INNOVATION AND ITS CORRELATION WITH NEW INDUSTRIAL PROCESSES IN SMALL MEXICAN ENTERPRISES

LA INNOVACIÓN Y SU CORRELACIÓN CON NUEVOS PROCESOS INDUSTRIALES EN PEQUEÑAS EMPRESAS MEXICANAS

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SUMMARY

The objective of this study was to determine the level of statistical correlation between the variable innovation, which comprises four dimensions (market-oriented innovation, process innovation, product or service innovation, and human resources innovation), and the variable Industry 4.0 (new industrial processes) in micro and small enterprises (MSEs) in the municipality of Durango, Mexico. This is a quantitative, non-experimental, cross-sectional study with a correlational scope. The method applied was the calculation of Pearson's Correlation Coefficient. The study concludes that the variables analyzed in Durango's MSEs are similar to those found in larger contexts such as MSEs in Latin America. Furthermore, the correlation coefficient obtained between the variable MSE 4.0 and the dimensions of the variable Innovation ranges from .236 to .299, which implies a moderate association between both variables. The correlation is significant, as the associated p-value is practically zero.

KEYWORDS: Industry 4.0; business entities; investment; technology management

RESUMEN

El objetivo de este trabajo consistió en determinar el nivel de correlación estadística de la variable innovación que tiene 4 dimensiones (innovación dirigida al mercado, innovación en los procesos, innovación de los bienes o servicios e innovación en recursos humanos) con la variable industria 4.0 (nuevos procesos industriales) en las micro y pequeñas empresas (Mypes) del municipio de Durango, México. Es un estudio cuantitativo, no experimental, transversal y con un alcance correlacional. El Método aplicado fue el cálculo del Coeficiente de Correlación de Pearson. Se concluye que las variables analizadas en la Mypes en Durango son similares a la de otros entornos más grandes como el de la Mypes en América Latina, además que el coeficiente de correlación alcanzado entre la variable Mype 4.0 y las dimensiones de la variable Innovación van de .236 a .299, lo que implica una asociación moderada entre ambas variables y la correlación es significativa, ya que el p-valor asociado es prácticamente 0.

PALABRAS CLAVE: industria 4.0; entidades empresariales; inversión; gestión tecnológica

INTRODUCTION

Micro, small, and medium-sized enterprises are a fundamental component of the business fabric in Latin America; in Mexico, 98.9% of enterprises are MSEs, 0.9% are medium-sized, and only 0.2% are large (INEGI, 2020). Their contribution to the formal economy, together with medium-sized enterprises, can be assessed based on three important factors: they represent 99.5% of formal enterprises, generate 61.2% of formal employment, and contribute 24.6% of production; this makes them a central actor enabling continuous, innovative, technological, inclusive, and sustainable economic growth (Heredia, 2020; Dini, 2018).

According to studies and information compiled by the Spanish Confederation of Business Organizations (de Organizaciones Empresariales 2018), the innovation scarcity is one of the weaknesses of micro, small, and medium-sized enterprises in Latin America; this is reflected in a notable gap in this area, observed not only in the field of research and development (R&D) and patents but also in product and process innovation. Falling behind in digitalization processes and the incorporation of new disruptive technologies could be considered a threat to the survival of these enterprises. Mexican MSMEs are no exception.

It is important to highlight that, in Latin America, most of these enterprises have carried out minimal technology management, as indicated in their studies (Estrada, Cano & Aguirre, 2018); only to meet the requirements of basic or generic technological resources that allow them to enter and stay in contact with the market. This gives rise to the idea for this research.

It is common for micro and small enterprises (hereinafter MSEs) to consider that being an Industry 4.0 (equivalent to new industrial processes) simply means having a website, using social networks, and storing data in the cloud. However, it essentially consists of physical machinery, sensor-equipped devices, and software that work in networks and allow for better prediction, control, organization, and planning of business and organizational outcomes; AI or artificial intelligence is also part of this process.

Experts recognize that adopting these types of technologies will allow MSEs to enhance their resources, reduce costs, and help them become more efficient, even if this entails financial implications.

These entities (MSEs) are a fundamental component of Durango business fabric; according to INEGI (2020), they represent 97.2% of economic units.

The above makes them a central figure, generating a development dynamic that allows for continuous and innovative economic growth, as well as technological, inclusive, and sustainable growth (Dini, 2018; Heredia, 2020).

These antecedents show that it is necessary to conduct studies focused on the analysis and importance of innovation in MSEs and its correlation with new industrial processes or Industry 4.0. The objective of the research consisted of determining the level of statistical correlation of the innovation variable with the Industry 4.0 variable in micro and small enterprises (MSEs) of the Municipality of Durango, Durango, Mexico.

MATERIALS AND METHODS

A quantitative, non-experimental, cross-sectional approach with a correlational scope was employed. Variables were classified into two groups: Analytical (innovation with 4 dimensions: market-oriented, processes, goods or services, and Human Resources (HR), and MSE 4.0), and descriptive (permanent workers, female workers, family workers, sales, profits, personal business income, and standard of living) for sample description.

Data collection was conducted using the questionnaire by Posada, Peña & Aguilar (2020), applied to 449 directors of micro and small enterprises in the Municipality of Durango, Durango, Mexico. The analysis was exploratory of a dataset that allowed obtaining statistics and graphs describing the variables and revealing their behavior.

Simple Random Sampling (S.R.S) was used, targeting directors of MSEs in the Municipality of Durango, with a representative sample of 449 MSEs out of the total existing in the Municipality.

Data analysis was completed in 2024. The database used was obtained from the applied questionnaire by Posada, Peña & Aguilar (2020). An MSE was defined as any for-profit organization with at least two and up to 50 people working in it. The director was considered the person who makes the majority of decisions.

The Pearson Correlation Method was applied in the study, allowing for the calculation and definition of the correlation level between the studied variables. After processing the questionnaire information, statistical tools

such as Sum, Frequency, Arithmetic Mean, and Boxplot graphs were applied to the collected data.

Industry 4.0 has been one of the most innovative topics within the business sector, becoming an obligation for any MSE and entrepreneurship. The adaptation of new technologies to prevent businesses from dying out and the digital era are global trends, a change that is circulating increasingly faster worldwide, and Mexico is not an exception.

The (MSEs) of Durango could be at risk of disappearing if they do not implement innovation and Industry 4.0 strategies in the short term, as they represent a significant percentage of the business entities in the Municipality of Durango. The above justified this study, which constitutes a relevant contribution to define possible strategies for the studied MSEs.

In Mexico, according to the National Institute of Statistics and Geography (hereinafter INEGI), MSMEs have a very short lifetime. Only 7% survive within a three-year period, and only 15% of these are digitized in their processes. They represent 99.8% of all existing Mexican enterprises (Figure 1), employ 68.4% of the available labor force in the country, and account for 52.2% of the Gross Domestic Product (hereinafter GDP) (Vásquez & Ávila, 2020).

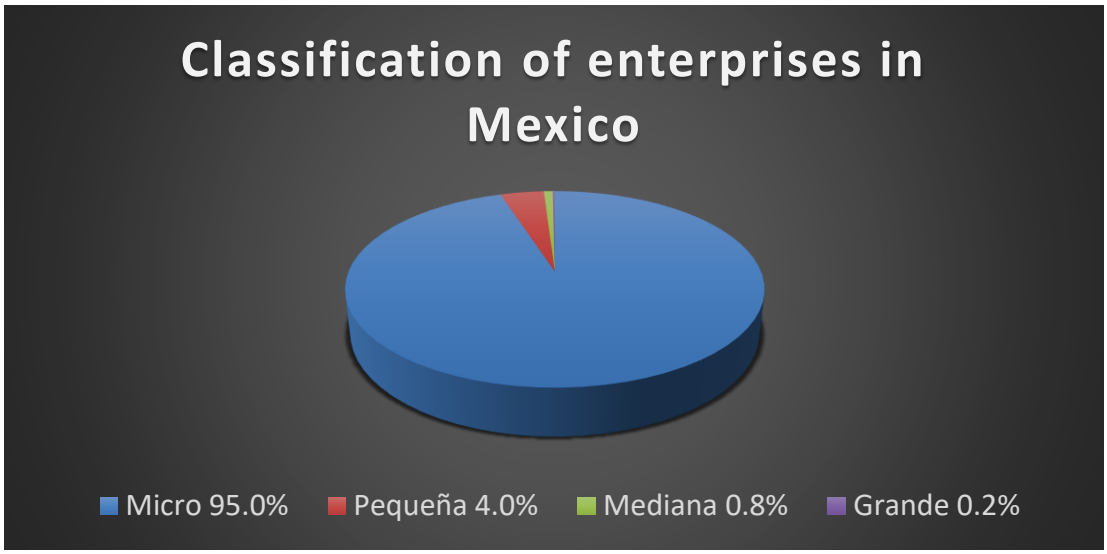

Figure 1 Classification of enterprises in Mexico by size. Source: Rojero et al. (2022) based on INEGI (2020).

In this sense, it is necessary for MSMEs to develop strategies for their competitiveness, favoring increased productivity and promoting sustained growth (Solleiro & Castañón 2005). In a regional context, the reality in the

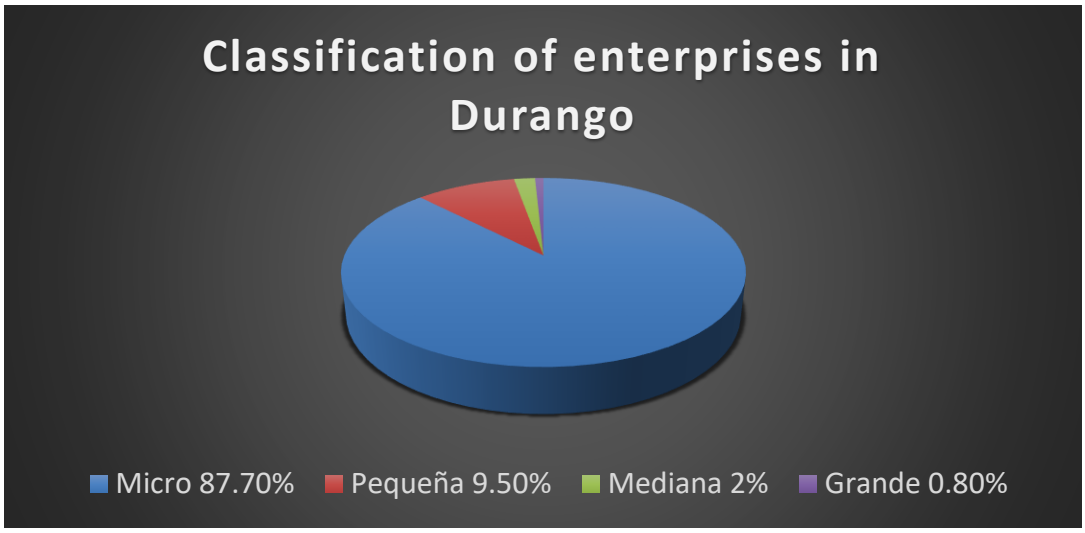

Figure 2 Classification of enterprises in Durango. Source: Rojero et al. (2022) based on INEGI (2020).

In Durango, according to studies by Gómez (2016), in MSMEs, coaching leadership is the most frequent style in enterprises, being the predominant style. This could be one of the characteristics of MSME managers that can drive these small enterprises along the path to implementing 4.0 technology.

Internal and external financing (Castillo, 2010) should also be considered as a mechanism to insert them into Industry 4.0, for the purpose of acquiring goods or technologies, where investment in innovation facilitates the achievement of their goals, development, and competitiveness with innovative and creative response (Cañete, 2020).

It is important to highlight that, according to Estrada, Cano & Aguirre (2019), MSEs in Latin America have carried out minimal technology management; only to meet the requirements of basic or generic technological resources that allow them to enter and stay in contact with the market.

Latina (2000) points out that the ongoing fourth industrial revolution forces a rethinking of the role of MSEs in this region, as well as the generation of policies that allow them to develop capabilities to compete successfully in current productive systems.

The economic challenges presented daily and globalization processes make ICTs key elements of great operational importance for MSMEs.

According to Núñez (2020), they impact productivity, investment returns, and sales increases. In industrialized countries, almost 30% of the established research and development budget is focused on the use, development, and adaptation of ICTs. According to studies by Alam & Noor (2009), MSMEs have recently begun to use technological tools.

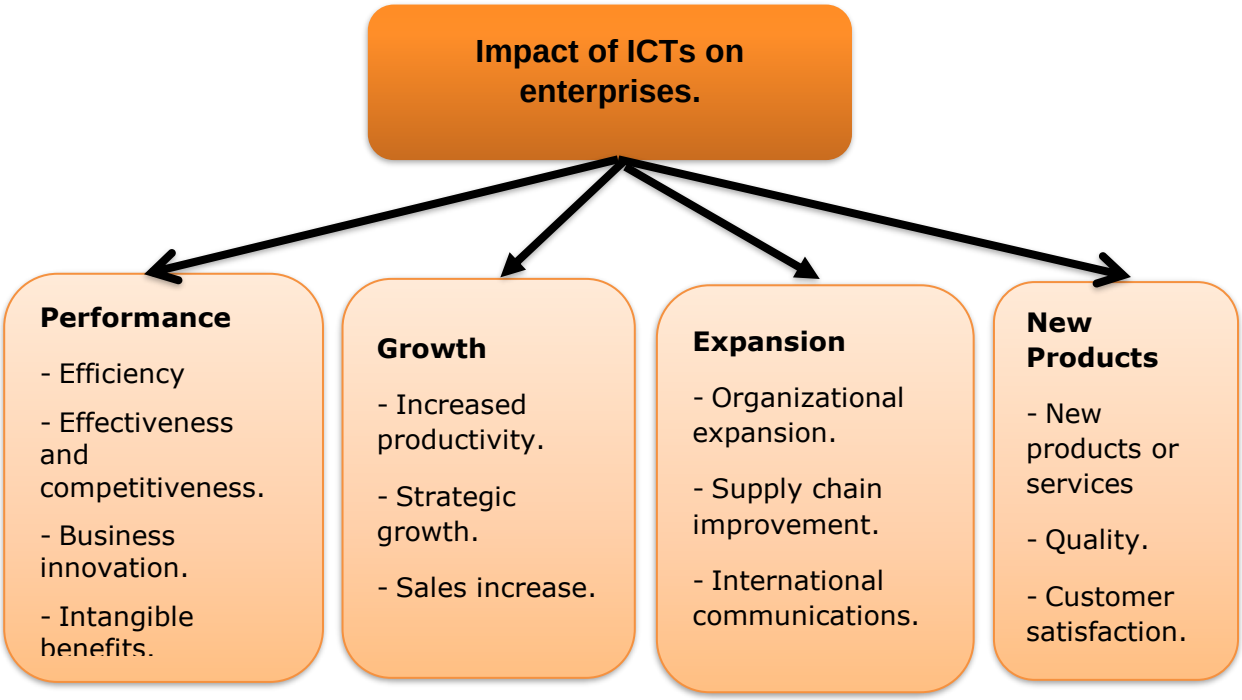

Figura 3 *Impact of ICTs on enterprises. Source: Consoli (2012).*

Figure 3 shows a model of the role of information and communication technologies in MSMEs with important aspects such as their performance, growth, expansion, and new products.

Recent data indicate that only 23% of MSMEs in Mexico have the solvency to migrate to new digital technologies. These data reflect the panorama of the conditions in which Mexican MSMEs find themselves regarding ICT use and the challenges they must overcome to insert themselves into Industry 4.0.

The most important concept used in the study was that of MSE 4.0, considered by Posada, Peña, & Aguilar (2020) as the physical machinery, sensor-equipped devices, and software that work in networks and allow for better prediction, organization, and planning of business, as well as the organizational results of these small enterprises.

ANALYSIS OF RESULTS

Upon conducting the exploratory analysis of the database, the following statistical results were obtained:

	Total
Permanently	2174
Women	1103
Family members	699

Table 1 People currently working in the enterprise. Source: Own elaboration using RStudio (R Core Team, 2023)

From Table 1, it is deduced that of the people currently working in the enterprise, 50.7% are women and 32.2% are family members.

%	Sales	Profits	Employees	My income	Standard of living
Decreased significantly	3.8	4.2	3.8	3.3	2.7
Decreased somewhat	16.1	15.4	8.5	15.2	12.5
Remained the same	24.8	31.9	62.5	32.1	37.7
Increased somewhat	39.1	36.4	18.3	37.7	33.7
Increased significantly	16.3	12.1	6.9	11.6	13.4

Table 2- Enterprise results over the last three years. Source: Own elaboration using RStudio (R Core Team, 2023).

By summing the percentages of the modalities «remained the same» and «increased somewhat», percentages between 63.9 and 80.8 are obtained, indicating that the change in the results of the studied enterprises over the last three years was minimal.

When reviewing the average of the studied variables (Table 3) and knowing that they are evaluated from 1 to 5, we can appreciate through comparison with previous studies that innovation in general in the studied enterprises is low, as argued by some authors for the rest of Latin America, unlike the MSE 4.0 variable which yields an average of (3.68), not overlooking that it is the variable with the greatest dispersion, having a standard deviation of (1.02).

	Market oriented innovation	Process innovation	Product or service innovation	Human Resources innovation	MSE 4.0
Average	1.8571	1.6977	1.9013	1.6473	3.6813
Deviation	0.50709	0.48146	0.58236	0.58535	1.02002
Skewness	0.295	0.610	0.238	0.660	-0.837
Kurtosis	-0.665	-0.293	-0.791	-0.366	-0.218

Table 3- Main statistics of the studied variables. Source: Own elaboration using RStudio (R Core Team, 2023).

The correlation coefficient achieved (Table 4) between the variable MSE 4.0 and the dimensions of the Innovation variable ranges from .236 to .299.

Implying a moderate association between both variables, and the correlation is significant, as the associated p-value is practically 0.

	Process innovation	Product or service innovation	Human Resources innovation	MSE 4.0
Market oriented innovation	.732	.657	.597	.243
Process innovation		.592	.606	.236
Product or service innovation			.619	.299
Human Resources innovation				.254

Table 4- Bivariate correlations. Source: Own elaboration using RStudio (R Core Team, 2023).

The implication of the findings allows for making practical and viable short-term recommendations in the environment of the studied *MSEs*, which, if applied and implemented, will favor the level of adaptation and survival of these economic entities in an environment where *Industry 4.0* or the *fourth industrial revolution*, as experts have called it, will prevail.

Based on the statistical analysis performed on the correlation coefficient between the analyzed variables, we arrive at the following conclusions:

1. Moderate and Significant Correlation: It was determined that there is a moderate statistical correlation between the Industry 4.0 variable (new industrial processes) and the dimensions of the Innovation variable in the MSEs of the municipality of Durango, Mexico. The values of Pearson's correlation coefficient range between 0.236 and 0.299, indicating a positive association of moderate magnitude.

2. Statistical Significance: The observed correlation is statistically significant, as the associated p-value is practically 0. This confirms that the relationship between the variables is not due to chance and can be generalized to the study population.

3. Comparison with Broader Contexts: The results obtained in the MSEs of Durango are consistent with findings reported in other larger-scale environments, such as MSEs in Latin America. This suggests that the dynamics between the adoption of Industry 4.0 processes and innovation present similar patterns, regardless of geographical scale.

4. Implications of the Innovation Dimensions: The four dimensions of the Innovation variable analyzed —market-oriented innovation, process innovation, product or service innovation, and human resources innovation— show a moderate, yet significant, relationship with the implementation of new industrial processes. This reinforces the importance of addressing innovation comprehensively in MSEs.

5. Relevance of the Methodological Approach: The study, of a quantitative, non-experimental, cross-sectional, and correlational nature, allowed for the objective validation of the relationship between the variables through Pearson's correlation coefficient, providing solid evidence for decision-making in the field of business management and policies promoting innovation and digitalization.

CONCLUSIONS

The research confirms a moderate and significant association between Industry 4.0 and Innovation in the MSEs of Durango, with results aligned with regional trends in Latin America. These findings underscore the need to promote integrated strategies that simultaneously foster digital transformation and innovative capabilities in this type of enterprise.

BIBLIOGRAPHIC REFERENCES

Alam, S. S., & Noor, M. K. M. (2009). ICT adoption in small and medium enterprises: An empirical evidence of service sectors in Malaysia. *International Journal of Business and management*, *4*(2), 112-125. https://www.researchgate.net/profile/Syed-Alam-11/publication/41890937_ICT_Adoption_in_Small_and_Medium_Enterprises_an_Empirical_Evidence_of_Service_Sectors_in_Malaysia/links/544072250cf2be1758d003a8/ICT-Adoption-in-Small-and-Medium-Enterprises-an-Empirical-Evidence-of-Service-Sectors-in-Malaysia.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail&_rtd=e30%3D

Cañete, N. (2020). Coronavirus: ¿Cómo apoyar desde el sector de fomento a la innovación y las pymes? *Puntos sobre la I*.

Castillo, S. J. (2010). el financiamiento a la "pequeña empresa" en México. *UNAM, México*.

Consoli, D. (2012). Literature analysis on determinant factors and the impact of ICT in SMEs. *Procedia-social and behavioral sciences*, *62*, 93-97. https:// www.sciencedirect.com/science/article/pii/S187704281203457X

Dini, M. (2018). Mipymes en América Latina: un frágil desempeño y nuevos desafíos para las políticas de fomento. https://www.sidalc.net/search/Record/dig-cepal-11362-44148/Description

Estrada, S., Cano, K., & Aguirre, J. (2019). ¿Cómo se gestiona la tecnología en las pymes? Diferencias y similitudes entre micro, pequeñas y medianas empresas. *Contaduría y administración*, *64*(SPE1), 0-0. https://www.scielo.org.mx/scielo.php?pid=S0186-10422019000200009&script=sci_arttext

Gómez Romero, J. G. I. (2016). El liderazgo de aprendizaje y su incidencia en la innovación y competitividad de las MIPYMES de la ciudad de Durango, México. *Investigación administrativa*, *45*(117), 0-0. https://www.scielo.org.mx/scielo.php?pid=S2448-76782016000100004&script=sci_arttext

Heredia, A. (2020). Políticas de fomento para la incorporación de las tecnologías digitales en las micro, pequeñas y medianas empresas de América Latina: revisión de experiencias y oportunidades. *Documentos de Proyectos*, (45096). https://ideas.repec.org/p/ecr/col022/45096.html

Instituto Nacional de Estadística y Geografía. (2020). Directorio estadístico nacional de unidades económicas.

Latina, A. (2000). Comisión Económica para América Latina y el Caribe (CEPAL). *División de Desarrollo*. https://repositorio.cepal.org/bitstream/handle/11362/16835/S9030431_es.pdf

Núñez, J. E. (2020). El rol de las tecnologías de información y comunicación en las MiPyMEs. Aproximación metodológica. *Daena: International journal of good conscience*, *15*(3), 1-13. https://www.spentamexico.org/v15-n3/A11.15(3)1-13.pdf

Posada, R., Peña, N., & Aguilar, O. (2020). Resultados generales del estudio de Innovación e industria 4.0 en las micro y pequeñas empresas en América Latina. *Mc Graw Hill Education (Ed.), Innovación e industria*, *4*, 322.

Rojero-Jiménez, R., Romero, J. G. I. G., & Cabrales, K. V. A. (2022). El liderazgo de aprendizaje y el compromiso organizacional: un estudio a MiPyMEs. *Ibero-American Journal of Economics & Business Research*, *2*(1), 33-46. http://publish.iberojournals.com/index.php/ECB/article/view/4

Solleiro, J. L., & Castañón, R. (2005). Competitividad y sistemas de innovación: los retos para la inserción de México en el contexto global. *Revista Iberoamericana*, *5*(15), 165-197.

Soto, E., & Dolan, S. (2004). Las PYMES ante el desafío del siglo XXI: los nuevos mercados globales. *México: Thomson Learning*, 24-26.

Vázquez, R. L., & Avila, D. D. (2020). La Mortandad de las MiPyMEs en Colombia y México. *Visión Internacional (Cúcuta)*, 8-14.