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Technological Innovation and Business Competitiveness in Peruvian Microenterprises: An Empirical Analysis from a Regional Perspective

Luis Ricardo Flores-Vilcapoma[1]; Augusto Aliaga-Miranda[2]; Christian Efrain Raqui-Ramirez[2]; Yuri Sánchez-Solis[2]; Wilmar Salvador Chávarry-Becerra[3]; Nilton Marx Huaroc-Ponce[4]; Angel Raúl Dueñas-Carbajal[2]

[1]Universidad Tecnológica del Perú, Perú, *C28305@utp.edu.pe*
[2]Universidad Nacional Intercultural de la Selva Central Juan Santos Atahualpa, Perú, *aaliaga@uniscjsa.edu.pe*, *craqui@uniscjsa.edu.pe*, *ysanchez@uniscjsa.edu.pe*, *aduenas@uniscjsa.edu.pe*
[3]Universidad Continental, Perú, *wchavarry@continental.edu.pe*
[4]Universidad Nacional Daniel Alcides Carrión, Perú, *nhuarocp@undac.edu.pe*

Abstract*– This study analyzes the relationship between technological innovation and business competitiveness in microenterprises in the central region of Peru. It is based on the premise that the incorporation of technologies, the provision of qualified human resources and the implementation of quality control systems are key factors to improve the performance of these organizations in a challenging environment. The data were analyzed using inferential statistics, specifically multiple linear regression, to evaluate the impact of the dimensions of technological innovation on business competitiveness. The results reveal that the adoption of new technologies is a key determinant of productivity and product quality, suggesting the need for business strategies aimed at digitalization. Furthermore, a positive and significant impact of human resource provision (0.240 to 0.264, $p < 0.001$), quality control systems (0.259 to 0.309, $p < 0.001$) and information and communication technologies (0.283 to 0.310, $p < 0.001$) on product quality, productivity and performance was identified in the market. It was also confirmed that companies that invest in the training of their human capital and in the implementation of quality standards achieve a better competitive positioning. The model specification analyzes ensure the validity of the findings, by not presenting problems of heteroskedasticity, autocorrelation or specification errors. This study not only contributes to academic development on the competitiveness of microenterprises in regional contexts, but also offers an empirical basis for the formulation of business strategies and public policies that promote the sustainability and growth of the sector in the central region of Peru.

Keywords—Technological Innovation, Human Resources Provision, Business Competitiveness, Microenterprises, Information and Communication Technologies.

I. Introduction

[1] Currently, microenterprises play a very relevant role since they are establishing jobs, activating local markets and contributing to the progress of social development. However, according to [2] these organizations face contextual and structural challenges that in some ways limit their ability to compete in a globalized environment. In the central region of Peru, which is characterized by cultural and geographic diversity, microenterprises face significant barriers such as a restricted technological infrastructure and little access to financing, as well as the lack of integration into a developed value chain [3]. In this sense, technological innovation becomes a strategic tool with the power to transform business capacity in this region [4].

[5] Points out that within technological innovation, microenterprises seek to execute a set of feasible practices, one of them locating the importance of incorporating new technologies and optimizing processes. [6] Point out that providing support generates a positive impact on business competitiveness since it demonstrates improvement in productivity, diversification, in addition to being able to obtain differentiated products and reduction in costs, being clear that, with these factors, microenterprises manage to obtain greater access to international markets. These capabilities are especially critical in regions such as central Peru where these microenterprises work in challenging environments and require constant innovation to remain competitive [7].

[8] Business competitiveness has been defined as the capacity in which they can stand out in their sector, creating sustainable value and also diversifying from their competitors. Regarding the central region of Peru, competitiveness is influenced by quality factors as well as the validity of the processes and how companies obtain the ability to integrate into more complex supply chains [9]. In this sense, competitiveness and technological innovation obtain an interaction to be exploited and thus know the success factors and be able to identify the structural barriers that these organizations have been facing [10].

This research seeks to contribute to the existing literature on innovation and competitiveness in regional contexts and also provides a conceptual and empirical framework that can be used in other similar environments. In this way, the study contributes to academic development and also a basis for the design of practical interventions that will contribute to sustainable development in the central region of Peru.

II. LITERARY REVIEW

A. Technological Innovation

Technological innovation, according to [11], lies in the introduction of new products, services, innovative management methods and processes that increase the operational efficiency and competitive capacity of organizations. In the context of microenterprises, [12] point out that technological innovation capacity faces significant limitations, primarily due to insufficient financial resources, a lack of investment in machinery and intangible assets, and difficulties in accessing modern technologies. The study highlights that vertical cooperation along the value chain, together with horizontal alliances, can serve as an effective strategy to strengthen these enterprises by facilitating the exchange of resources, knowledge, and access to technological innovations that enhance their competitiveness and sustainability in the market.

B. Human Resources Provision

According to [13], human resource provision refers to the quality of trained personnel and their availability within the organization to execute and lead constant innovation processes. This dimension highlights the importance of having collaborators within the organization who have updated knowledge in technology and innovation [14]. Having well-trained human capital implements innovation and also contributes to the generation of new ideas and solutions for the different negative situations that may occur [15]. As for microenterprises, this dimension will allow them to maximize the efficiency of these limited resources and also respond quickly to changes that occur in the market [16].

C. Quality Control Systems

In accordance with [17], quality control systems can be defined as tools and processes that benefit so that services, processes and products can meet certain standards. In the field of technological innovation, according to [18] these systems help to ensure continuous improvement and act as organizers to identify areas of opportunity in which organizations can implement improvements. Now referring to microenterprises, they can have quality certifications as well as standards and this is a strategy that helps access new markets as well as improve customer satisfaction and reduce costs [19].

D. Information and Communication Technologies

[20] Defines Information and Communication Technologies (ICT) as digital tools and systems designed to facilitate the transmission, storage, and processing of information within an organization. In the context of microenterprises, the adoption of ICT enhances communication with suppliers and clients, streamlines internal processes, and supports market expansion through modern, updated platforms. Moreover, these technologies provide essential resources for task systematization, promoting the development of personalized marketing strategies to improve customer engagement and strengthen competitive positioning [21].

E. Product Quality

[22] Refer to the ability of a company or organization to offer goods and services meeting or exceeding the expectations of its customers and market standards. In order to maintain the competitive advantage in a company, it is important to constantly guarantee the quality of the products, thus generating customer loyalty and differentiation of the company from its other competitors, strengthening the business prestige and its brand. In relation to microenterprises, technological innovation plays an important role, allowing the development of innovative products, the improvement of processes and compliance with standards, even with limited resources [23].

F. Productivity

According to [24], productivity in microenterprises is closely associated with innovation capability, particularly through the adoption of product and process innovations. The study emphasizes that initiatives focused on addressing social challenges, along with strategic partnerships with external stakeholders, play a crucial role in enhancing productivity by promoting process optimization and efficient resource utilization. In this context, microenterprises can strengthen their performance by incorporating technological tools that broaden their market reach and streamline their operations. This, in turn, contributes to increased profitability and ensures the business's sustainability over the medium and long term [25].

G. Market Performance

According to [26] is a company's ability to attract new customers, expand its reach, and maintain its competitiveness. In addition, it implies the introduction to local markets as a basis for obtaining opportunities in international markets. In relation to microenterprises, the implementation of digital strategies will promote the innovation of products and services, thereby achieving the expansion of their participation in the international market and the acquisition of new customers, promoting the maintenance of a constant competitive environment [27].

H. Regional Environment and Microenterprises

Knowing the scope in the central region of Peru we can see that microenterprise face challenges such as limited access to financing, in addition to the lack of adequate infrastructure, this hinders growth and generates technological barriers. However, they also have growth opportunities thanks to their natural resources and the adoption of digital technologies, thus facilitating their insertion into internal and external trade [28].

Organizational adaptability is important since it shows the ability to respond assertively and productively to changes in the environment. Therefore, microenterprises that adapt to innovative practices manage to be more competitive and

flexible. This adaptability is linked to technological innovation since it provides them with tools to face different market situations [29].

III. Methodology

A. Sample

The research adopted a quantitative approach with a non-experimental, cross-sectional, and correlational design. The study population was made up of 15,000 microenterprises registered in the departments of Junín, Huancavelica and Pasco, from which a sample of 384 microenterprises was selected through simple random probabilistic sampling.

TABLE I
MAIN VARIABLES

Variables	Dimensions	Indicators
Business competitiveness	Product quality (PQ)	Encourage participation, identify professional roles, invest in training, increase capacity to innovate.
	Productivity (PR)	Quality standard, innovation strategy, systematization of new processes, operational efficiency.
	Market performance (MP)	Introduction of systematization, technology maintenance, generation of new services, innovative policy.
Technological innovation	Human resources provision	Product standardization, compliance with quality regulations, product certification.
	Quality control systems	Process optimization, cost reduction, efficiency in the use of resources.
	New information and communication technologies	Increase in sales, market expansion, customer loyalty.

Table I presents the main variables, dimensions, and indicators that support the analysis of business competitiveness and technological innovation in microenterprises in the central region of Peru. Two fundamental variables are identified: business competitiveness and technological innovation, each broken down into dimensions that allow for a specific evaluation of their impact. In the case of business competitiveness, three dimensions are distinguished: product quality, productivity, and market performance. Product quality (PQ) is measured based on the ability to promote participation, identify professional roles, invest in training, and enhance innovative capacity. Productivity (PR), in turn, is assessed through quality standards, innovation strategies, process systematization, and operational efficiency. Finally, market performance (MP) is analyzed by examining the introduction of systems, technology maintenance, the generation of new services, and the implementation of innovative policies that foster commercial expansion.

On the other hand, technological innovation is examined through three key dimensions: human resources provision, quality control systems, and new information and communication technologies. Human resources provision is evaluated through product standardization, compliance with quality regulations, and product certification, which are essential factors for ensuring the company's adaptation to market requirements. Quality control systems are measured by considering process optimization, cost reduction, and resource efficiency, reflecting the organizational commitment to continuous improvement. Finally, new information and communication technologies are analyzed in terms of increased sales, market expansion, and customer loyalty—elements that enable microenterprises to strengthen their competitive position in the market. The structure presented in this table provides a comprehensive view of the factors that determine business competitiveness in the regional context under study.

B. Regression models

For the results, a multiple linear regression model and correlation analysis are used to determine the impact that exists between the dimensions of variables, as well as their statistical significance. For this, the estimation method will be ordinary least squares, since it is the method that is very important to make a consistent estimate if it meets the conventional assumptions.

$$y_i = \theta_{i.0} + \theta_{i.1}x_1 + \theta_{i.2}x_2 + \theta_{i.3}x_3 + u_i, \quad \text{for } i = EQ, LNR, CEMP \tag{1}$$

Where

y_{PQ}: Product quality
y_{PR}: Productivity
y_{MP}: Market performance
x_1: Human resources provision
x_2: Quality control systems
x_3: New information and communication technologies
u_i: Disturbance term, $u_i \sim iid(0, \sigma^2)$

The formula represents the estimation process through Ordinary Least Squares (OLS), aiming to obtain unbiased, efficient, and consistent parameter estimates under the standard classical assumptions.

$$SSR = (y_i^T - \alpha_i^T X^T)(y_i - X\alpha_i) \tag{2}$$

Where SSR is sum square of residuals, $\alpha_i = [\alpha_{i,0}, \alpha_{i,1}, \alpha_{i,2}, \alpha_{i,3}]^T$ and $X = [1, x_1, x_2, x_3]$.

$$\alpha_i = (X^T X)^{-1} X^T y_i \tag{3}$$

This methodological approach ensures a rigorous and reliable analysis, facilitating a deeper understanding of the

relationships between the dimensions of variables and their influence within the business competitiveness.

IV. Results

A. Descriptive statistics

TABLE II
DESCRIPTIVE STATISTICS

Stats	PQ	PR	MP	Human resources provision	Quality control systems	New information and communication technologies
N	384	384	384	384	384	384
Max	4.800	4.556	4.667	5.000	4.500	5.000
Min	1.200	1.556	1.333	1.000	1.000	1.250
Mean	3.012	2.999	3.005	3.024	3.001	3.018
SD	0.670	0.536	0.620	0.676	0.662	0.730
Variance	0.449	0.287	0.385	0.457	0.439	0.533
P_{50}	3.000	3.000	3.000	3.000	3.000	3.000
Skewness	0.031	-0.082	0.117	-0.092	-0.118	-0.034
Kurtosis	2.885	2.700	2.767	2.963	2.618	2.518

Table II presents the descriptive statistics of the variables included in the analysis, providing an overview of their distribution and central tendency. All variables have a sample size of 384 observations, ensuring a robust database for subsequent analyses. In terms of maximum and minimum values, Human Resources Provision and New Information and Communication Technologies reach the maximum value of 5.000, while their minimum values are 1.000 and 1.250, respectively. The means of all variables fall within a narrow range, between 2.999 (Productivity) and 3.024 (Human Resources Provision), suggesting a balanced distribution around intermediate values. The dispersion of the data, measured through the standard deviation (SD), indicates that variability is relatively homogeneous among the variables, with New Information and Communication Technologies being the most dispersed (SD = 0.730) and PR the least dispersed (SD = 0.536).

Regarding skewness, all variables present values close to zero, suggesting an approximately symmetric distribution, with no significant biases toward higher or lower values. Likewise, the kurtosis values indicate that the distribution of the variables is slightly platykurtic or mesokurtic, meaning with moderate tails compared to a normal distribution. PQ and Human Resources Provision exhibit the highest kurtosis values (2.885 and 2.963, respectively), implying a slightly greater concentration of data around the mean. These results ensure that the variables exhibit an adequate distribution for inclusion in inferential analyses such as regression and correlation, minimizing issues related to biases or extreme data that could affect the robustness of the statistical models.

B. Statistical analysis

Table III presents the correlation matrix between the analyzed variables, providing information on the intensity and direction of their relationships. The strongest correlation is observed between New Information and Communication Technologies and PR (0.431), suggesting that the adoption of new technologies is positively associated with an increase in productivity. Likewise, New Information and Communication Technologies also shows significant correlations with PQ (0.320) and MP (0.379), indicating that technological innovation may play a key role in enhancing business competitiveness. Similarly, Quality Control Systems exhibits a moderate relationship with PQ (0.305) and MP (0.350), highlighting the importance of quality assurance mechanisms for market success.

TABLE III
CORRELATION MATRIX

	PQ	**PR**	**MP**	Human resources provision	Quality control systems	New information and communication technologies
PQ	1.000	-	-	-	-	-
PR	0.249	1.000	-	-	-	-
MP	0.203	0.362	1.000	-	-	-
Human resources provision	0.272	0.369	0.307	1.000	-	-
Quality control systems	0.305	0.344	0.350	0.060	1.000	-
New information and communication technologies	0.320	0.431	0.379	0.039	0.010	1.000

On the other hand, the variable Human Resources Provision shows positive associations with PR (0.369) and MP (0.307), suggesting that proper staffing and talent management influence operational efficiency and commercial performance. However, the correlation between Quality Control Systems and Human Resources Provision (0.060) is relatively low, indicating that the implementation of quality controls is not strongly related to the availability of human capital in this context. Overall, the correlation coefficients suggest that business competitiveness is driven by a combination of technological, organizational, and quality management factors, supporting the hypothesis that the synergy between these dimensions is crucial for improving organizational performance.

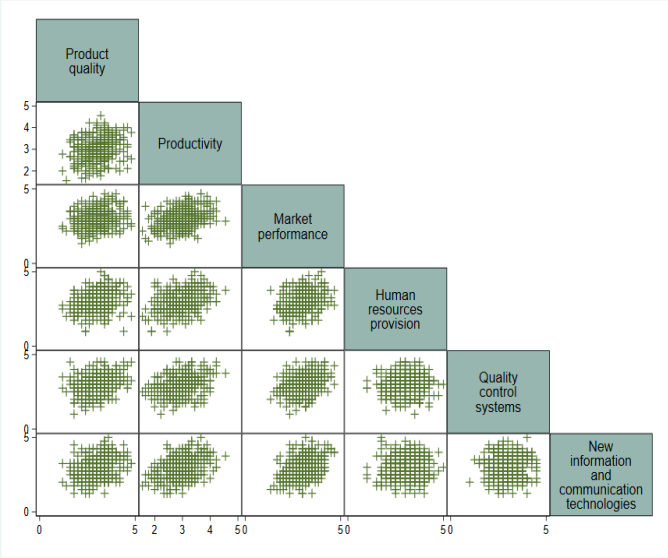

Fig. 1 Scatterplot matrix

Figure 1 presents a scatterplot matrix that allows visualization of the bivariate relationships between the variables included in the study. A relatively clustered distribution of points is observed in all combinations, suggesting the existence of associations between the variables. In general, the relationships display patterns aligned in positive directions, which is consistent with the correlation coefficients reported in Table 3. For example, the scatterplots between New Information and Communication Technologies and PR, as well as between Quality Control Systems and MP, show an upward trend, supporting the idea that the adoption of technologies and the implementation of quality systems contribute to the improvement of organizational performance.

Moreover, the density of points in each graph suggests different degrees of dispersion, which may indicate variability in the strength of the associations. While some combinations, such as Human Resources Provision and PR, show a higher concentration of points around an upward trend, other relationships, such as Quality Control Systems and Human Resources Provision, display greater dispersion, suggesting a weaker relationship. These findings reinforce the need for more robust inferential analyses, such as multiple linear regression, to more precisely quantify the impact of each dimension on business competitiveness.

C. Modelling

Considering the data previously obtained, and according to the objectives proposed, multiple regression models will be carried out where the impact between the dimensions and their significance will be determined.

Table 4 presents the results of the multiple linear regression models estimated using the ordinary least squares (OLS) method. In all three regressions, all independent variables have positive and statistically significant coefficients at the 0.001 level, indicating that human resource provision, quality control systems, and new information and communication technologies have a positive impact on business outcomes. In particular, the coefficients for Quality Control Systems and New Information and Communication Technologies stand out due to their magnitude in all three specifications, with values above 0.28 in every model, suggesting that these factors are key in enhancing business competitiveness.

TABLE IV
OLS RESULTS

	(1) PQ	(2) PR	(3) MP
Human resources provision	0.240*** (5.46)	0.264*** (8.47)	0.251*** (6.54)
Quality control systems	0.291*** (6.46)	0.259*** (8.13)	0.309*** (7.90)
New information and communication technologies	0.283*** (2.54)	0.304*** (1.26)	0.310*** (8.75)
Constant	0.559* (2.54)	0.503** (3.23)	0.382* (2.00)
F statistic (3,380)	42.73	88.88	64.70
Adjusted R-squared	0.246	0.408	0.333

t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001.

The F-statistic is highly significant in all three models, confirming the overall validity of the regressions and the explanatory power of the independent variables. Regarding model fit, the adjusted R-squared indicates that the model best explaining the variability of the dependent variable is PR (Adjusted R-squared = 0.408), followed by MP (Adjusted R-squared = 0.333) and PQ (Adjusted R-squared = 0.246). These results suggest that the analyzed factors primarily explain productivity, although they also have a relevant impact on product quality and market performance. Overall, the findings support the importance of investing in human capital, technologies, and quality systems as fundamental pillars to enhance business competitiveness and sustainability.

TABLE V
MODEL SPECIFICATION BY REGRESSION MODELS P-VALUES

	Heteroscedas-ticity	Autocorrelation		Normality	Identifi-cation
Test	Breusch-Pagan	Durbin-Watson	Breusch-Godfrey	Jarque-Bera	Ramsey RESET
Model 1	0.6609	2.0771	0.2257	0.1979	0.1652
Model 2	0.8346	2.1623	0.2245	0.4284	0.1665
Model 3	0.6604	2.1552	0.4055	0.5231	0.6804

Table 5 presents the results of the model specification tests, evaluating heteroscedasticity, autocorrelation, normality, and correct functional specification. The p-values from the Breusch-Pagan test are all above 0.05 across the three models (0.6609, 0.8346, and 0.6604), indicating the absence of heteroscedasticity and suggesting that the error terms have constant variance, thus meeting one of the fundamental assumptions of the linear regression model. Regarding

autocorrelation, the Durbin-Watson statistic values fall within an acceptable range in all three models (between 2.0771 and 2.1623), implying that there is no strong evidence of serial correlation in the residuals. Complementarily, the Breusch-Godfrey test yields p-values greater than 0.05 in all specifications, confirming the independence of errors and the validity of estimation using ordinary least squares (OLS).

Regarding the normality of residuals, the p-values from the Jarque-Bera test are well above the 0.05 threshold (0.1979, 0.4284, and 0.5231), suggesting that the error terms follow a normal distribution, fulfilling another key requirement for the inferential validity of the model. Lastly, the Ramsey RESET test shows high p-values (ranging from 0.1652 to 0.6804), indicating that there are no functional specification issues in any of the evaluated models. Taken together, these results confirm that the estimated models satisfy the classical assumptions of multiple linear regression, ensuring the reliability and robustness of the obtained estimates in explaining business competitiveness.

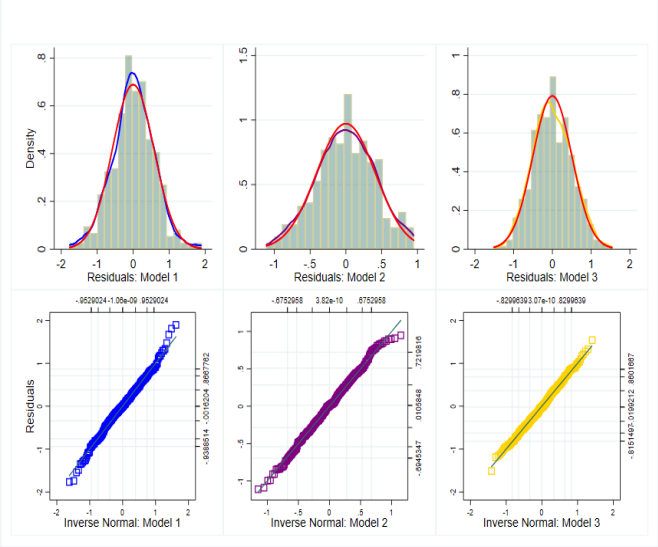

Fig. 2 Estimated kernel density and Q-Q plots. The normal distribution is represented by the red line. Grid lines are 5, 10, 25, 50, 75, 90, and 95 percentiles.

Figure 2 presents the kernel density estimates and Q-Q (Quantile-Quantile) plots to assess the normality of residuals in the three analyzed models. In the density plots (top row), the empirical distributions of the residuals, represented by histograms and estimated density curves, show substantial alignment with the theoretical normal distribution indicated by the red line. Although there are slight deviations at the extremes, the overall shape of the distributions suggests that the residuals exhibit an approximately normal behaviour. This visual evidence is consistent with the results of the Jarque-Bera test reported in Table 5, where p-values above 0.05 indicate that the normality hypothesis is not rejected in any of the models.

The Q-Q plots (bottom row) provide a more detailed evaluation of residual normality by comparing their quantiles with those of a standard normal distribution. The points closely align along the diagonal, indicating a strong correspondence with the theoretical normal distribution. However, slight deviations are observed at the extremes of the plots, suggesting the presence of some outliers, though not to an extent that would compromise the validity of the normality assumption. Overall, these results confirm that the residuals exhibit appropriate behavior for applying multiple linear regression models, supporting the robustness of the inferential analyses conducted in the study.

V. COMPARATIVE DISCUSSION

The results of this study are consistent with findings reported in other emerging economies, reinforcing the broader applicability of the positive relationship between technological innovation and business competitiveness. In Indonesia, [6] demonstrated that the adoption of information and communication technologies notably enhanced the productivity and market reach of micro and ultra-micro enterprises. Likewise, [1] identified that technological integration, combined with strategic human capital development, was pivotal for the sustainable growth of micro and small enterprises in Zambia. Comparative research by [28], focused on China and Peru, further underscored the role of digitalization in facilitating the formalization of business operations and the integration of firms into larger value chains. In the Peruvian context, [30] confirmed that strengthening digital competencies significantly improved educational performance in public universities, suggesting that investments in digital infrastructure and training have a transversal impact on organizational development across sectors.

These external findings, in conjunction with the evidence from the central region of Peru, suggest that although technological innovation consistently fosters competitiveness, its impact is highly contingent on contextual factors such as the availability of infrastructure, access to technological training, and the design of supportive public policies. Recognizing these moderating elements is essential for accurately assessing the transformative potential of innovation across diverse environments. Accordingly, future research should prioritize comparative analyses across countries with varying levels of economic development and institutional maturity, thereby deepening the understanding of how local conditions shape the effectiveness of technological adoption strategies.

V. CONCLUSIONS

The results obtained in this study confirm the importance of the synergy between human resource provision, quality control systems, and information and communication technologies in enhancing business competitiveness.

Empirical evidence supports that these factors have a positive and statistically significant impact on product quality, productivity, and market performance, highlighting the relevance of an integrated management approach to strengthening organizational competitiveness. In particular, the adoption of new technologies emerges as a key determinant, showing a strong relationship with productivity and product quality, suggesting the need for business strategies that prioritize digitalization and innovation. Furthermore, the model specification analysis confirms the validity of the results, as it does not present issues of heteroscedasticity, autocorrelation, or specification errors, ensuring the reliability of the findings.

From a practical perspective, these results imply that companies should focus their investments on strengthening human capital and implementing rigorous quality control systems to maximize their market performance. The evidence suggests that organizations adopting strategies based on technology and efficient human resource management gain a sustainable competitive advantage, emphasizing the importance of business policies oriented towards training, technological infrastructure development, and continuous process improvement. Academically, this study contributes to the body of knowledge on business competitiveness by providing a robust analysis of the factors that drive it, laying the groundwork for future research exploring sector-specific dynamics and the impact of emerging technological trends on organizational performance.

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