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THEORETICAL FOUNDATIONS OF COMPETITIVENESS IN SMES OF THE STEEL-AUTOMOTIVE SECTOR IN NORTHEASTERN MEXICO

FUNDAMENTOS TEÓRICOS DE LA COMPETITIVIDAD EN PYMES DEL SECTOR SIDERÚRGICO-AUTOMOTRIZ EN EL NORESTE DE MÉXICO.

Arlethe Yarí Aguilar Villarreal
Universidad Autónoma de Nuevo León, Facultad de Ciencias Químicas

Jesús Fabián López Pérez
Universidad Autónoma de Nuevo León, Facultad de Contaduría Pública y Administración

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Theoretical Foundations of Competitiveness in SMEs of the Steel-Automotive Sector in Northeastern Mexico

Arlethe Yarí Aguilar Villarreal[1]
arlethe.aguilarvll@uanl.edu.mx
https://orcid.org/0000-0002-1438-2180
Universidad Autónoma de Nuevo León,
Facultad de Ciencias Químicas
San Nicolás de los Garza, Nuevo León, México

Jesús Fabián López Pérez
jesus.lopezpz@uanl.edu.mx
https://orcid.org/0000-0002-8283-6359
Universidad Autónoma de Nuevo León,
Facultad de Contaduría Pública y Administración
San Nicolás de los Garza, Nuevo León, México

ABSTRACT

This article presents a theoretical review of the factors that influence the competitiveness of small and medium-sized enterprises (SMEs) in the steel-automotive sector in Northeastern Mexico. Based on a rigorous analysis of academic literature and national and international empirical studies, twelve key variables affecting the level of SME competitiveness are identified. These factors include: degree of technological innovation, productivity, energy efficiency, business profitability, level of Industry 4.0 adoption, strategic alliances, supply chain, employee training, globalization, innovation capacity, market orientation, and quality. The main objective is to establish a robust theoretical framework that explains how these variables interact and shape competitiveness in a global, dynamic, and highly demanding environment such as the steel industry linked to the automotive sector. Findings from previous research are integrated to support the relevance of each construct, enabling the design of a measurement instrument to assess the level of business competitiveness. This work aims to contribute to the development of a theoretical foundation for understanding the impact of competitiveness on industrial SMEs, and to offer a basis for the design of strategies that enhance their performance in both national and international markets.

Keywords: Competitiveness, SMEs, Steel Industry-Automotive Sector, Theoretical Framework, Northeastern México

[1] Autor principal.
Correspondencia: arlethe.aguilarvll@uanl.edu.mx

Fundamentos teóricos de la competitividad en PyMEs del sector siderúrgico-automotriz en el noreste de México.

RESUMEN

Este artículo desarrolla una revisión teórica sobre los factores que inciden en la competitividad de las pequeñas y medianas empresas (PyMES) del sector siderúrgico-automotriz en el Noreste de México. Con base en un análisis riguroso de literatura académica y estudios empíricos nacionales e internacionales, se identifican 12 variables clave que influyen en el nivel de competitividad de las PyMES, los factores relacionados son: grado de innovación tecnológica, productividad, eficiencia energética, rentabilidad empresarial, nivel de adopción de tecnologías 4.0, alianzas estrategias, cadena de suministros, nivel de capacitación para el personal, globalización, capacidad innovadora, mercado y calidad. El objetivo principal es establecer un marco teórico robusto que explique cómo estas variables se relacionan y condicionan la competitividad en un entorno global, dinámico y altamente demandante como el de la industria del acero vinculada al sector automotriz. Se integran hallazgos de investigaciones previas que sustentan la pertinencia de cada constructo, lo que permite diseñar un instrumento de medición para diagnosticar el nivel de competitividad empresarial. Este trabajo busca contribuir en el desarrollo del marco teórico que permita comprender el impacto de la competitividad en PyMEs industriales, así como ofrecer una base para el diseño de estrategias que impulsen su desempeño en mercados nacionales e internacionales.

Palabras clave: Competitividad, PyMEs, Sector Siderúrgico-Automotriz, Marco Teórico, Noreste de México.

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INTRODUCTION

On a global scale, micro and small enterprises (MSEs) play a fundamental role in economies, not only due to their capacity to generate employment and income, but also for their contribution to productive dynamism, innovation, and economic growth (OECD, 2021). However, the advancement of globalization has intensified competition, particularly with large multinational corporations, which has weakened the competitive position of many local businesses (Porter, 2007). In this context, Wanjohi (2008) highlights that the business environment is one of the determining factors for the sustained growth of MSEs.

In Latin America, these enterprises are a vital pillar of the productive structure. According to the Economic Commission for Latin America and the Caribbean (ECLAC, 2021), micro and small businesses account for 99% of all businesses and generate approximately 67% of regional employment (Europyme, 2021). Nevertheless, their impact on economic development still faces limitations due to structural barriers that affect their competitiveness.

In Mexico, the steel industry holds significant weight in the national productive apparatus, largely comprised of micro and small enterprises. These organizations face major competitive challenges, both domestically and internationally, especially in their linkage to strategic sectors such as the automotive industry, where the competition for market positioning is increasingly intense (Espinoza, Cavazos, & Cruz Álvarez, 2019). Within this context, MSEs in the steel-automotive sector emerge as key players for economic development, while requiring strengthening strategies to improve their participation in global value chains (Nahuat Arreguín, Blanco Jiménez, Cruz, & Buenrostro, 2016).

The steel industry represents a strategic sector in northeastern Mexico, particularly in the states of Nuevo León and Coahuila. In Nuevo León, the steel value chain encompasses various activities, including raw material production, pipe manufacturing, casting and rolling processes, production using electric furnaces, service centers, marketing, and other steel-related industries (CANACERO, 2023).

In Coahuila, pipe production and steelmaking using both blast and electric furnaces are also concentrated. The state also benefits from significant mineral deposits and a strategic border location that provides customs infrastructure for the import and export of steel products (CANACERO, 2023).

Within the national supply chain, the basic iron and steel industry, along with the manufacture of derived products, are key sectors in supplying the automotive industry. According to INEGI (2021), inputs from the steel sector account for 6.3% of the total demand from the automotive industry, making it the second most important source, only surpassed by the manufacture of auto parts.

A significant portion of regional steel production is destined for the automotive industry, which is divided into two main branches: final vehicle assembly and auto parts manufacturing. This study focuses on companies dedicated to the production of vehicles and engines.

According to INEGI (2021), the Mexican automotive industry is primarily concentrated in ten federal entities, which account for 97.5% of national production and generate 88.8% of sectoral employment. Coahuila ranks second nationwide in automobile and truck manufacturing, with a 15.9% share, while Nuevo León ranks sixth, with 8.6% of total production.

Globally, automotive production is divided into two major categories: light and heavy vehicles. In Mexico, the official classification defines light vehicles as passenger cars with up to eight seats, as well as light commercial vehicles such as pickups, SUVs, minivans, and panel trucks. Heavy vehicles include trucks over seven tons and buses with a capacity for more than eight passengers and also exceeding that weight.

The automotive value chain relies on both domestic and imported inputs from various economic sectors. In this regard, 41.5% of the inputs used are of national origin, while 58.5% come from foreign sources. Among the most relevant national inputs are those from the basic iron and steel industry, which account for 72.7% domestic participation, as well as the manufacture of iron and steel products, with 85% of components being domestically sourced.

The competitiveness of small and medium-sized enterprises (SMEs) in the steel-automotive sector in Mexico faces challenges that limit their ability to integrate sustainably and efficiently into national and international value chains. Despite the economic and strategic relevance of this industry, significant gaps remain. This work presents empirical studies on the competitive performance of SMEs across various sectors, particularly in this sector, which is highly relevant to the country's economic development.

This contribution provides a theoretical framework that encourages the development of analytical instruments and effective strategies to strengthen the competitive position of these companies. The aim

is to create a solid conceptual base that allows for comparison between studies and contexts, reflecting the generation of cumulative and transferable knowledge. This article outlines a comprehensive theoretical model that identifies, classifies, and relates the most relevant variables influencing the competitiveness of these types of organizations.

This study presents the consolidation of a robust theoretical framework that underpins the analysis of competitiveness in SMEs within the steel-automotive sector—a strategic segment for industrial development in northeastern Mexico. The theoretical approach helps systematize existing knowledge and facilitates the identification of conceptual gaps and the integration of dispersed empirical findings. This theoretical contribution is key for guiding future research focused on business strengthening and performance evaluation mechanisms.

The conceptual framework presented offers a useful tool for developing diagnostic instruments to measure business competitiveness levels. This work contributes theoretical knowledge about competitiveness in key industrial sectors.

THEORETICAL FRAMEWORK

As part of this research, a theoretical review is presented for each of the proposed variables in relation to the dependent variable of competitiveness, as the central focus of study in this context.

Technological Innovation Degree

Regarding the variable of technological innovation degree, Skuza et al. (2020) state that despite the growing demand for steel in Poland, the restructuring process of recent decades has driven both structural and technological change in the steel industry. The privatization of major steel producers and the influx of foreign capital have placed Polish metallurgy in a challenging period due to rising energy prices, CO_2 emission fees, and a market shift toward “green steel.”

Additionally, Sekiguchi (2021) argues that OECD countries experienced an increase in steel production, which led to improved international competitiveness. At the micro level, the analysis evaluated the link between technology and export performance of major non-OECD steel-producing countries. The technology selection of Chinese steel companies has contributed to the development of the steel industry.

On the other hand, Yuguo et al. (2021) present a study in which the development and application of a multidimensional model provide a method for assessing low-carbon emissions. This technique helps determine a company's carbon level and raise awareness among stakeholders about competitiveness trends in low-carbon contexts. Low-carbon competitiveness will become an integral part of business rivalry and a driving force for corporate survival and sustainability.

Tong et al. (2022) investigated the impact of core technological competence on the competitive advantage of high-tech SMEs in China, using 379 survey responses and a Structural Equation Modeling (SEM) approach. The results show that infrastructure and technology, advanced technologies, and R&D capacity significantly affect competitive advantage and organizational flexibility, which mediates the relationship between R&D and competitiveness. The study highlights the importance of strengthening technological infrastructure and organizational adaptability to achieve competitive advantage.

Radicic et al. (2023) analyzed the impact of digitalization on technological product and process innovations in German SMEs using data from the Mannheim Innovation Panel (MIP). They assessed three types of digitalization: production and logistics, digital value chains, and big data analytics using binary probit models across different company sizes. Results showed a heterogeneous impact depending on the type of digitalization and innovation. Internal R&D mitigates the effect of digitalization, proving to be beneficial for SMEs.

Finally, Merung A.Y. et al. (2024) examined social capital, technological innovation, and entrepreneurial orientation and how they influence the competitiveness of MSMEs in Kintamani, Bali. Using quantitative analysis with data from 276 firms and a SEM-PLS model, they found a positive correlation between competitiveness, social capital, innovation, and entrepreneurial behavior. Social capital acts as a moderator, strengthening the effects on competitiveness. The model showed a good fit, suggesting strategies to improve competitiveness and sustainable growth in Kintamani through enhanced social capital, technology adoption, and entrepreneurial orientation.

Productivity

As an independent variable, productivity has been examined in several studies. Conceição et al. (2017) presented a scenario where it was necessary to increase competitiveness without additional investment—only by optimizing products and the production process. The objective was achieved by updating equipment and reducing waste in certain areas. Ultimately, the project led to a 41% increase in productivity through the implementation of Lean tools. It also met customer demand and avoided the need to purchase a new production line, resulting in significant cost savings for the company while minimizing losses from the original line through increased output.

Similarly, Kumar (2021) argues that in India, over the past 30 years, both steel production and consumption have increased, leading to expanded production capacity. However, the competitiveness of India's steel industry does not show a significant break from the pre-reform decade. Real productivity—both labor and capital—has improved during the period studied. Kumar concludes that productivity is a critical factor in competitiveness. Using longitudinal time-series data, he offers a measurement framework to evaluate productivity trends, attributable to technological progress, under the identification of three key parameters for India's steel industry: changes in ownership structure, trade integration, and technological shifts in production routes.

Additionally, Owalla et al. (2022) conducted a systematic literature review to map global research on SME productivity, analyzing 109 empirical studies. They identified six key themes influencing productivity: organizational environment, capabilities, investment, types of innovation, external knowledge base, and commercialization. The results reveal the fragmented nature of current research and significant knowledge gaps. The authors propose a future research agenda and discuss policy implications for enhancing SME productivity in the context of evolving global trends.

Mansur et al. (2023) assessed the impact of various capabilities and orientations on the competitiveness of informal small businesses in Surabaya. Using surveys from 187 participants and SEM analysis, findings showed that production capacity, innovation, and labor productivity positively influence performance and competitiveness. Innovation and labor productivity contribute to competitiveness through performance. These results underscore the importance of strengthening productive and innovative capacities to enhance competitiveness.

Energy Efficiency

Chowdhury et al. (2018) report that in the United Kingdom, the industrial and manufacturing sectors face a major challenge in contributing to the national goal of reducing CO_2 emissions by 80%, while also improving economic competitiveness in the face of low-cost imports. The study explores energy efficiency improvements from three perspectives: steam network system efficiency, waste heat recovery technologies, and bioenergy utilization, particularly in two sectors—the iron and steel industry and the food and beverage sector. Currently, there are no standardized business models for energy efficiency in industry, so adapting a known business model that integrates energy systems optimization is necessary.

Haider et al. (2019) conducted an analysis comparing energy use in India's steel industry. The objective was to estimate energy efficiency within the framework of total factor productivity and identify potential energy savings across states at optimal scale. The study recommends implementing a standardized energy efficiency program and promoting a market-based and regulatory mechanism to realize the enormous energy-saving potential.

Vögele et al. (2020) provide a broad overview of the challenges facing the steel industry in the European Union, such as volatile input prices, uncertainties regarding CO_2 regulations, emissions, and market shocks caused by import tariffs.

Radoslaw (2020) also studied the steel sector—critical to both Poland's national economy and the global market. In response to global steel market challenges and the need to boost competitiveness, the study outlines a series of actions to improve energy efficiency in steel production. It seeks to identify energy efficiency trends within companies, particularly those aiming to improve production processes. It offers investment policy recommendations for Poland's steel sector in the Industry 4.0 era. The proposed econometric model shows the relationship between electricity consumption per ton of steel and investment levels, linking these expenditures to Industry 4.0 implementation strategies. The study suggests that steel companies should engage in network-based cooperation with cyber-physical intelligence to improve flexibility along the supply chain and reduce energy consumption.

Stroud et al. (2020) propose energy efficiency as a key area of innovation activity in the European steel industry, with authorities aiming to "green" worker behavior. The focus is on combining digital innovation and strategic management with gamification to drive behavioral change toward energy

efficiency. The study presents challenges for workers and unions in the sector, highlighting the dual pressure of green transformation and digitalization. It outlines labor relations, digital innovation management for green practices, and potential outcomes for workers within a heavily unionized industry.

Talaei et al. (2020) developed a system-based model to assess the long-term potential of energy efficiency alternatives in reducing household gas emissions. A case study was conducted on Canada's iron and steel sector. The results informed the development of energy demand projections, offering detailed insights into unit operations, fuel types, and energy intensities. These data were used in a long-term energy alternatives planning model.

Di Foggia (2021) analyzed how energy-efficient servitization capabilities impact business performance in 293 manufacturers of electrical and machinery equipment. Using two structural equation models, the mediating role of servitization was assessed in relation to competitive strategy analysis and regulatory framework awareness. The findings show both factors positively influence business performance through servitization. The growing demand for energy-efficient products and energy management services highlights the importance of these approaches for decarbonization and enhanced industrial competitiveness.

Gąsior et al. (2022) also studied the relationship between energy-efficient servitization and business performance in 293 manufacturers of electrical and machinery equipment. Using structural equation models, they tested how competitive structure analysis and regulatory knowledge affect performance through servitization. Results show both factors significantly enhance business performance. With expected growth in demand for energy-efficient products, the need for lower energy footprints and energy management services becomes critical to support industrial decarbonization and competitiveness.

Majid et al. (2023) examined the impact of eco-efficiency actions—such as resource savings and renewable energy use—on SME performance across 28 EU countries. Using survey data and logistic regression analysis in SPSS, they analyzed how these practices influence costs, investments, and barriers. Findings reveal that SMEs often lack information about the financial and innovation benefits

of these practices. The results provide guidance for SMEs and policymakers to promote sustainable development and improved decision-making.

Tazhibekova et al. (2024) evaluated the environmental sustainability of SMEs in Kazakhstan by analyzing their adoption of green strategies and energy-saving technologies through surveys with entrepreneurs and managers. Results indicate high environmental awareness and willingness to implement sustainable practices, reflecting SMEs' potential for sustainable development. The growing adoption of energy-efficient technologies enhances competitiveness and reduces ecological footprints. These findings support the development of effective environmental policies and green investment strategies to strengthen SMEs' resilience and environmental responsibility.

Business Profitability

As part of the study, business profitability was also considered an independent variable. Nguyen et al. (2016) developed a research model to examine the influence of organizational capabilities in Taiwan's steel industry, considering manufacturing strategy, business performance, and the effect of manufacturing strategy on performance. The study concluded that organizational capabilities positively affect both the manufacturing strategy and business performance. The results empirically verify that improving organizational capabilities is the most critical factor for enhancing manufacturing strategy and business outcomes. The authors suggest that Taiwanese steel companies should strengthen their organizational capabilities to develop manufacturing strategies that improve profitability.

Vătămănescu et al. (2017) analyzed the relevance of strengthening relational capital in SMEs operating in a globalized market. Their study demonstrated how competitiveness influences business networks with the goal of facilitating the internationalization of European SMEs in the steel tube sector. The results indicate that internationalization effectiveness is indirectly influenced by competitiveness, which drives SME managers to leverage personal and organizational relationships through consistent work networks and capitalized trust. At this level, business networking had a positive and significant impact.

Lesáková et al. (2019) analyzed SME profitability in Slovakia's mechanical engineering industry by evaluating influential internal and external factors. Using the DuPont pyramid analysis and survey data, the study identified elements affecting profitability. Friedman and Wilcoxon tests were applied to assess survey responses and test three defined hypotheses. The findings provide key guidelines for short- and

long-term decision-making, highlighting the importance of strategically managing profitability in this essential sector of Slovakia's economy.

Ramirez-Garzon et al. (2020) assessed the application of the Organizational Management Modernization Model (MMOM) and its impact on Return on Assets (ROA) in 144 Colombian SMEs. Using multiple regression analysis, they found that components such as strategic direction, production management, human resource management, logistics, and innovation and knowledge accounted for 20% to 23% of profitability. The findings underscore the importance of these organizational elements for business competitiveness and their influence on SME profitability, providing a foundation to improve management and performance in the sector.

Gajdzik et al. (2021) analyzed resource intensity in the Polish steel industry and its relationship with investment, focusing on energy consumption during steel production. Using statistical data from 2004 to 2018, the authors developed econometric models to evaluate the impact of investment on reducing electricity and coke consumption per facility. The results confirmed that higher investments contribute to reducing resource intensity, thus improving competitiveness and environmental protection. These findings are relevant for public policy and business leaders, suggesting a focus on technological investments to optimize efficiency and sustainability.

Shashina et al. (2022) emphasized that profitability management is key to improving long-term efficiency and business competitiveness. Their study analyzed how to optimize profitability through an integrated model within the company’s general strategy. The importance of internal factors such as productive efficiency, organizational structure, leadership quality, and asset composition is highlighted. The proposed model includes an information base and indicator system to evaluate both internal and external environments, aligning with strategic goals. Proper implementation of the model can identify opportunities and ensure sustainable economic growth.

Mansur et al. (2023) studied various factors influencing performance and competitiveness in informal small businesses in Surabaya, Indonesia. Based on primary data from 187 surveys and using Structural Equation Modeling (SEM), results show that production capacity, innovation, and labor productivity significantly affect performance and competitiveness. Market orientation, however, only affects competitiveness. Furthermore, innovation and labor productivity enhance competitiveness through their

influence on business performance. This study offers key insights for improving business competitiveness.

Henríquez-Calvo (2024) analyzed activities, limitations, and challenges related to process innovation in 56 Colombian exporting SMEs through a 19-question survey, artificial neural networks (ANN), and Spearman correlation. The findings reveal that collaboration with research institutions and suppliers is critical for process innovation, which is prioritized by SMEs to boost competitiveness. Innovation was linked to growth, productivity, and internationalization, despite Colombia's innovation gap. Companies are investing in R&D and external collaboration with a focus on efficiency. The study recommends exploring innovation connections using machine learning.

Strategic Alliances

Strategic alliances were also studied as an independent variable. Yeh et al. (2017) report that companies seek to create synergy through research and development partnerships. This study examines the performance of firms within such alliances, focusing on their dependence on resources, organizational learning, and the impact on alliance performance. The results indicate that alliances have significant implications for effectiveness, and practitioners aim to improve their outcomes. A company's ability to leverage both internal and external R&D activities influences its capacity to generate economic value through innovation and sustain its competitive advantage.

Adoption Level of Industry 4.0 Technologies (First Part)

Götz et al. (2020) reported on the implications and effects of adopting Industry 4.0 in internationally-oriented companies. Their study reveals that businesses are preparing to face challenges such as acquiring the necessary knowledge and becoming familiar with implementing 4.0 technologies. The study highlights that the path toward Industry 4.0 favors quality over low cost, arguing that a company's competitiveness will depend on its maturity in adopting Industry 4.0. Furthermore, this impact is shaped by cooperation among partners.

Sima et al. (2020) explored major opportunities and challenges, especially in education, related to changes in the work environment brought by Industry 4.0, such as evolving occupations, job profiles, and other human capital drivers. The study analyzes consumer behavior and workforce development from the perspective of the Fourth Industrial Revolution. The findings reflect technological shifts—

especially digitalization, information technology, and communication technologies—as drivers of transformation in labor dynamics and competitiveness.

Miśkiewicz et al. (2020) conducted a case study analyzing the implementation of digitalization in a manufacturing company, which led to improved efficiency and changes in the organizational structure. The study emphasizes that technological changes require the integration of information technologies. The authors recommend that production companies adopt digital processes and cloud computing to improve production efficiency and financial performance. Applied specifically to the steel industry—where digital production processes are still rare, this study identifies the need to address multiple dimensions: economic, political and legal, environmental, technical, technological, and sociodemographic. Technological changes also imply the adoption of IT and communication systems for production management.

As part of the analysis, the study highlights the importance of identifying all relevant domains necessary for the transformation of the steel industry under Industry 4.0, including economic, legal, environmental, technical, and demographic aspects. This holistic view reinforces the idea that digital transformation must be systemic to improve competitiveness.

Technological changes also demand the implementation of information and communication systems for production management. In particular, the integration of these technologies enables real-time monitoring, enhanced traceability, and data-driven decision-making, which are critical to optimizing steel production processes and reducing inefficiencies.

Moreover, companies must not only invest in technologies but also in the upskilling of their workforce to handle new tools and adapt to a digitally connected production environment. The transition to Industry 4.0 goes beyond machinery, it implies cultural and organizational change.

In summary, the literature highlights that the level of Industry 4.0 adoption is a determining factor in the competitiveness of firms in the steel sector. Organizations that are able to integrate advanced technologies with flexible, data-driven management strategies are more likely to maintain a sustainable competitive advantage in increasingly dynamic and globalized value chains.

Supply Chain Management

As part of the study, the variable supply chain was analyzed. Popescu et al. (2016) conducted an analysis and assessment of the growth in excess steel production capacity and its integration into the international supply chain, as well as the effects of steel manufacturing on employment in the United States. This study provides evidence on mechanisms that drive top-tier productivity growth in the U.S. steel industry, the growth models within international steel supply chains, and the advantages of implementing corrective trade measures for this sector.

Pradabwong (2017) examined the interrelationships between business process management and supply chain collaboration, collaborative advantage, and organizational performance. The study highlights the role of both intra- and inter-organizational practices, demonstrating the combined and joint impact of business process management and supply chain collaboration. The author suggests that focusing solely on internal improvements is insufficient and that enhancing supply chain collaboration is necessary to raise overall organizational performance levels.

Pinto et al. (2020) conducted a study identifying various strategies for supply chain integration aimed at self-sufficiency and resource ownership retention. In this case study of the European steel industry, improvements were reported that increased the self-sufficiency of raw materials and retention of resource ownership. The study also describes the adoption of vertical integration strategies on the supply side, and horizontal strategies at end-of-life stages for recycling, restoration services, repairs, and maintenance. These approaches strengthen the resilience and sustainability of the supply chain, contributing to the long-term competitiveness of steel-producing companies.

Training and Workforce Development

As part of the study, workforce training was analyzed as a variable. Carreño et al. (2016) presented the results of research conducted on a sample of companies from the steel and metal-mechanical sectors in the department of Boyacá, Colombia. The study evaluated workers' standing in relation to the labor competency standards relevant to their daily activities. The objective was to highlight the importance of human talent training as a key factor for business competitiveness.

Evans et al. (2016) presented a study that explores the actions needed to "green" existing occupations and meet the skill demands of new environmental sectors and jobs. The authors argue that efforts to

green the workforce are developing at different levels of intensity, primarily due to variations in institutional contexts. These efforts include adapting existing training systems and creating new skill frameworks to respond to the environmental transformation of industries like steel.

Bismala et al. (2017) analyzed how to optimize human resource management (HRM) to improve the competitiveness of 69 SMEs using observations, surveys, interviews, and literature review. The results show that SME competitiveness increases when key HRM functions are strengthened—such as targeted recruitment based on skills and knowledge, employee retention through fair compensation and a positive work environment, talent development, and performance evaluation using objective and equitable indicators. This comprehensive HRM approach is emphasized as an essential strategy to enhance competitiveness in small and medium-sized enterprises.

Globalization

As part of the study, globalization was analyzed as an independent variable. Parc (2018), using the generalized double diamond model, incorporated internationalization as a crucial element—especially for Asian countries such as Japan. The study compared Japan's competitiveness with neighboring countries competing in the global market. It concluded that Japan's current economic challenges and its slow recovery are due more to a lack of globalization compared to its regional counterparts, rather than specific macroeconomic issues.

Konak et al. (2019) presented a study aiming to test the effect of steel production on global output and the Global Competitiveness Index. The analysis examined the extent to which iron and steel production influence these variables. According to the results, a one-unit increase in total steel production boosts long-term economic growth by 0.104 and short-term growth by 1.386 units. Additionally, a one-unit increase in steel production reduces unemployment in the long term by 0.105 units, and global competitiveness increases by 0.22 units.

Yuguo et al. (2021) assumed that low-carbon competitiveness is an effective way for companies to remain relevant in the global green economy agenda. They selected three Chinese steel companies as case studies and assessed their low-carbon performance using a set of mathematical methods. The approach allowed them to quantitatively compare the low-carbon competitiveness of the three firms.

The proposed evaluation method demonstrates the capacity to measure and compare the abstract concept of low-carbon competitiveness, emphasizing its growing importance in a globalized context.

Innovation Capacity

Innovation capacity was also considered an independent variable in this study. Álvarez et al. (2021) provided empirical evidence on the complementarity between different sources of knowledge and innovation performance in manufacturing companies in Argentina's automotive and iron & steel industries. The authors tested the relationship between national and foreign knowledge sources and their influence on innovation.

The findings reveal that while international markets and activities can enhance firms' innovation performance, they do not necessarily undermine local knowledge bases. This supports the argument in favor of building national and local capacities—particularly relevant for Latin American countries. These empirical results highlight the ongoing relevance of developing internal capabilities within firms as a foundation for absorbing external knowledge, especially in emerging economies. Furthermore, they emphasize the predominance of embedded knowledge acquisition as a key mechanism for innovation in developmental contexts.

Market Orientation

Market orientation was also analyzed as an independent variable. Guzmán et al. (2019) conducted an econometric analysis of steel production in Mexico to determine the price elasticity of domestic steel production and quantify the impact of international prices on wholesale prices in Mexico. The study covered annual data from 1980 to 2017 and included three regression equations.

The findings indicate that in both the short and long term, steel production in Mexico responds inelastically (0.0425% in the short term and 0.2419% in the long term) to a 1% change in its own price. Additionally, the international steel price influences Mexico's wholesale price by a factor of 0.05 for every 1% change. These results suggest that international market conditions are a significant determinant of pricing and competitiveness in the domestic steel industry.

Quality

Finally, quality was analyzed as part of the theoretical framework. Whang (2017) conducted an analysis of bilateral trade data from the 83 largest economies in the world to examine the relationship between

empirical findings and theoretical models. The study found support for a “quality competition” model rather than a “price competition” one. In this model, companies in countries with a comparative advantage in a particular product tend to improve product quality rather than reduce production costs—competing on price adjusted for quality. The results emphasize the strategic importance of product quality in differentiated product markets.

Compañero et al. (2021) conducted a study based on interviews to identify the different quality dimensions of steel scrap. The research revealed varying definitions among scrap traders and steel mills regarding the desired condition, physical state, shape, size, and homogeneity of the material. The study established that the relationship between quality and the level of information about material characteristics increases opportunities for efficient resource use.

Valdez de la Rosa et al. (2021) identified the causal relationship between independent variables such as process quality and product innovation, and the dependent variable of competitiveness in the manufacturing sector of the automotive industry, which relies heavily on steel inputs. The study found that both process quality and product innovation have independent and positive causal effects on competitiveness in automobile manufacturing.

RESEARCH OBJECTIVE

To develop a comprehensive theoretical framework that identifies and analyzes the key factors influencing the competitiveness level of micro, small, and medium-sized enterprises (MSMEs) in the steel-automotive sector in northeastern Mexico, based on a review of specialized literature and empirical evidence. The purpose is to support future research and inform the design of strategies aimed at strengthening the competitive position of this sector.

METHODOLOGY

This study adopts a qualitative, exploratory approach based on a systematized theoretical and documentary review. An extensive search of scientific literature was conducted, selecting documents published between 2005 and 2023.

As a result, over 80 primary sources were analyzed, from which theoretical constructs and variables related to business competitiveness were extracted. In addition, national and international empirical studies were included to validate and contextualize the identified factors.

Through thematic and comparative analysis, the variables were organized into conceptual categories, and an integrative theoretical framework was proposed. This framework comprises 12 key factors that influence the competitive performance of SMEs in the steel-automotive sector in northeastern Mexico.

RESULTS

The analysis led to the identification of 12 critical variables consistently associated with competitiveness levels in industrial SMEs, particularly those linked to the steel-automotive sector. These variables are:

1. Degree of Technological Innovation
2. Productivity
3. Energy Efficiency
4. Business Profitability
5. Adoption Level of Industry 4.0 Technologies
6. Strategic Alliances
7. Supply Chain
8. Employee Training Level
9. Globalization
10. Innovative Capacity
11. Market Orientation
12. Quality

These factors were categorized into internal dimensions (degree of technological innovation, productivity, business profitability, innovative capacity) and external dimensions (strategic alliances, globalization, market orientation). Additionally, the analysis confirmed the importance of interactions between variables such as technological innovation, employee training, energy efficiency, and profitability in enhancing competitiveness.

DISCUSSION

The theoretical framework presented shows that the competitiveness of SMEs in the steel-automotive sector does not rely solely on internal factors such as productivity or quality, but rather on the dynamic combination of technological capabilities, linkage strategies, and adaptability to the global environment.

The literature shows consensus that the incorporation of emerging technologies (such as Industry 4.0) and continuous workforce training are key catalysts for enhancing competitive performance.

There are identified theoretical gaps regarding the integrated measurement of these factors and how they interrelate under the specific conditions of the Mexican industrial context. The proposed theoretical framework aims to fill this gap by serving as a foundation for future research that can empirically validate the relationships between the variables, as well as for the development of diagnostic instruments and strategic proposals aimed at improving business competitiveness. This theoretical approach can be adapted and applied to industrial sectors across Latin America, contributing to the conceptual understanding of competitiveness in emerging economies.

Based on a systematic analysis of literature and empirical studies, twelve variables were identified as having a significant impact on the competitiveness of SMEs in the steel-automotive sector in northeastern Mexico. These variables were organized into an integrative conceptual model based on four key dimensions: technological, internal organizational, external environment, and human capital.

The results highlight relevant relationships between variables, such as the direct influence of technological innovation on productivity and innovation capacity; the contribution of Industry 4.0 adoption to energy efficiency and profitability; and the strategic role of alliances and supply chain management in integration into global markets. Furthermore, the cross-cutting effect of workforce training on multiple dimensions of business performance is emphasized. This theoretical model provides a structured view of the interrelated factors that shape the competitiveness of industrial SMEs, enabling further empirical validation and the development of diagnostic tools to support strategic decision-making within the sector.

CONCLUSIONS

This study proposes a comprehensive theoretical framework that synthesizes the main factors determining the competitiveness of micro, small, and medium-sized enterprises (MSMEs) in the steel-automotive sector. It is based on an exhaustive review of scientific literature and empirical evidence. The conceptual model developed identifies 12 key variables and establishes connections among them, allowing for an understanding of their interaction within a complex and highly competitive industrial environment.

Among the main findings are the central role of technological innovation, the adoption of emerging technologies, and workforce training as strategic pillars for strengthening competitiveness. Additionally, the study underscores the need to improve connections with international markets, optimize production processes, and consolidate strategic alliances to enhance business positioning.

The primary value of this research lies in its theoretical contribution: it offers a solid conceptual foundation that can serve as a starting point for quantitative studies, the development of measurement instruments, and the design of intervention strategies for industrial SMEs. Furthermore, the model has the potential to be adapted to other manufacturing sectors in similar contexts, thereby broadening its applicability and relevance in the study of business competitiveness in emerging economies.

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