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CHALLENGES IN THE DIGITALISATION OF MANUFACTURING SMES: PERSPECTIVES AND SOLUTIONS

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ABSTRACT

The purpose of this study is to identify and analyze the main challenges faced by small and medium-sized manufacturing enterprises (SMEs) in their digitalization processes, and to propose strategic solutions based on specialized literature. Despite the widely recognized benefits of digitization, SMEs in the manufacturing sector lag significantly behind in their adoption. The lack of knowledge, resources and technical skills limits their ability to innovate and adapt to the current digital environment. This situation compromises their competitiveness and long-term sustainability. The research was developed under a qualitative approach, with a descriptive scope, and used documentary review as the methodological design. A bibliographic corpus of approximately 80 studies extracted from recognized academic sources was constructed, applying rigorous inclusion and exclusion criteria. The analysis was structured in three phases: retrieval of documents, analysis of barriers and discussion of solutions. The study offers a comprehensive look at the factors hindering the digitization of manufacturing SMEs and proposes viable and contextualized solutions. This research contributes to the field of digital transformation by systematizing barriers and strategies, and is a useful resource for entrepreneurs, policymakers and academics. Three major challenges were identified: the low perception of the benefits of digitalization, financial and technological barriers, and the cognitive gap in technical skills. These obstacles limit the use of emerging technologies and hinder the competitiveness of the sector. In addition, it became evident that the success of digitalization initiatives depends on strategic alignment, organizational cultural transformation and internal capacity building. It is suggested to implement awareness programs, facilitate access to financing through subsidies or partnerships with technology providers, and promote continuous training in digital skills. Public policies should focus on generating enabling environments and fostering multisectoral partnerships. It is necessary to move towards empirical studies that evaluate the effectiveness of the proposed solutions in specific contexts, as well as to explore the relationship between digitization, sustainability and organizational resilience in manufacturing SMEs. The

effective digitalization of manufacturing SMEs has a direct impact on national competitiveness, employment and economic recovery. By strengthening their innovation capacity, these companies can become key drivers of regional economic development. It is necessary to deepen the design of collaborative training models between universities, business and government to reduce the cognitive gap, as well as to explore technological tools adapted to the particularities of SMEs in the manufacturing sector in emerging countries.

KEYWORDS: Manufacturing SMEs, Digitalization, Technological Barriers, Innovation, Digital Transformation.

1. INTRODUCTION

Digitalisation is an important aspect of the contemporary business context, offering opportunities and benefits for organisations in all industries. However, despite the rapid adoption of this digital transformation by large corporations, small and medium-sized enterprises (SMEs), especially those in the manufacturing sector, are often constrained from fully integrating digitalisation into their operations. By analysing different specialised bibliographic sources, factors that hinder digitalisation in SMEs are identified. Among the most prominent challenges is the lack of knowledge about the benefits and opportunities that digitalisation can provide. According to Masood and Sonntag (2020), many manufacturing SMEs have yet to fully understand the transformative potential of digitalisation in terms of operational efficiency, access to new markets, and improved competitiveness.

Additionally, economic barriers represent a significant obstacle to digitalisation in manufacturing SMEs. The costs associated with implementing digital technologies, coupled with limited budget availability for such investments, are challenges these organisations may face (Raj et al., 2020). The lack of clarity regarding the return on investment of digitalisation also contributes to the reluctance of SMEs to make substantial investments in this area. On the other hand, technological barriers also limit digitalisation in these companies. The lack of adequate technological infrastructure and the shortage of technical knowledge to implement digital solutions are common obstacles faced by manufacturing SMEs (Brunswicker and Vanhaverbeke, 2015; Masood and Sonntag, 2020). Specifically, the insufficiency of university education in digital skills relevant to the current labour market further exacerbates this situation.

From this perspective, and considering the insights of Priyono et al., (2020), it is necessary to address these issues and find solutions that allow SMEs to fully leverage the benefits of digitalisation. Therefore, this study aims to analyse each of these barriers, exploring the underlying causes, their implications, and possible strategies to overcome them. Through a qualitative approach with a descriptive scope and utilising a specialised literature review design, the primary objective is to elucidate the factors that limit digitalisation in manufacturing SMEs and, consequently, propose viable solutions to overcome the inherent challenges of the digitalisation process.

2. LITERATURE REVIEW

Digitalisation has emerged as a fundamental aspect of the current business landscape, offering organisations various benefits and advantages. As noted by Björkdahl (2020), digitalisation has become a necessity for companies, especially for manufacturing SMEs, that seek to improve their competitiveness and operational efficiency. In this context, Matarazzo et al., (2021) highlight that manufacturing SMEs are being driven to adopt digital processes as a means to adapt to an increasingly competitive and dynamic business environment. Digitalisation in these organisations entails a series of significant benefits, including process optimisation, task automation, enhanced operational efficiency, real-time access to information, facilitation of decision-making, development of new products and services, market expansion, and improvement in customer experience. Therefore, this preliminary literature review focuses on exploring the benefits and importance of digitalisation in manufacturing SMEs. However, the specialised literature review in the study's results aims to identify the factors that limit digitalisation in these organisations, with the goal of proposing solutions to overcome these barriers and enable them to fully leverage the benefits of technology in the current market.

2.1. Digitalisation in Organizations

Digitalisation is a fundamental aspect in the contemporary business context. Ghobakhloo and Fathi (2019), refer that it can be defined as the process of integrating digital technologies into all aspects of an organisation to transform its operations and deliver added value to customers. In this sense, Reinartz et al., (2019) and Di Vaio et al., (2021) highlight that digitisation encompasses not only the implementation of digital technologies, but also the redefinition of business processes and the creation of new ways of interacting with customers and other market actors. Digitalisation has a significant impact on several areas of organisations. Firstly, it affects the way internal processes are carried out. From the perspective of Ortt et al., (2020) the use of emerging technology enables the automation of routine tasks and the optimisation of processes, leading to greater operational efficiency and cost savings. In addition, digitisation facilitates access to real-time information, enabling organisations to make more informed and agile decisions (Fuentes-Gavilánez et al., 2023; Lira et al., 2023). Overall, digitisation in organisations not only involves the adoption of digital technologies, but

also the transformation of processes and the creation of value for both the organisation and its customers.

2.2. Benefits and Advantages of Digitisation in Sme Manufacturing Companies

Digital innovation offers significant benefits and advantages for manufacturing SMEs in today's business environment. According to Masood and Sonntag (2020), one of the main benefits of digitalisation is improved operational efficiency. The implementation of digital technologies allows automating repetitive tasks and optimising processes, resulting in reduced costs and production times. This efficiency improvement contributes directly to the competitiveness of manufacturing SMEs in the globalised market (Vázquez Ávila, 2020).

In addition to operational efficiency, digitisation also facilitates informed and agile decision-making in manufacturing SMEs. Llopis-Albert et al., (2021) note that digitisation provides access to real-time information on the status of processes, inventories, sales and other relevant aspects of the business. This availability of data enables business leaders to make more informed and adaptive decisions, allowing them to respond more effectively to market demands and changing conditions in the business environment.

2.3. The Importance of Digitalisation in Sme Manufacturing Companies

Digital transformation plays a key role in manufacturing SMEs by offering benefits that contribute to their competitiveness and growth in today's market. One of the most prominent aspects is process optimisation. Furthermore, Bienhaus and Haddud (2018) and Kamble et al., (2020) argue that digitalisation allows for improved efficiency in task execution and resource management, leading to reduced costs and production times. This optimisation is crucial to remain competitive in an increasingly dynamic and demanding business environment. Task automation is another key aspect of digitalisation in SMEs. According to Rangel et al., (2024), the implementation of digital systems and technologies makes it possible to automate repetitive and routine processes, thus freeing up employees' time for more strategic and creative tasks. This not only increases productivity, but also improves the quality and precision of the manufactured products.

Likewise, digitalisation also contributes to improved operational efficiency, as Kamalaldin et al., (2020) and Parviainen, et al., (2022) report that the integration of digital systems into business processes allows for more efficient management of resources, better coordination between departments and greater agility to adapt to changes in the market. This translates into an overall improvement in the ability of companies to meet customer requirements in a timely and effective manner.

Another important benefit derived from digital innovation processes is access to real-time information. Horváth and Szabó (2019) and Veile et al., (2020) argue that digitisation provides manufacturing SMEs with the ability to monitor and analyse real-time data on the status of processes, inventories, sales and other key aspects of the business. This real-time information enables more informed and agile decision-making, improving the company's ability to respond quickly to market demands and customer needs.

Likewise, digitalisation also facilitates the development of new products and services, and the expansion of markets. Researchers such as Hinings et al., (2018) and Tortorella et al., (2020) underline that the implementation of digital technologies enables organisations to innovate in product and service offerings, to reach new markets more effectively. This not only expands the company's growth opportunities but also enhances the customer experience by offering personalised products and services tailored to their needs and preferences (Weyer et al., 2015).

3. METHODOLOGY

The approach adopted in this research focuses on the qualitative domain, with the purpose of investigating the challenges that small and medium-sized enterprises (SMEs) in the manufacturing sector face in their digitisation process. According to Seidman (2013), this methodological approach offers a detailed understanding of the object of study by analysing the diversity of arguments that lead to the interpretation of social phenomena, which facilitates the capture of multiple aspects related to the researched topic. In terms of the scope of the study, the descriptive method is used to delve deeper into aspects inherent to the object of research. According to Neuman (2014), this methodology allows for a detailed exposition of the features and characteristics of the phenomenon or situation under study, as they are naturally observed in the context of the research.

As for the methodological design, it focuses on desk review, drawing on recent research tradition,

especially studies related to the barriers faced by SMEs in their digitisation process. Citing Hart (2018), desk research, also known as bibliographic research, is characterised by the use of secondary data as the main source of information. The purpose of this method is to guide the research process from two fundamental perspectives: firstly, by establishing the correlation between existing information and the topic of study; and secondly, by analysing this information to obtain a complete understanding of the phenomenon or situation under investigation. In this context, desk research is carried out with the aim of exploring the perspective of the existing literature on the barriers or factors that manufacturing SMEs face in their digitalisation process.

3.1. Research Techniques and Instruments

For a better understanding of the research techniques and instruments used in the study, it is important to highlight that a qualitative approach was chosen, which implied special attention to the nature and quality of the data collected. In this sense, the main technique employed was the documentary review, which was carried out using a corpus of documents, managed through Microsoft Excel software. This documentary corpus served as a tool to collect, organise and analyse relevant information from the research tradition associated with the object of study. It was also designed to link and compare different studies related to the research in question. Key aspects considered in this process include:

- Identification and documentation of the research problems addressed by each study included in the documentary corpus.
- Recording of the specific objectives of each study to understand its focus and purpose.
- - Analysis and documentation of the research methods used in each study, providing information on the methodological design and data collection strategy.
- - Compilation and synthesis of the main findings of each study, allowing for the identification of patterns, trends or divergences in the existing literature.
- - Exploration of the conclusions reached by each research study to assess its relevance and contribution to the field of study.

In general terms, the use of the documentary review as the main technique, supported by the documentary corpus, allowed for an exploration and analysis of the existing literature in the field of study, providing a solid basis for the development and contextualisation of the research.

3.2. Phases of the Investigation

The stages defined are linked to the objectives guiding the research, so the study is divided into three phases.

3.3. Phase One - Document Retrieval

The first phase of the research focused on retrieving information related to the factors affecting digitisation in SMEs in the manufacturing sector. For this purpose, several searches were carried out in documents such as articles, theses and books. Inclusion and exclusion criteria were established for the selection of literature related to the study. Inclusion criteria included academic articles related to digitisation in SMEs, analyses of the benefits of digitisation, studies on the obstacles organisations face in the digitisation process, and peer-reviewed publications published in indexed journals. The exclusion of bibliographic sources took into account aspects such as the lack of relevance to the object of study, the absence of analysis of the benefits and limitations of digitisation in SMEs and the lack of scientific rigour in the results. The bibliographic material was organised into a documentary corpus that included approximately 80 research studies related to the object of study.

3.4. Second Phase - Analysis

In the second phase of the research process, an analysis of the collected documents was carried out to identify aspects related to the barriers or constraints faced by SMEs in their digitisation processes.

3.5. Third Phase – Debate

In the last phase of the study, we reflect on the needs that manufacturing SMEs face when introducing technological innovations through digitalisation processes.

4. RESULTS

4.1. Results First Phase - Document Retrieval

This stage of the research focused on the search for academic documents inherent to the digitisation of manufacturing SMEs. In particular, the bibliographic sources consulted belong to the SCOPUS repository. Around 80 bibliographic sources were consulted, and a bibliometric network was created (see Figure 1) that integrated different key aspects surrounding the object of study.

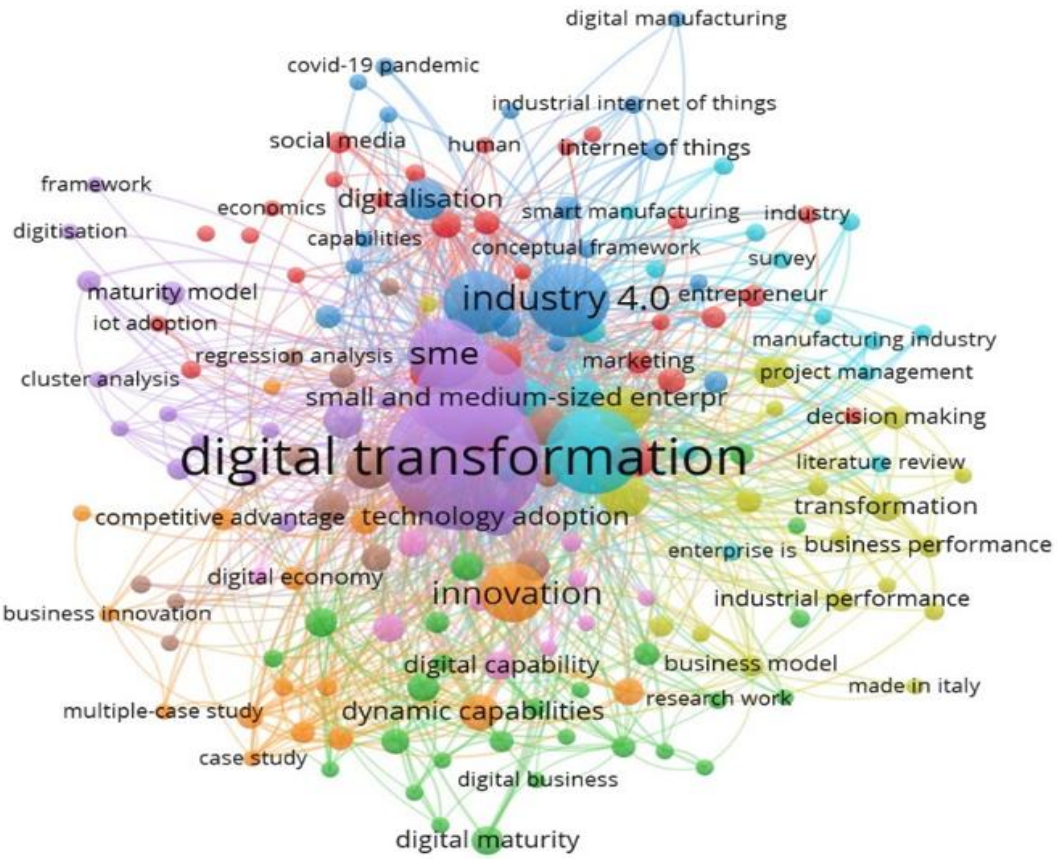

Figure 1: Keyword Co-Occurrence Network.
Note: The Figure Shows in Detail Key Aspects of The Digitisation of Manufacturing Smes.
Source: Vosviewer.

The construction of the network considered the full count method and a minimum threshold of 3 keyword co-occurrence matches. The map visualises the relationship between digitisation or digital transformation of SMEs and Industry 4.0, which are intrinsically linked concepts. In addition, representative constructs such as innovation and especially the dynamic capability cluster were identified. This theory focuses on the ability of an organisation to integrate, build and reconfigure its internal and external resources in response to changes in the environment. It is therefore crucial to take it into account in related studies, as it is designed for innovation-based environments. These capabilities allow firms to create, expand and modify their resources. According to Teece (2012) and Warner & Wäger (2019), these capabilities can be classified into three main levels: identifying and assessing opportunities, exploiting opportunities to generate value and constantly renewing the business model, which can be understood as a transformation following the authors' approaches.

4.2. Second Phase Results – Analysis

The results of the second phase of the research reveal that the digitisation of manufacturing SMEs faces a number of challenges in the current business context, which hinder the adoption of technological innovations. Academic literature points out that some of the barriers that interfere with this process include lack of awareness of the benefits of digitisation, as well as economic and technological barriers and lack of technical know-how. The following sections therefore present the findings of some studies that address these issues.

4.3. Limited Awareness of the Potential Benefits of Digitisation

From the review of the research tradition inherent in the field of digitisation of manufacturing SMEs, a convergence in the academic literature has been identified regarding the limited perception of the potential benefits associated with this process. According to Amaral and Peças (2021), firms in the manufacturing sector often underestimate the benefits that digitisation can bring, resulting in a lack of initiative to adopt digital technologies. This lack of perception is compounded by a lack of understanding of how digitalisation can improve the efficiency and competitiveness of SMEs (Ulaş, 2019).

Furthermore, studies by (Kilimis, et al., 2019; Zhang, et al., 2022; Tick, et al., 2022) reveal that the limited perception of the benefits of digitisation can also be attributed to the lack of adequate information about the opportunities offered by technological transformation. The researchers suggest that the lack of awareness of the potential benefits of digitisation may be due to poor communication by technology providers and lack of education about the implications of digitisation in the context of manufacturing SMEs. Kala'lembang (2021) suggests that the limited perception of the benefits of digitalisation may be the result of an ingrained resistance to change in the organisational culture of manufacturing SMEs. This resistance may stem from the perception that the implementation of digital technologies is costly or detrimental to the firm's existing operations. In this regard, academics stress the importance of addressing misperceptions and fostering a fuller understanding of the benefits of digitisation in this sector (Situmorang, 2022).

In the same vein, the study by Cenamor et al., (2019) highlights that the limited perception of the benefits of digitalisation may also be influenced by the lack of concrete examples of successful implementation of digital technologies in manufacturing SMEs. The researchers suggest that sharing case studies and good practices can help illustrate the tangible benefits of digitalisation and overcome the negative perception associated with this process. The literature review highlights the importance of addressing the limited perception of the potential benefits of digitisation in manufacturing SMEs. It is crucial to develop strategies that improve awareness and understanding of the opportunities that digitisation can offer, as well as to overcome cultural and organisational barriers that may hinder the adoption of technologies in this sector.

4.4. Financial and Technological Challenges in the Digitisation of Manufacturing Smes

Based on the analysis of the research overview it appears that in the digital innovation process of organisations there are financial and technological challenges that hinder digitalisation processes. According to the research conducted by Favoretto et al., (2022), one of the main financial obstacles is the initial investment required to implement digital technologies, which could be a considerable impediment for most companies. Furthermore, Peillon and Dubruc (2019) point out that manufacturing SMEs face technological challenges due to the lack of access to technology resources and expertise, which hinders the adoption and full exploitation of digital solutions available in the market.

Another financial challenge identified in academic literature is the uncertainty about the return on investment in digital technology. According to the study by Eller et al., (2020), SMEs are often hesitant to invest in digitisation due to a lack of assurances about the long-term financial benefits. In addition, Prasanna et al., (2019) highlight that the rapid obsolescence of technology and the need for constant upgrades also represent a significant financial challenge for these companies, as they may result in unanticipated additional costs.

In terms of technological challenges, researchers agree that manufacturing SMEs face difficulties in integrating new digital technologies with their existing systems. According to Ottesjö et al., (2020), the lack of interoperability between different platforms and systems can lead to compatibility issues and hinder the adoption of digital solutions. Furthermore, Abdallah et al., (2021) point out that the shortage of technological talent in the manufacturing sector also represents a major challenge, as it limits the ability of companies to implement and manage technologies effectively.

Considering the big picture, the review and analysis of the specialised literature on digitisation of manufacturing SMEs shows that financial and technological challenges are significant barriers to technology adoption in this sector. These challenges include the initial investment required, uncertainty about the return on investment, technological obsolescence, lack of interoperability and shortage of technological talent. Overcoming these challenges requires formulating specific strategies and policies that address both the financial and technological concerns of manufacturing SMEs and promote an enabling environment for digitisation in the sector.

4.5. Lack of Technical Skills - Cognitive Digital Divide

From the systematic analysis of the specialised literature on the digitisation of manufacturing SMEs, it was possible to identify a significant gap in terms of the technical skills required to adopt and use emerging technologies, such as those related to Industry 4.0. According to (Vieru et al., 2015; Nurhidayati, 2020; Shakina et al., 2021), this gap, also known as the cognitive digital divide, refers to the disparity between the technological skills required by companies and the skills possessed by their employees. This problem is exacerbated by the lack of adequate training in emerging technologies in university programmes, as Muljono et al., (2021) point out that although SMEs have the necessary

technological infrastructure, the lack of qualified personnel hinders their ability to take full advantage of these technological tools.

The lack of adequate technical skills in SMEs is a key challenge hindering their ability to adopt and leverage digital technologies. From the position of Hamburg (2020) and Ollanketo et al., (2023) insufficient vocational training from university programmes does not prepare graduates with the necessary skills to work with emerging technologies, such as Industry 4.0. Furthermore, (Anim-Yeboah et al., 2020; González-Varona et al., 2021; Turkyilmaz et al., 2021) point out that the rapid evolution of digital technologies requires constant updating and training processes to strengthen technical skills, making it even more difficult to bridge this cognitive digital divide. As a result, manufacturing SMEs may find themselves in a situation where they possess the necessary technological infrastructure but lack the skilled personnel to use it effectively.

On the other hand, the literature also highlights that the lack of adequate technical skills in manufacturing SMEs not only affects the implementation of digital technologies but can also influence the ability of these firms to compete in the global market. Based on research by (Gamache et al., 2019; Klein and Todesco, 2021; Ramdani et al., 2022), firms that lack skilled technology personnel risk falling behind competitors that can take full advantage of digital tools to improve efficiency and productivity. The cognitive digital divide therefore not only represents an internal challenge for firms but may also have wider implications in terms of competitiveness and long-term sustainability.

Another relevant aspect that emerges from the analysis of academic literature is the importance of fostering an organisational culture that values and promotes training and technical skills development among employees. According to Li et al., (2018), companies that prioritise technical training and facilitate access to continuous training programmes are more likely to bridge the cognitive digital divide and keep up with emerging technology trends. To achieve this, senior management must be committed to investing in the development of internal talent and creating an environment that fosters learning and technological innovation.

In addition, scholars highlight the need for collaboration between the public sector, private sector and academic institutions to address the skills gap in manufacturing SMEs. According to research by (Doyle and Cosgrove, 2019; Ghobakhloo and Ching, 2019; Rupeika-Apoga et al., 2022) collaboration between these actors can facilitate access to resources and training programmes, as well as promote research and development of innovative solutions to bridge the cognitive digital divide. This requires a coordinated and strategic approach that involves multiple stakeholders and takes into account the specific needs of manufacturing SMEs in terms of technical training.

Globally, the literature reveals that the lack of technical skills in manufacturing SMEs represents a significant challenge in the context of digitalisation. The cognitive digital divide not only hinders the effective adoption of emerging technologies but can also sustain labour market inequalities and undermine the competitiveness of firms in the digital economy. To address this issue effectively, comprehensive strategies need to be formulated that include improvements in technical training from university curricula, the promotion of an organisational culture of learning and skills development, collaboration across sectors, and investment in research and development of innovative solutions. Only a coordinated and collaborative approach can close the cognitive digital divide and ensure that manufacturing SMEs are equipped to meet the challenges and seize the opportunities.

4.6. Results Third Phase – Discussion

In this final stage of the study, possible solutions to the challenges identified in the digitisation of manufacturing SMEs are presented. These solutions are derived from the analysis of literature in the field of business digitisation. Through a review of various academic and practitioner sources, strategies and approaches have been identified that can help to overcome the financial, technological and cognitive barriers faced by manufacturing SMEs on their way to digitisation.

The perception of the benefits of digitalisation is critical to the success of any digital transformation initiative in manufacturing SMEs. However, this perception can be hindered by various psychological and organisational barriers. According to Sanchez et al., (2022), the adoption of technological innovations is influenced by factors such as the perception of relative benefits, compatibility with existing values and the perceived complexity of the technology. In this sense, it is essential that SMEs implement effective strategies to communicate and demonstrate the tangible benefits of digitisation to their managers and employees.

Furthermore, Marino et al., (2024) suggest that the perception of benefits can be influenced by the perceived ease of use of the technology and the clarity of organisational objectives related to digitisation.

Therefore, it is important for SMEs to develop a clear and coherent vision of the benefits that digitisation can bring to their business, aligning these benefits with the organisation's strategic objectives.

From this perspective, it is essential that SMEs develop a clear and deep understanding of the benefits that digitalisation can bring to their business. This involves understanding in detail how the implementation of digital technologies can positively impact different aspects of the business operation, from optimising internal processes to improving customer experience. To achieve this, SMEs need to conduct an analysis of their business context and specific needs, identifying key areas where digitalisation can generate the greatest added value.

In developing this vision, it is essential that SMEs align the potential benefits of digitisation with their long-term strategic objectives. This involves not only considering how digitisation can improve operational efficiency and reduce costs, but also how it can contribute to competitive differentiation, market expansion and the creation of new business opportunities. As noted by (Daidj, 2022; Zinchenko et al., 2022), strategic alignment is essential to ensure that investment in digitisation is aligned with the company's vision and mission, thereby maximising its impact on long-term success.

Furthermore, it is important to recognise that digitisation is not just about adopting new technologies, but also about transforming organisational culture and processes. As Zhang et al., (2022) suggest, successful digitisation requires a change in mindset and working practices, as well as an investment in training and digital skills development. Therefore, SMEs must ensure that all levels of the organisation are committed to the digitisation process and are prepared to adapt to the changes it brings. In general, developing a clear and coherent vision of the benefits of digitalisation is a key step for SMEs on their journey towards digital transformation. By aligning these benefits with the organisation's strategic objectives and promoting cultural and organisational change, SMEs can maximise the impact of digitalisation on their competitiveness, growth and long-term sustainability.

Financial and technological challenges represent another major obstacle in the digitisation process of manufacturing SMEs. Lack of financial resources and the complexity of technology can discourage organisations from embarking on digitisation projects. According to Guan (2023), access to finance is critical to the success of any digitisation initiative. SMEs can explore options such as government grants, loans at preferential rates or collaborative financing with technology providers to overcome these financial barriers. Furthermore, Straková et al., (2022) suggest that adopting scalable technology solutions can help these organisations mitigate the risks associated with technology investment. By opting for technology platforms and tools that fit their needs and budget, SMEs can implement digitisation gradually and flexibly, minimising organisational resistance and maximising long-term return on investment.

To overcome the financial barriers associated with digitisation, SMEs have a number of options at their disposal that they can explore in order to obtain the necessary financial support. According to research by authors such as Feng et al., (2022), government grants represent an alternative, as they offer non-refundable funds or tax credits specifically earmarked for digital transformation projects. In addition, as these authors point out, SMEs can consider the option of obtaining loans at preferential rates, both through traditional financial institutions and government programmes aimed at promoting investment in technology and business development. These loans offer more favourable conditions in terms of interest rates and repayment terms, which facilitates access to the financing needed for digitisation projects (Jin and Pan, 2023).

On the other hand, as suggested by authors such as Hossain et al., (2023), SMEs may also consider entering into collaborative financing arrangements with technology providers. These agreements, according to the authors, can offer flexible financing options or even direct financing for the acquisition of specific digital products or services. This approach can be particularly beneficial in cases where specific technology adoption is critical to the operation and competitiveness of the SME, but financial resources are limited. Taken together, these options offer a variety of financial tools that can be leveraged to overcome financial barriers and advance their digitisation process.

Lack of technical skills and the cognitive digital divide are additional challenges that manufacturing SMEs face in their digitisation process. The rapid evolution of technology and the complexity of digital solutions can leave organisations lagging behind if they do not have adequate knowledge and training. According to Demirkan et al., (2022) continuous training and education of employees are essential to bridge this cognitive digital divide. SMEs can invest in training and professional development programmes to provide their employees with the technical and digital skills needed to adapt to new technologies and work processes. In line with the above, collaboration

with external digitalisation experts can be beneficial. Chierici et al., (2021) highlight the importance of collaboration with external consultants and experts to guide these organisations through the technology implementation process and improve their internal capacity for digital innovation. By leveraging external knowledge and expertise, SMEs can accelerate their digitisation process and overcome the challenges associated with a lack of technical expertise.

Por todo ello, la aplicación de soluciones para superar los retos de digitalización de las PYME manufactureras es fundamental para su adaptación y supervivencia en un entorno empresarial cada vez más digitalizado. Sin embargo, es importante señalar que la eficacia de estas soluciones puede verse influida por una serie de factores contextuales y organizativos. Según Shahadat et al., (2023), la adopción de innovaciones tecnológicas en las organizaciones se ve influida por factores como la cultura organizativa, la estructura de poder y la disponibilidad de recursos. Por lo tanto, es elemental que las PYME tengan en cuenta estos factores a la hora de aplicar las soluciones propuestas.

Furthermore, it is important to recognise that digitisation is not a static process, but rather a continuous and evolving process. As pointed out by (Remedi-Rumi and Arzuaga-Williams, 2024; Saeedikiya et al., 2024) digitisation requires a dynamic and flexible management approach that enables organisations to adapt quickly to changes in the business environment and to take advantage of new technological opportunities. In this sense, the proposed solutions can be considered as starting points for the digitisation process, but they should also be regularly reviewed and adjusted according to market development and organisational needs.

Finally, it is crucial to highlight the crucial role of collaboration and knowledge sharing in the digitisation process of manufacturing SMEs. As Khan et al., (2021) point out, organisational learning and knowledge creation are fundamental processes for innovation and continuous improvement in organisations. Therefore, SMEs need to foster a culture of internal learning and collaboration, as well as establish strategic alliances with suppliers, academic institutions and other industry organisations to share knowledge, resources and best practices in digitisation. Overall, while the proposed solutions provide a solid framework for addressing the digitisation challenges of manufacturing SMEs, their effectiveness will ultimately depend on the ability of organisations to adapt, learn and collaborate in a dynamic business environment.

5. CONCLUSIONS

After conducting an analysis of the challenges and solutions in the digitisation of manufacturing SMEs, the critical importance of this process for their adaptation and competitiveness in an increasingly digitised business environment is undeniable. The solutions outlined in this study represent a comprehensive and multifaceted approach to address the financial, technological and cognitive barriers faced by these organisations. However, it is essential to recognise that successful implementation of these solutions is not a light process and requires careful strategy and long-term organisational commitment. One salient conclusion is that digitisation is not simply a matter of adopting new technologies but involves a profound transformation in the culture and processes of organisations. As discussed, the success of technological innovation lies largely in the ability of SMEs to align the potential benefits of digitisation with their long-term strategic objectives, as well as to promote a cultural change that fosters organisational transformation and agility.

In addition, it underlines the critical importance of collaboration and knowledge sharing in the digitisation process. Strategic partnerships with suppliers, academic institutions and other industry organisations can play a key role in sharing knowledge, resources and best practices in digitisation. It is recommended that SMEs foster a culture of internal collaboration and establish external collaboration networks to maximise the impact of digitisation on their long-term competitiveness and growth. In general terms, while this study provides a framework for addressing the challenges in digitising manufacturing SMEs, it is critical to recognise that the path to technological innovation is full of evolving challenges and opportunities. The successful adoption of emerging technologies will ultimately depend on the ability of organisations to adapt, learn and collaborate in an ever-changing technological environment.

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