

    summarise(across(Q1:Q14, mean, na.rm = TRUE)) %>%

    mutate(Total_Mean = rowMeans(across(Q1:Q14), na.rm = TRUE)) # Add Total Mean

}

# Comparative analysis for firm size

firm_size_summary <- calc_means(survey_data, Var_Firm_Size)

print(firm_size_summary)

# Comparative analysis for industry

industry_summary <- calc_means(survey_data, Var_Industry)

print(industry_summary)

# Comparative analysis for digital maturity state

maturity_summary <- calc_means(survey_data, Var_Digital_Maturity_state)

print(maturity_summary)

# 2. Visualization: Graphs for Q1-Q14 Means

# Firm Size Comparison Plot

ggplot(firm_size_summary, aes(x = Var_Firm_Size, y = Total_Mean)) +

  geom_bar(stat = "identity", fill = "skyblue") +

  labs(title = "Total Mean (Q1-Q14) by Firm Size", x = "Firm Size", y = "Total Mean") +

  theme_minimal()

# Industry Comparison Plot

ggplot(industry_summary, aes(x = Var_Industry, y = Total_Mean)) +
```

```
  geom_bar(stat = "identity", fill = "lightgreen") +
  labs(title = "Total Mean (Q1-Q14) by Industry", x = "Industry", y = "Total Mean") +
  theme_minimal()
# Maturity State Comparison Plot
ggplot(maturity_summary, aes(x = Var_Digital_Maturity_state, y = Total_Mean)) +
  geom_bar(stat = "identity", fill = "coral") +
  labs(title = "Total Mean (Q1-Q14) by Digital Maturity State", x = "Digital Maturity State", y = "Total Mean") +
  theme_minimal()
# 3. Line plot comparing means of each question (Q1-Q14) across Firm Size
firm_size_long <- survey_data %>%
  group_by(Var_Firm_Size) %>%
  summarise(across(Q1:Q14, mean, na.rm = TRUE)) %>%
  pivot_longer(cols = Q1:Q14, names_to = "Question", values_to = "Mean")
ggplot(firm_size_long, aes(x = Question, y = Mean, group = Var_Firm_Size, color = Var_Firm_Size)) +
  geom_line() +
  geom_point() +
  labs(title = "Mean of Q1-Q14 by Firm Size", x = "Question", y = "Mean") +
  theme_minimal()
# 4. Scatter plot comparing Q1-Q14 across Industry
industry_long <- survey_data %>%
  group_by(Var_Industry) %>%
  summarise(across(Q1:Q14, mean, na.rm = TRUE)) %>%
  pivot_longer(cols = Q1:Q14, names_to = "Question", values_to = "Mean")

ggplot(industry_long, aes(x = Question, y = Mean, group = Var_Industry, color = Var_Industry)) +
  geom_point() +
  labs(title = "Mean of Q1-Q14 by Industry", x = "Question", y = "Mean") +
  theme_minimal()
# 5. Regression Analysis
# Regression model for Q15-Q17 based on Q1-Q14
regression_model_q15_q17 <- lm(Q15 ~ Q1 + Q2 + Q3 + Q4 + Q5 + Q6 + Q7 + Q8 + Q9 + Q10 + Q11 + Q12 + Q13 + Q14, data = survey_data)
summary(regression_model_q15_q17)
# Regression model for Q18-Q22 based on Q15-Q17
regression_model_q18_q22 <- lm(Q18 ~ Q15 + Q16 + Q17, data = survey_data)
summary(regression_model_q18_q22)
####### Calculate the correlation matrix for Q1 to Q14
# Select the relevant questions (Q1 to Q14)
questions <- survey_data[, c("Q1", "Q2", "Q3", "Q4", "Q5", "Q6", "Q7", "Q8", "Q9", "Q10", "Q11", "Q12", "Q13", "Q14")]
# 1. Calculate the correlation matrix
```

```
correlation_matrix <- cor(questions, use = "complete.obs")

# 2. Print the correlation matrix

print(correlation_matrix)

# 3. Visualize the correlation matrix using a heatmap

corrplot(correlation_matrix, method = "circle", type = "full",

        tl.col = "black", tl.srt = 45, addCoef.col = "black",

        col=colorRampPalette(c("red", "white", "blue"))(200),

        title = "Correlation Matrix for Q1 to Q14")

# 6. Save tables as CSV if needed

write.csv(firm_size_summary, "firm_size_summary.csv")

write.csv(industry_summary, "industry_summary.csv")

write.csv(maturity_summary, "maturity_summary.csv")
```

R CODE FOR TEXT MINING AND SENTIMENT ANALYSIS

```
# Install and load necessary libraries

install.packages(c("tm", "tidytext", "dplyr", "wordcloud", "RColorBrewer", "syuzhet", "ggplot2", "stringr"))

library(tm)

library(tidytext)

library(dplyr)

library(wordcloud)

library(RColorBrewer)

library(syuzhet)

library(ggplot2)

library(stringr)

# Set the path to your interviews folder

path <- "C:/Users/franc/Downloads/Interviews"

# Load all text files from the directory

files <- list.files(path = path, pattern = "*.txt", full.names = TRUE)

#  text from all interview files into a single data frame

interviews <- lapply(files, function(file) {

  text <- readLines(file, warn = FALSE)

  text <- iconv(text, to = "UTF-8", sub = "")  # Convert to UTF-8 and clean text

  paste(text, collapse = " ")  # Combine lines into a single string

})

interviews_df <- data.frame(text = unlist(interviews), stringsAsFactors = FALSE)

#  construct-related keywords for sentiment analysis

construct_keywords <- list(
```

```
  ICT_Literacy = c("ICT", "digital skills", "technical literacy", "computer literacy", "IT knowledge"),
  Technical_Skills = c("Technical Skills", "technical competence", "expertise", "proficiency", "know-how"),
  Agility_Adaptability = c("agility", "adaptability", "flexibility", "quick response", "adjustment", "nimble", "resilience"),
  Technology_Complexity = c("Technology Complexity", "technical challenges", "system complexity", "sophistication","Complex Technology","Complex"),
  Data_Quality = c("Data Quality", "accuracy", "reliability", "data integrity", "data accuracy", "data standards"),
  Integrated_Systems = c("systems", "integration", "interoperability", "connected systems", "data flow", "infrastructure"),
  Top_Management_Support = c("Top Management Support", "leadership support", "executive backing", "management involvement", "strategic direction", "senior management", "administration", "executives", "management", "leadership", "adminstrators"),
  Individual_Creativity = c("Individual Creativity", "innovation", "idea generation", "problem-solving", "personal initiative", "creative thinking"),
  Collaboration = c("Collaboration", "teamwork", "partnership", "cross-functional", "cooperation", "joint effort"),
  Competitive_Pressure = c("competitive pressure", "competition", "market competition", "industry rivalry", "competitors", "market forces", "competitive landscape"),
  Customer_Satisfaction = c("Customer Satisfaction", "customers", "client satisfaction", "customer experience", "user feedback", "customer service", "client loyalty"),
  Regulation_Government = c("Regulation", "Government", "compliance", "legal requirements", "policy", "legislation", "government mandates", "standards")
)
#
construct_sentiments <- data.frame(Construct = character(), Sentiment = numeric(), stringsAsFactors = FALSE)
# sentiment analysis for each construct
for (construct in names(construct_keywords)) {
  keywords <- construct_keywords[[construct]]
    # Filter text containing construct-specific keywords
  construct_text <- interviews_df %>%
    filter(str_detect(text, paste(keywords, collapse = "|"))) %>%
    pull(text)
    #  sentiment score for the filtered text
  construct_sentiment <- get_sentiment(construct_text, method = "syuzhet")
  # average sentiment score
  avg_sentiment <- mean(construct_sentiment, na.rm = TRUE)
  construct_sentiments <- rbind(construct_sentiments, data.frame(Construct = construct, Sentiment = avg_sentiment))
}
# Order  constructs
construct_order <- c(
  "ICT_Literacy", "Technical_Skills", "Agility_Adaptability",
  "Technology_Complexity", "Data_Quality", "Integrated_Systems",
  "Top_Management_Support", "Individual_Creativity", "Collaboration",
  "Competitive_Pressure", "Customer_Satisfaction", "Regulation_Government"
)
construct_sentiments <- construct_sentiments %>%
  mutate(Construct = factor(Construct, levels = construct_order)) %>%
  arrange(Construct)
```

```
print(construct_sentiments)

# Plot  sentiment scores

ggplot(construct_sentiments, aes(x = Construct, y = Sentiment, fill = Sentiment > 0)) +

 geom_bar(stat = "identity") +

 scale_fill_manual(values = c("red", "green")) +

 labs(title = "Sentiment Analysis of Constructs", x = "Construct", y = "Average Sentiment Score") +

 theme(axis.text.x = element_text(angle = 45, hjust = 1))
```

PYTHON CODE FOR QUADRANTS PLOT

```
import matplotlib.pyplot as plt

# Data for favorability scores, reordered to match the table order

factors = [

   "T/C 1", "T/C 2", "T/C 3", "T/C 4", "T/C 5", "T/C 6", "O/C 1", "O/C 2", "O/C 3",

   "E/C 1", "E/C 2", "A/C 1", "A/C 2", "E/C 3"

]

scores = [5, 6, 5, 4, 7, 6.8, 6.5, 5, 5.5, 4.8, 4.7, 4.2, 4.9, 3.5]

# Create the figure and axis with adjusted size

plt.figure(figsize=(12, 8))

# Color zones for the updated favorability score ranges with quadrant labels in legend

plt.axhspan(6, 7, color='#FFDDC1', label='Quadrant 1: High Favorability (>6)')        # High favorability (Quadrant 1)

plt.axhspan(5, 6, color='#FFECB3', label='Quadrant 2: Moderate-High Favorability (5-6)')  # Moderate-high favorability (Quadrant 2)

plt.axhspan(4, 5, color='#D0F0C0', label='Quadrant 3: Moderate Favorability (4-5)')      # Moderate favorability (Quadrant 3)

plt.axhspan(1, 4, color='#CCE5FF', label='Quadrant 4: Low Favorability (<4)')           # Low favorability (Quadrant 4)

# Scatter plot for each factor with custom styling

plt.scatter(factors, scores, color='black', s=100, zorder=3)



# Adding labels on top of each dot with customized font size and positioning

for i, (factor, score) in enumerate(zip(factors, scores)):

   plt.text(i, score + 0.1, factor, ha='center', va='bottom', fontsize=10, color='black')

# Labels and title with adjusted font sizes

plt.xlabel("Model Items (Enabling Factors)", fontsize=12)

plt.ylabel("Favorability Scores", fontsize=12)

plt.title("Item Models and Favorability Distribution", fontsize=14, weight='bold')

# Legend and threshold lines with customized styling

plt.legend(title="Score Range", loc="upper left", bbox_to_anchor=(1.05, 1), fontsize=10)

plt.axhline(y=4, color='grey', linestyle='--', linewidth=0.8, label='Neutral')

plt.axhline(y=5, color='grey', linestyle='--', linewidth=0.8)

plt.axhline(y=6, color='grey', linestyle='--', linewidth=0.8)

# Customize tick parameters and grid for cleaner look
```

```
plt.xticks(rotation=90, fontsize=10)

plt.yticks(fontsize=10)

plt.grid(True, linestyle=':', color='grey', linewidth=0.5)

# Adjust layout for spacing

plt.tight_layout()

# Show the plot

plt.show()
```

APPENDIX E- RESEARCH ETHICS FORM

This is to certify that
Project No.: **OTHER2024-10-117413**
Project Title: **Value of Digital Transformation Initiatives in Manufacturing**
Principal Researcher: **Francisco Almeida**

according to the regulations of the Ethics Committee of NOVA IMS and MagIC Research Center this project was considered to meet the requirements of the NOVA IMS Internal Review Board, being considered **APPROVED** on 10/11/2024.

It is the Principal Researcher's responsibility to ensure that all researchers and stakeholders associated with this project are aware of the conditions of approval and which documents have been approved.

The Principal Researcher is required to notify the Ethics Committee, via amendment or progress report, of
- Any significant change to the project and the reason for that change;
- Any unforeseen events or unexpected developments that merit notification;
- The inability of the Principal Researcher to continue in that role or any other change in research personnel involved in the project.

Lisbon, 10/11/2024

NOVA IMS Ethics Committee
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