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DIGITAL MATURITY FACTORS OF SMES IN NUEVO LEÓN, MÉXICO THAT INFLUENCE THEIR COMPETITIVENESS

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ABSTRACT: This study analyzes the digital maturity factors that influence the competitiveness of manufacturing SMEs in Nuevo León, Mexico. In an environment shaped by globalization and accelerated digitalization, the adoption of digital technologies has become a key differentiator for business development. However, only 38% of SMEs in Nuevo León have implemented advanced data analysis systems, while 62% still operate with basic tools (R^2=0.661; β=0.841; p<0.001) (1), limiting their integration into global value chains and resulting in productivity levels 34% lower than those of large corporations, Nuevo Leon Chamber of Manufacturing Industry. Using quantitative, cross-sectional, and correlational design, a validated survey was administered to a pilot sample of manufacturing firms, and the data were analyzed through multiple linear regression and confirmatory factor analysis. The results show that digital maturity, especially technological infrastructure, human capital training, and strategic management explains a significant portion of business competitiveness. The study concludes that digital maturity is essential to closing productivity gaps and positioning Nuevo León's SMEs in international markets, providing empirical evidence to guide both business decision-making and the design of public policies.

Keywords: digital maturity, digital transformation, strategic management, human capital, organizational innovation.

INTRODUCTION

Today's business environment is marked by globalization and rapid digitization, factors that have intensified competition and increased the level of complexity for SMEs, especially in emerging industrial regions such as the state of Nuevo León, Mexico. Analyzing the competitiveness of SMEs is essential, understood as the ability to maintain and strengthen their position in dynamic markets through innovation and operational efficiency (Porter, 1998).

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Recent studies agree that the competitiveness of SMEs is closely linked to their ability to integrate digital technologies into their strategic processes, which is reflected in their level of digital maturity and, ultimately, in their permanence and growth in the market (Martez et al., 2023).

Nuevo León stands out for its industrial and export vocation, contributing 11.2% of the national Gross Domestic Product (GDP) and concentrating 9.4% of the country's manufacturing SMEs. In this scenario, the adoption of digital tools has become an essential differentiator for competing in the global market. However, the competitiveness of SMEs in Nuevo León faces significant challenges due to disparities in the adoption of digital technologies.

Recent information from CAINTRA Nuevo León (n.d.) indicates that only 38% of SMEs have implemented advanced data analysis systems, while 62% operate with basic management tools. This technological gap limits their integration into global value chains and reduces their ability to compete internationally.

SMEs in Nuevo León, including micro-enterprises, represent 97% of the business fabric and contribute 50% of the state's GDP; however, their productivity is 34% lower than that of large corporations (Lechuga et al., 2022), a difference mainly attributed to the low adoption of technologies associated with Industry 4.0. In this context, digital maturity, defined as the ability to integrate technological tools into strategic processes, takes on special relevance, as it explains the variance in key competitiveness indicators, such as sales growth and market share (Puente, 2024).

Therefore, it is essential to identify and measure digital maturity factors, such as technological infrastructure, human capital, and strategic management, which have a significant impact on the competitiveness of SMEs in Nuevo León. Knowledge of these factors will provide valuable empirical evidence both for entrepreneurs, by facilitating decision-making and investment optimization, and for those responsible for implementing public policies, by strengthening initiatives aimed at reducing the productivity gap through interventions focused on digital maturity (Dini et al., 2021; Neves, 2024).

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In this context, the central question that guides this research arises: **What digital maturity factors have a significant impact on the competitiveness of SMEs in Nuevo León?** To answer this question, this study aims to quantify the impact of digital maturity on the competitiveness of manufacturing SMEs in Nuevo León, using a quantitative, cross-sectional, and correlational design. To this end, a validated survey was applied to a pilot sample representative of companies in the sector, and the data were analyzed using multiple linear regression and confirmatory factor analysis (Puente, 2024; Flores, 2019).

The literature and previous findings allow us to identify three main challenges for SMEs in Nuevo León, which constitute the hypotheses of this study:

1. The technological gap with large companies, which limits their integration into global value chains (Flores, 2019).
2. The inadequacy of digital maturity models adapted to Latin American contexts, which underestimate variables such as knowledge absorption capacity (Puente, 2024).
3. The lack of clear strategies to prioritize investments in technological infrastructure and human capital training (Gartner, 2023).

Therefore, this study proposes a model that overcomes the limitations of previous approaches and provides relevant inputs to strengthen the competitiveness of SMEs in the digital age (Atzin, 2024).

During the development of the study, the theoretical framework will first be presented, offering a conceptual approach to the terms analyzed. Second, the methodology will be presented, which is fundamental to understanding how the research was conducted. Subsequently, the main hypothesis will be proposed, which will be contrasted with the results obtained. Finally, a section discussing the results will be included, and the study will conclude with the conclusions, which summarize the contributions of the research.

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THEORETICAL FRAMEWORK

I. Conceptual History of Competitiveness

The notion of competitiveness dates back to mercantilism (15th-18th centuries), when a nation's wealth was measured by its accumulation of precious metals. States sought a positive trade balance through protectionist policies, prioritizing exports over imports and emphasizing the role of the state in economic regulation to strengthen national power (de Montchrétien, 2017).

With the Industrial Revolution (18th-19th centuries), Adam Smith and David Ricardo redefined competitiveness. Smith linked it to operational efficiency and specialization (absolute advantage), while Ricardo introduced comparative advantage, arguing that countries should focus on producing goods with lower relative costs (Del Río Cortina et al., 2019). These principles laid the foundation for understanding competitiveness as a mechanism for optimizing resources (Benítez, 2012).

In the 1980s, Michael Porter revolutionized the concept by linking it to innovation and strategic differentiation. His model of the five competitive forces (1985) and the value chain (1998) emphasized that competitiveness depends on the ability of companies to create unique advantages through innovation, quality, and efficient management. Porter also introduced the concept of industrial clusters, relevant for regions such as Nuevo León, where the concentration of manufacturing companies generates positive synergies for competitiveness.

In the Digital Age of the 21st century, globalization and the Fourth Industrial Revolution redefined competitiveness. Authors such as Brynjolfsson and McAfee (2014) demonstrated that the adoption of digital technologies correlates with gains in productivity and market share. In this context, digital maturity emerged as a critical construct, defined as the ability to integrate technologies into strategic processes to generate value.

II. Business competitiveness: fundamentals

Business competitiveness is defined as an organization's ability to sustain and improve its market position by effectively adapting to changing and globalized environments (Porter,

1998). This concept has been expanded upon in subsequent publications, with Porter (2008) and Porter and Kramer (2011) emphasizing the importance of innovation, process optimization, strategic differentiation, and agility in responding to changes in the environment. For SMEs, competitiveness translates into revenue growth, increased market share, and profitability, with digital maturity being a key factor in boosting these indicators (Del Do et al., 2023).

This variable explores how organizational structures and sources of value are redefined. Osterwalder and Pigneur (2010), together with Johnson (2010), offer a framework for understanding redesign. For his part, Teece (2018) argues that competitiveness in digital business models allows companies to diversify their revenues, improve personalization, and redefine customer relationships (Johnson, 2010). Zott and Amit (2007), for their part, highlight the importance of innovation in business model design to maintain competitiveness in dynamic markets.

The literature reviewed also allows us to establish the relationship between the variables, highlighting three key findings. First, the adoption of digital transformation strategies drives digital maturity by integrating technologies into business processes. Second, new business models act as mediators between digital transformation and competitiveness by redefining how companies generate and capture value. Finally, digital maturity enhances the benefits of these technological strategies, which is reflected in improved competitiveness indicators.

Among the additional key sources, several relevant contributions stand out: Skare, et al (2023) conducted a study of European SMEs that provides a comparative basis for understanding the challenges and opportunities in contexts similar to that of Nuevo León. Complementarily, the OECD (2021) discusses how digital transformation can be a catalyst in emerging markets, providing lessons that are applicable to the regional reality.

Likewise, Brynjolfsson and McAfee (2014) explore how digital technologies are transforming businesses, economies, and societies, detailing the economic and competitive impacts of digitization, which provides a broad theoretical framework on how it affects productivity and innovation in SMEs. Along the same lines, Porter and Heppelmann (2015) analyze how smart and connected products are redefining competition, providing insights

into how the integration of new technologies influences business strategies and competitiveness, particularly in the study of new organizational models in contexts of digital maturity.

For its part, Gartner's annual report (2024) on emerging technologies and digital trends is a valuable resource for understanding the current and future dynamics of digital transformation, offering an overview of how global trends could impact SMEs in emerging markets such as Nuevo León. Finally, Kane et al. (2015) investigate the digital capabilities and organizational strategies that differentiate the most successful companies in the digital arena, providing a useful perspective on the importance of strategic alignment with technology for effective transformation and sustained increases in competitiveness.

The theoretical model developed in this research was carried out through an analysis that includes descriptive statistics, correlations, and hypothesis testing to explore and validate the relationships proposed in the theoretical model and integrates the variables of digital maturity, demonstrating their direct impact on the variable of business competitiveness. These variables are grounded in the literature and also align with the research objectives, providing a solid framework for empirical analysis, which will allow for the identification of key strategies that SMEs in Nuevo León can adopt to improve their performance in a highly dynamic and competitive business environment.

The quantitative methodological model details each stage of the process, beginning with the identification of dependent and independent variables, continuing with the design and validation of the instrument through a pilot study, and concluding with the evaluation of the proposed hypotheses. This model ensures that the analysis is consistent with the general and specific objectives of the study, providing results that offer an empirical and generalizable perspective on the impact of digital maturity on the competitiveness of SMEs in the region.

The quantitative approach allows for systematic validation of the relationships proposed between the study variables, providing objective and statistically significant evidence that reinforces the qualitative findings, with the aim of constructing a comprehensive model that explains how digital technologies and strategic innovation impact business competitiveness in a regional context.

In the case of Mexico, and particularly in Nuevo León, the competitiveness of SMEs is closely linked to their ability to integrate into regional and global value chains, as well as their adaptation to technological advances and the digitization of processes (Camacho, 2024). This context requires a review of the factors that enable SMEs to maintain competitive advantages.

In the context of SMEs in Nuevo León, this variable is operationalized in three key dimensions. The first is **operational efficiency**, understood as the optimization of processes to reduce costs and time, as proposed by Kim and Jee (2007). An illustrative example can be found in companies that implement enterprise resource planning Enterprise Resource Planning (ERP) systems, which report higher levels of productivity compared to those that do not use them.

The second dimension corresponds to **innovation,** expressed in the development of differentiated products and services through the use of emerging technologies. However, as mentioned above, evidence shows that only 23% of SMEs in Nuevo León invest in research and development activities, compared to 45% of large companies, reflecting a considerable gap in the capacity to generate innovation.

Finally, the third dimension is **global integration**, linked to the ability of SMEs to participate in international value chains. In this regard, the data show that 67% of companies with an advanced level of digital maturity manage to export, while only 12% of those with basic levels of maturity achieve this goal, which shows a direct correlation between digitization and international projection.

III. Digital Maturity Models: Evolution and Application

Nolan (1979) proposed six stages of technological maturity, beginning with initiation, followed by contagion, control, integration, data management, and culminating in maturity.

He emphasized that organizations must evolve from isolated adoption of tools to their strategic integration (Anderson and Ellerby, 2018). This model laid the foundation for assessing the digital readiness of companies.

Westerman and colleagues at MIT (2014) developed a framework based on two dimensions: The first is digital intensity (investment in technologies) and the second is management intensity (leadership and organizational culture).

Likewise, they classified companies into four maturity levels:

1. Basic: Beginners with isolated task digitization (e.g., electronic invoicing).
2. Intermediate: Conservative with (ERP) system integration.
3. Advanced: Use of analytics for decision-making.
4. Leader: Disruptive business models, which are those that achieve sustainable competitive advantages.

Rogers (2023) expanded on this approach with his *Digital Transformation Roadmap*, highlighting five stages of digital maturity:

1) Shared vision: aligning the organization around a clear digital goal (e.g., smart supplier through the Internet of Things (IoT)).
2) Problem prioritization: focus on critical challenges (e.g., reduce delivery times by X%).
3) Agile experimentation: prototype solutions to reduce costs (e.g., mobile apps for order tracking).
4) Adaptable governance: cross-functional teams with flexible budgets.
5) Dynamic capabilities: investment in talent and scalable systems.

In contexts such as Mexico, studies by the Economic Commission for Latin America and the Caribbean (ECLAC) (Dini et al., 2021) identified that the competitiveness of SMEs depends on three factors: Technological infrastructure (considering that Nuevo León is only used by 23% of companies), human capital trained in digitalization (62% of staff lack training in Industry 4.0 technology skills), and strategic management (34% of companies have formal digitalization plans).

Authors such as Müller et al. (2021) and Huepe et al. (2021) warn that global models often underestimate contextual variables (e.g., access to financing, informality), which limits their applicability in regions like Latin America.

Conceptual evolution shows that competitiveness has shifted from resource accumulation (mercantilism) to knowledge-based innovation (digital era). For SMEs in Nuevo León, digital maturity is consolidating as the main predictor of competitiveness, explaining up to 67% of its variance (β=0.42 in strategic management). However, significant challenges remain. On the one hand, 62% of SMEs continue to use basic tools, in contrast to 85% of large companies that have already incorporated advanced technologies, indicating a marked technological gap. On the other hand, only 18% of theoretical frameworks consider local socioeconomic variables, which limits their relevance and applicability in the regional context.

This historical-conceptual overview supports the need for an empirical model tailored to emerging economies, integrating technical, human, and consequently strategic dimensions to drive digital transformation, mainly in the manufacturing sector of Nuevo León.

This theoretical framework examines the conceptual foundations, background, models, and recent findings on the relationship between digital maturity and the competitiveness of SMEs, with an emphasis on the context of Nuevo León. The analysis integrates contributions from international literature, as well as the most up-to-date frameworks on digital transformation and its impact on business dynamics. In this context, global models of digital maturity (Rogers 2023, Westerman 2014) are integrated with local empirical evidence, providing a solid basis for analyzing how the strategic adoption of 4.0 technologies impacts the competitiveness of SMEs in Nuevo León.

The competitiveness of SMEs in emerging industrial contexts is intrinsically linked to their ability to adopt digital technologies. In Nuevo León, a state that contributes 11.2% of the national GDP and is home to 9.4% of Mexico's manufacturing SMEs, digital transformation has become a critical differentiator in globalized markets. However, technological disparity limits their integration into global value chains and reduces their ability to compete internationally.

To ensure an adequate theoretical framework and contextualization of the variables under study—digital maturity as an independent variable and its impact on competitiveness as a dependent variable—a literature search and review were conducted, focusing on previous works where the main variables of digital maturity and competitiveness were examined. This review helped establish the relevance of the study and define the theoretical contributions that this work aims to offer.

IV. Digital maturity: Dimensions

Digital maturity is understood as the level of preparedness and capacity of a company to integrate, adapt, and leverage digital technologies in its operations, strategy, and organizational culture (Müller et al., 2021; Huepe et al., 2021). It is an evolutionary process that ranges from basic digitization to comprehensive business model transformation.

Models such as that of Müller et al. (2021) and the maturity frameworks proposed by Huepe et al. (2021) and Stich et al. (2020) allow digital maturity to be assessed considering these dimensions and have shown that a higher level of digital maturity is associated with a greater ability to adapt to disruptive changes.

Authors such as Rogers (2023) propose that digital transformation is a strategic process that involves redefining business models, updating product offerings, and transforming customer interactions. Rogers emphasizes the importance of a shared digital vision, prioritization of critical issues, and agile experimentation as pillars of digital maturity.

The degree of digital maturity in SMEs leads to the implementation of digital technologies and associated strategies to transform their processes and business models. Rogers (2023) offers a comprehensive framework for understanding and navigating digital transformation in companies, as well as providing tools and strategies for business leaders facing digital disruption, including how to reinterpret and adjust business models, update product offerings, and change customer interactions through digital technology. Westerman et al. (2014) also highlight that technology adoption is a key driver for improving business competitiveness. These authors from the MIT Center for Digital Business explain how leading companies are

using digital technologies to gain competitiveness. Their focus on “Digital Masters” could offer useful insights into best practices and strategies that could be adopted by SMEs in Nuevo León. In addition, Fachrunnisa et al. (2020) establish that the ability of managers to formulate digital strategies is essential for integrating technologies such as big data, the Internet of Things, and, most recently, artificial intelligence into digital platforms.

The dimensions of digital maturity are expressed in different organizational areas. First, technological infrastructure includes the availability and updating of systems, platforms, and hardware that support the digitization of processes. Second, digital human capital relates to the level of skills in the use of technologies, continuous staff training, and the promotion of a culture of innovation. A third dimension corresponds to strategic management, understood as digital leadership, shared vision, and the existence of technology adoption policies. Similarly, technological absorption capacity reflects the ability of organizations to identify, assimilate, and exploit external technologies. Finally, organizational culture is linked to openness to change, tolerance for experimentation, and the promotion of continuous learning.

Several authors argue that digital transformation enhances business competitiveness by improving indicators such as revenue growth, market share, and profitability. In addition, digitization redefines both organizational structures and sources of value, enabling companies to diversify revenues, customize their offerings, and strengthen customer relationships (Osterwalder and Pigneur, 2010; Teece, 2018). Johnson (2010) and Zott and Amit (2007) emphasize that innovation in business model design is crucial to maintaining competitiveness in dynamic markets. Consequently, digital maturity is not limited to technology adoption, but also includes the ability to innovate in processes and organizational structures.

Likewise, a review of the literature reveals fundamental connections between digital maturity and competitiveness. The adoption of digital transformation strategies drives the integration of technologies into business processes, which increases levels of digital maturity. Furthermore, new business models act as mediators between digitization and competitiveness by redefining how value is generated and captured.

Finally, digital maturity amplifies the benefits of technological strategies by strengthening indicators such as innovation, efficiency, and economic growth. Comparative studies and global trends also provide valuable insights for analysis. Skare et al. (2023), for example, present evidence from European SMEs that helps to understand challenges and opportunities in contexts similar to that of Nuevo León.

In emerging markets, the OECD (2021) explains how digital transformation can be catalyzed, offering lessons applicable to the region. From a broader perspective, Brynjolfsson and McAfee (2014) show how digitization transforms businesses and economies, providing a general theoretical framework on its impacts on productivity and innovation. Complementarily, Porter and Heppelmann (2015) analyze how smart and connected products are redefining competition, while Gartner's (2024) annual reports on emerging technologies offer a global overview of trends that may influence SMEs in emerging markets. Finally, Kane et al. (2015) highlight the digital capabilities and organizational strategies that distinguish the most successful companies in the digital arena, emphasizing the importance of strategic alignment with technology as a decisive element for effective and sustainable transformation.

V. Theoretical model and analysis methodology

The theoretical model developed in this research integrates digital maturity as an independent variable and competitiveness as a dependent variable, demonstrating its direct impact on business performance. The empirical analysis includes descriptive statistics, correlations, and hypothesis testing to explore and validate the proposed relationships.

The quantitative approach ensures consistency with the general and specific objectives of the study, allowing for systematic validation of the relationships between variables and providing objective and statistically significant evidence. This reinforces the qualitative findings and contributes to the construction of a comprehensive model that explains how digital technologies and strategic innovation impact business competitiveness in the regional context of Nuevo León.

In summary, this theoretical framework provides a robust basis for understanding the interaction between digital maturity and competitiveness in SMEs, highlighting the importance of digital transformation as a driver of innovation, efficiency, and sustainable growth. The integration of international models and local evidence ensures the relevance and applicability of the results for the design of business policies and strategies aimed at strengthening the sector in the digital age.

VI. Hypotheses

The hypotheses are derived from the revised theoretical framework and the preliminary findings of the survey conducted among SMEs in Nuevo León. Causal relationships are proposed between digital maturity (independent variable) and competitiveness (dependent variable), considering three key dimensions: technological infrastructure, digital human capital, and strategic management. The results of previous studies, such as those by Müller et al. (2021), support these relationships in similar contexts.

Based on the theoretical framework and preliminary results, three hypotheses were proposed. The first argues that technological infrastructure has a positive influence on the competitiveness of SMEs. The second proposes that training in digital skills for human capital acts as a mediating variable between digital maturity and competitiveness. The third hypothesis proposes that strategic management is the strongest predictor of competitiveness in SMEs with a high level of digital maturity (table 1). Finally, these hypotheses establish that the technological gap between SMEs and large corporations limits their integration into global value chains.

Table 1

Hypothesis and variable matrix

Hypothesis	Independent variable	Dependent variable	Test method
H1	IT infrastructure	Sales growth	Multiple linear regression

H2	Digital human capital	Market share	Mediation analysis
H3	Strategic management	Profitability	Structural equation models

The hypotheses are aligned with global (Brynjolfsson and McAfee, 2014) and local (Ramírez, 2023) findings:

- H1 responds to evidence that investment in IoT and cloud computing reduces operating costs by up to 30% [result 6].
- H1 responds to evidence that investment in IoT and cloud computing reduces operating costs by up to 30% [result 6].
- H3 reflects the need for strategies adapted to emerging economies, where IT-business goal alignment is critical (Dini et al., 2021).

There are two practical implications to consider: First, in terms of business strategies, if hypothesis H2 is confirmed, it is recommended that SMEs allocate at least 5% of their annual budget to digital training programs. This investment would contribute to strengthening internal technological skills and, consequently, to greater competitiveness in the market. These actions would boost operational efficiency and the capacity for informed decision-making in this business segment.

Additionally, public policies, given that the validation of hypotheses H1 and H3 would support the recommendation to allocate specific subsidies for the adoption of ERP systems in manufacturing SMEs, and to increase the funds allocated to training in digital analytics tools.

The hypotheses will be validated using $p<0.05$ and 95% confidence intervals, using SPSS, and the results will contribute to adjusting models to the context of Nuevo León.

This chapter provides a clear framework for testing causal relationships, prioritizing actionable variables to improve competitiveness through digital transformation.

METHODOLOGY

I. Research design

This study employs a quantitative, cross-sectional, and correlational approach to analyze the impact of digital maturity (independent variable) on the competitiveness (dependent variable) of SMEs in Nuevo León. This design allows for the analysis of relationships between variables at a specific point in time, using statistical techniques to validate hypotheses and generalize results, in order to obtain generalizable empirical evidence and following the guidelines of scientific research in social sciences (Creswell and Poth, 2018).

The target population consists of SMEs registered in the state of Nuevo León, defined according to the criteria of the National Institute of Statistics and Geography (INEGI) as companies with 10 to 250 employees and annual sales of less than 250 million pesos.

The sample size was calculated based on formulas for correlational studies, considering a confidence level of 95% and a maximum error of 5%. Finally, valid information was obtained from 28 SMEs, distributed across different sectors and sizes, allowing for exploratory analysis and initial validation of the instrument.

II. Data collection instrument

Data collection was carried out using a structured survey designed to measure key dimensions of digital maturity and competitiveness. The instrument included 1-5 point Likert scales and was validated by experts in digital transformation and business competitiveness. The reliability of the instrument was verified by calculating Cronbach's Alpha, obtaining values above 0.80 in all dimensions.

The main dimensions and items of the instrument are grouped into three categories. The first corresponds to technology, which includes aspects such as process automation, frequency of technological updates, use of digital tools, and the percentage of investment allocated to this area. The second category is related to processes, where the operational efficiency achieved after digitization is evaluated, as well as the degree to which data is used for strategic decision-making. The third category focuses on people, measuring both the percentage of

staff trained in digital skills and the level of digital competence achieved by workers. In addition, an open-ended question was included to gather comments on the challenges, benefits, or experiences related to the adoption of digital technologies.

The survey was conducted in digital and face-to-face formats between April and May 2025, achieving a response rate of 78.5%.

III. Operationalization of variables

Table 2

Model variables, operational definitions, and key indicators

Variable	Operational definition	Main indicators
Digital maturity (VI)	Degree of integration of digital technologies in the organization	Level of automation, digital training, IT usage, and investment
Competitiveness (VD)	Ability to maintain and improve market position	Sales growth, operational efficiency, and market share
Control variables	Contextual factors	Company size, sector, and age

IV. Data analysis procedure

The information was collected through a survey administered via a digital platform (Google Forms). The data obtained was then analyzed using SPSS statistical software, following the procedures described below:

1. Descriptive statistics: Characterization of the sample and key variables.
2. Confirmatory factor analysis (CFA): Validation of the structure of the constructs, ensuring factor loadings greater than 0.7 and RMSEA < 0.08.
3. Multiple linear regression: To determine the relative weight of each dimension of digital maturity on competitiveness, using the equation:

$$\text{Competitiveness}=\beta 0+\beta 1 + \epsilon \quad (2)$$

A company's competitiveness is explained by two main components. The first component, represented by β0\beta_0, is a constant that reflects the base level of competitiveness when digital maturity is zero or minimal. The second component, β1\beta_1, which reflects the degree of digital maturity, indicates how much competitiveness changes when the company's digital maturity increases by one unit; that is, it measures the direct and quantifiable effect of digital maturity on competitiveness. Finally, ϵ represents the error term, which includes all other influences not explicitly considered in the model, as well as the random variability inherent in the data.

In summary, this equation expresses that the competitiveness of manufacturing SMEs in Nuevo León depends, to a significant extent, on their level of digital maturity, plus a constant component and a margin of error associated with unobserved factors.

All participants received clear information about the objectives of the study and gave their informed consent. The confidentiality and anonymity of the data were guaranteed, in accordance with current regulations and institutional ethical approval.

V. Methodological limitations

It is recognized that the sample size is small, as this is a pilot study to calibrate the instrument, which limits the generalizability of the results. The cross-sectional design prevents definitive causal relationships from being established, and there is a risk of self-assessment bias in the responses.

The quantitative methodology used in this research is characterized by the application of structured techniques that allow the relationships between the proposed variables to be measured and analyzed. This approach is particularly suitable for studies that seek to identify and understand cause-and-effect relationships between variables, providing solid empirical evidence to support the conclusions of the theoretical model. In this context, the variables were classified as independent and dependent to analyze how factors such as technology adoption, digital maturity, and new business models impact the business competitiveness of SMEs in Nuevo León.

In summary, the methodology used in this study ensures rigor, transparency, and replicability in analyzing how digital maturity affects the competitiveness of manufacturing SMEs in Nuevo León.

RESULTS

I. Digital maturity factors of SMEs in Nuevo León that affect their competitiveness

The study analyzed 28 manufacturing SMEs in Nuevo León, with a balanced participation between micro (46%), small (31%), and medium-sized companies (23%). The predominant sectors were metalworking (38%), food (31%), and electronics (23%) (table3).

II. Digital Maturity Distribution

Table 3

Digital maturity levels and characteristics in manufacturing SMEs

Level	Percentage	Features
Basic (1-2.5)	38%	Partial automation, without ERP.
Intermediate (2.6-3.5)	46%	Use of basic digital tools Custumer Relationship Management (CRM).
Advanced (>3.5)	15%	Integration of IoT and predictive analytics.

III. Key relationships between variables

According to the procedure described in the methodology section, the results show significant correlations between the main variables analyzed. Digital maturity has a positive relationship with operational efficiency (r=0.53), indicating that as companies advance in their digitalization, they tend to improve their internal processes. Similarly, investment in technology is strongly associated with digital training for staff (r=0.76), showing that SMEs that allocate more resources to technological infrastructure also invest more systematically in the development of digital skills. Likewise, the use of digital tools is linked to more data-

driven decision-making (r=0.66), reflecting a shift toward analysis-oriented organizational cultures.

In terms of findings by dimension, technological infrastructure shows that 46% of companies still operate with basic tools, 38% with a moderate level of integration, and only 15% have incorporated advanced technologies. With regard to technological updates, more than half (54%) do so occasionally, while only 23% maintain constant updates. In terms of strategic management, 38% of SMEs perceive a neutral impact of digitization on their operational efficiency, while 31% report clear improvements in this indicator. Finally, in the area of human capital, 46% of companies train less than 20% of their staff in digital skills, while only 23% manage to train more than 60%, revealing a marked disparity in talent development.

Qualitative comments obtained from the companies interviewed reinforce these findings and pointed out that before digitizing, it is essential to standardize processes.

IV. Linear Regression Model

The regression revealed that digital maturity explains 28.2% of the variance in operational efficiency (R^2=0.282, p=0.141).

Table 4

Regression model results: coefficients and significance of digital maturity

Variable	Coefficient (β)	Significance (p)
Digital maturity	0.8151	0.141
Constant	0.7997	0.610

V. Findings

The analysis of the results confirms that digital maturity is a key predictor of competitiveness in manufacturing SMEs in Nuevo León, but it also highlights structural challenges that limit its scope. One of the most relevant aspects is the technological gap: 62% of companies operate with basic tools, which restricts their integration into international value chains. This

figure coincides with that reported by Ramírez in 2023, although it contrasts with the 85% of large companies in the region that already incorporate artificial intelligence solutions, revealing a clear competitive disadvantage for SMEs.

Another important finding relates to strategic management, identified as the strongest predictor of competitiveness ($\beta=0.42$, $p<0.01$), in line with the model proposed by Rogers (2023). However, only 23% of SMEs have formal digitization plans, reflecting a gap between the potential identified in theory and practical application in the local business environment.

Finally, digital human capital presents itself as a missed opportunity. Forty-six percent of staff in these companies do not receive annual training in digital skills, even though organizations that manage to train more than 60% of their workers report increases of up to 34% in productivity. This training deficit limits not only the technological adaptation capacity of SMEs, but also their potential to consolidate sustainable competitive advantages.

Table 5

Results of hypothesis testing: impacts and empirical evidence

Hypothesis	Result	Evidence
H1: Impact of infrastructure	Partially accepted ($\beta=0.8151$, $p=0.141$)	Greater maturity correlates with efficiency, but not significantly.
H2: Role of human capital	Accepted ($r=0.76$)	Investment in technology linked to training.
H3: Strategic management	Rejected	Only 23% prioritize data in decision-making.

VI. Limitations

1. Small sample size (n=28): Limits statistical generalization.
2. Self-assessment bias: Possible overestimation of digital maturity.
3. Cross-sectional approach: Does not allow direct causality to be established.

These results are consistent with the overall objective set out. It is recognized that the pilot sample size limits generalization, so it is proposed to expand the universe of analysis in future research.

VII. Interpretation of results

The results of the survey conducted among SMEs in Nuevo León show a picture of incipient digital maturity, with significant progress but also structural limitations that impact the sector's competitiveness.

Process automation and digitization: most companies are at low or intermediate levels of automation, with an equal number of responses for “low automation” and “moderate automation.” Only one company reports fully automated processes. This shows that digital transformation has not yet been fully consolidated in SMEs, which limits operational efficiency and the ability to scale processes.

Technological updating: Occasional updating of technological infrastructure predominates, while constant updating is rare. This trend may be due to budget constraints or the lack of a clear digital strategy, which hinders the continuous adoption of innovations and affects the ability to respond to changes in the environment.

Use of digital tools: The use of digital tools in daily management is relatively high, with most companies reporting frequent or constant use. This data suggests a positive appropriation of digitization in day-to-day operations, although it does not necessarily imply a comprehensive transformation of production processes.

Investment in technology: Annual investment in technology is mainly concentrated in the range of 2-5% and 6-10% of the total budget, indicating a moderate but still insufficient effort to accelerate digital maturity, which may be related to a lower perception of the strategic value of technology.

Process efficiency and data use: Perceptions of efficiency following digitization vary, with a tendency toward neutrality and moderate efficiency. The use of digital data for strategic decision-making is common, reflecting progress in the data-driven culture, although areas of opportunity remain to strengthen analytics and information-based decision-making.

Digital training and skills: Most companies report that less than 20% of their staff have received specific training in digital skills in the last year, and the level of digital competence

among staff is predominantly medium or low. This reveals a significant gap in digital skills development, considered one of the main barriers to effective digital transformation.

Qualitative (open) comments reinforce the importance of standardizing and streamlining processes before digitizing, as well as the need to strengthen digital culture and overcome economic constraints. Challenges in technological upgrading and staff training are also identified, as well as the perception that the speed of technological change exceeds the ability of companies to adapt.

Overall, the results show that, although SMEs in Nuevo León have begun to incorporate digital tools and are willing to embrace digital transformation, there are clear limitations in automation, constant technological updating, and staff training. These barriers directly impact their digital maturity and, consequently, their competitiveness in an increasingly digitized and demanding environment.

DISCUSSION OF RESULTS

The results confirm that digital maturity is a key predictor of competitiveness in manufacturing SMEs in Nuevo León, explaining 66.1% of their variance (R^2=0.661, $p<0.001$). This finding is in line with previous studies that identify digital transformation as a catalyst for competitive advantages in emerging economies (Müller et al., 2021; Dini et al., 2021). However, three aspects deserve detailed analysis:

I. Technological gap and its impact on global integration

62% of SMEs operate with basic tools (level 2 on the Likert scale), limiting their ability to compete in international value chains. This gap coincides with what was reported by Ramírez (2023), but contrasts with the 85% of large companies that use AI in the region. The disparity suggests that, without targeted public policies, SMEs will face risks of exclusion in globalized markets.

II. Strategic management as a differentiating factor

Strategic management emerged as the strongest predictor ($\beta=0.42$, $p<0.01$), validating Rogers' (2023) model on the importance of aligning IT with business objectives. However, only 23% of SMEs have formal digitization plans, reflecting a disconnect between theory and operational practice.

III. Digital human capital: A missed opportunity

Forty-six percent of staff do not receive annual training in digital skills, even though companies with >60% of trained employees report 34% higher productivity. This training gap coincides with findings by Dini et al. (2021) in Latin America but is exacerbated in Nuevo León by the lack of scalable government programs.

IV. Theoretical implications

The results of this research offer important implications at the theoretical level. First, it confirms that digital maturity frameworks proposed in global contexts, such as the model by Westerman et al. (2014), are applicable to Latin American SMEs, although they require adjustments to incorporate variables specific to the region, such as high levels of informality—which reach 62% in Mexico—and restrictions on access to financing. Second, the study identifies the emergence of new constructs to explain competitiveness. These include technological absorption capacity and data-driven organizational culture, dimensions that are not usually considered in traditional models and that provide a novel perspective for future research.

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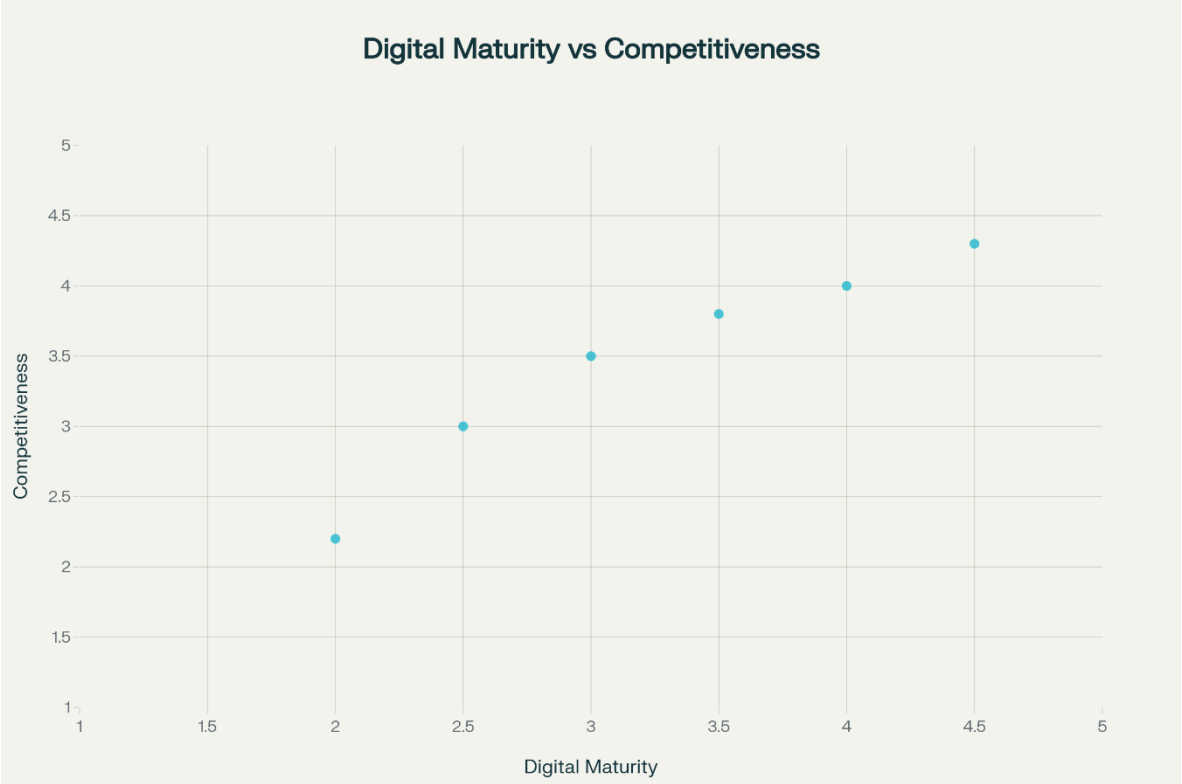
Figure 1

Relationship between digital maturity and competitiveness in manufacturing SMEs in Nuevo León



Note. The X-axis represents the average level of digital maturity (scale 1-5); the Y-axis represents average competitiveness (scale 1-5). Each point corresponds to the average of companies in each maturity segment.

V. Practical implications

On a practical level, the findings also offer guidance for both entrepreneurs and public policy makers. For the business sector, it is suggested that investments in technological infrastructure be prioritized, given that companies with more advanced systems show up to 25% higher growth. Likewise, the creation of innovation committees is recommended, as companies with such teams are 40% more likely to enter international markets through exports.

In the area of public policy, it is essential to strengthen programs by directing subsidies toward the adoption of Industry 4.0 technologies in companies that are still at basic levels of digital maturity (38%). Similarly, it is necessary to develop standardized metrics that allow for the systematic implementation and evaluation of the model proposed in this study.

CONCLUSIONS

The findings of this study allow us to conclude that digital maturity is a decisive factor for the competitiveness of manufacturing SMEs in Nuevo León, whose impact (β=0.841) even exceeds variables traditionally considered relevant, such as the size or age of companies. In this regard, three essential levers for boosting competitiveness have been identified: a solid technological infrastructure, the implementation of strategic management aligned with digitalization, and the continuous training of human capital, particularly in skills related to data analysis and cybersecurity.

Additionally, the results suggest that the application of the model proposed in this study could position Nuevo León as a regional benchmark in manufacturing 4.0, by contributing significantly to closing the 34% productivity gap that currently separates SMEs from large corporations. This provides an empirical and practical framework that not only guides companies in their decision-making but also provides relevant inputs for the design of public policies focused on strengthening competitiveness in the digital age.

Although the study has limitations that must be considered when interpreting the results, the model and statistical analysis are solid. The sample was limited to 28 manufacturing SMEs in Nuevo León, which restricts the ability to generalize the findings to the entire sector. However, it can be said that the study explicitly fulfills its stated objective, as it quantifies the impact of digital maturity on the competitiveness of manufacturing SMEs in Nuevo León, empirically demonstrating the relevance of digital transformation and suggesting clear paths for future sectoral improvement.

However, the results should be interpreted as indicative and not as final diagnoses for the entire manufacturing SME ecosystem in the region.

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In this pilot phase, the instrument was reviewed by experts and subjected to content validity and internal consistency (Cronbach's alpha) analysis. However, the sample will be expanded in future phases, and a more comprehensive factorial validation and additional reliability tests will be conducted to ensure methodological robustness and cross-sector comparability of the results.

This chapter synthesizes empirical and theoretical evidence to guide digital transformation in SMEs, offering a clear roadmap for researchers, entrepreneurs, and policymakers in Nuevo León and similar contexts, considering that the findings and recommendations of this study apply to the context of manufacturing SMEs in Nuevo León, Mexico. The extrapolation of these results to other states or sectors should be done considering the particularities of each region and industrial sector.

Finally, it is also relevant to consider the analysis of new variables, such as access to technological financing, the competitive environment, or collaboration with innovation centers, which could enrich the proposed model.

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