

Digital financial inclusion through electronic invoicing: A path towards the formalization of msmes in the central region of peru through a multiple linear regression analysis

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ABSTRACT

In Peru, micro and small enterprises (MSEs) form the backbone of the economy. However, the reality is that this sector is characterized by informality, especially in more remote areas. Faced with this reality and the advancement of digital transformation, various digital financial services now exist that effectively contribute to the inclusion of these MSEs within the financial system through the payment and receipt of transfers, the issuance of electronic receipts and invoices, and the payment of tax obligations. The main objective of this research is to analyze the effect of digital financial inclusion and the adoption of electronic invoicing on the level of formalization of MSEs in the Junín region. This research is quantitative, non-experimental, and cross-sectional, with an explanatory design. Multiple linear regression was used for statistical analysis, with a sample of 381 formally registered micro and small enterprises (MSEs) in the provinces of Huancayo, Tarma, Satipo, and Chanchamayo. Data was collected using a structured questionnaire and analyzed using standard econometric techniques. The results obtained demonstrate that the adoption of electronic invoicing in SMEs has positive and significant effects on their level of formalization. It was also observed that the adoption of both tools generates a complementary effect greater than that of either tool alone. These results highlight the importance of integrating digital innovation policies, financial education, and tax simplification as a strategy to promote formalization. This research contributes new knowledge to previous studies on business formalization, as it is analyzed using multivariate evidence within a specific context and offers results that can be used to improve and strengthen formal businesses in areas with high levels of informality.

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1. Introduction

In Peru, micro and small enterprises play a much bigger role than their size might suggest. In fact, they make up almost all of the businesses operating in the country, around 99.7%, and are responsible for most private sector employment, which already says a lot about their importance in the economy (Arauco et al., 2022). Even so, this relevance goes hand in hand with a long-standing problem: informality. More than 86.8% of these businesses still operate outside the formal system, a situation that not only affects workers' rights but also weakens tax collection and overall productivity (Comex Perú, 2024). In practical terms, staying informal often means limited access to support programs, financing opportunities, and legal protection, while increasing the risk of fines or even business closure. Over the past few years, however, this reality has slowly started to shift, mainly due to digitalization. Tools such as digital wallets, especially Yape and Plin, along with mobile banking apps, have made it easier for small business owners to enter the formal financial system. According to Aurazo and Gasmí (2024), digital payments per person increased by about 73% in 2024, reaching an average of 442 transactions per adult each year. This growth was not accidental. A key factor behind it was the Interoperability Strategy led by the Central Reserve Bank of Peru (BCRP), which allowed different digital wallets and banking apps to interact through QR codes and mobile phone numbers. Thanks to this initiative, just the first two phases implemented in 2023 generated over 80 million additional transactions and noticeably expanded the use of digital payments among businesses (BCRP, 2025; Fosu et al., 2025).

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In this context, digital transformation has facilitated a significant increase in financial access for micro and small enterprises (MSMEs). In 2024, 54.1% of micro and small business owners or self-employed workers had access to at least one formal financial product, reflecting a 2.3 percentage point increase compared to the previous year (ComexPerú, 2025). The growth of digital platforms such as Yape, Plin, and mobile banking has been key to expanding financial inclusion, especially through access to bank accounts, payment facilities, and transactions using mobile phones. The BCRP interoperability strategy, which allows transactions between digital wallets and banking applications, generated more than 165 million additional monthly transactions by the end of 2024 (BCRP, 2025).

Furthermore, the government, through SUNAT (the Peruvian tax authority), has mandated the issuance of electronic payment receipts (invoices, sales slips, notes, waybills, among others) for a wide range of taxpayers. This strengthens the traceability of transactions and allows for the development of a solid tax and credit history, useful for accessing formal financing (Grijalva et al., 2023). In addition, the Integrated Electronic Records System (SIRE) streamlines the automatic and secure generation of electronic sales and purchase records, improving tax management and reducing errors (SUNAT, 2024). Despite the potential benefits of tax formalization, such as the issuance of electronic receipts and access to financing, many micro and small enterprises (MSMEs) still do not take advantage of these tools. This phenomenon is explained by structural and contextual variables (Arteaga et al., 2024).

Despite regulatory and technological efforts, formalization rates among MSMEs remain low in the central region of the country. According to Mporfu and Mhlanga (2022), factors such as low digital literacy, distrust of the tax system, and the logistical difficulties inherent in intermediate areas continue to negatively impact the use of digital financial and tax tools. Consequently, it is crucial to empirically evaluate whether these tools, when implemented together, have a significant effect on formalization.

From a methodological standpoint, this research employs an explanatory design based on the use of a multiple linear regression model. This model allows for the simultaneous and comparative examination of the effect of two predictor variables: digital financial inclusion and electronic invoicing. The multivariate analysis contributes to understanding not only the individual relationship of each variable with the level of formalization, but also the combined effect of both on the transition to the formal economy. Therefore, the main objective of this study is to analyze the effect of digital financial inclusion and the adoption of electronic invoicing on the level of formalization MSMEs in the central region of Peru, using a multivariable multiple linear regression model. The hypothesis is that both predictor variables have a positive and statistically significant influence on the dependent variable, and that the combined effect is more explanatory than their isolated analysis. This article seeks to generate useful scientific evidence for the formulation of public policies that integrate digital innovation, financial education and tax simplification, aimed at business formalization.

This research also aims to fill a gap in Peruvian empirical literature regarding the multivariate effects of digitalization on the informal structure of MSMEs. The expected results will allow for the design of more effective and targeted programs based on the level of technological adoption by businesses in non-metropolitan regional contexts. Ultimately, this research seeks to address the existing gap in Peruvian empirical literature concerning the multivariate effects of digitalization on the informal structure of MSMEs. The results obtained will enable the development of more useful public policies, better adapted to the realities of regions both within the capital and in more remote areas of the country.

2. Literature Review

2.1 Informality and formalization of MSMEs

Informality is a characteristic of emerging economies, developing countries that have not been able to sustainably address this problem. This leads most micro and small enterprises (MSEs) to evade the regulatory framework, thus failing to comply with labor laws and tax obligations. Furthermore, informality not only harms the country but also limits the informal entrepreneurs themselves. They cannot obtain financing from regulated financial institutions and achieve greater productivity; instead, they are tempted to take out unregulated loans with high interest rates and significant risk (La Porta & Shleifer, 2014). Therefore, while this problem may benefit companies in the short term, by preventing them from allocating funds to formalize their operations, it also prevents them from accessing long-term financing and the resulting increased productivity. From an institutional economics perspective, informality represents a rational response to weak or costly formal institutions, rather than a simple preference for illegality (Rocha et al., 2018). Therefore, if the state, through its laws and their enforcement, is not sufficiently consistent and, moreover, is too costly in the eyes of informal entrepreneurs, it will only create a linear increase in the problem (North, 1990). Similarly, De Soto (1989) argues that the disadvantages of becoming a formal business include costs and bureaucracy; the process is often very cumbersome; and excessive regulation, which does not favor the entrepreneur, leading them to opt for informality despite having the initial willingness. Empirical evidence suggests that informality is not necessarily a transitional stage toward formality. La Porta and Shleifer (2014) demonstrate that the organizational structure of a formal institution differs significantly from that of an informal one. Specifically, administrative management, the application of planning, organization, direction, and control, is more prevalent in the former than in the latter. Furthermore, productivity at the end of the same period is higher in the former, and informality is linked to long-term growth through access to legal loans for infrastructure improvements, increased

merchandise purchases, and other needs. Additionally, Ulyssea (2018) argues that informality arises from the interaction between the country's diverse business landscape and the disadvantageous costs imposed on entrepreneurs by tax and oversight policies. These three factors must be addressed thoroughly to reach a middle ground that benefits both the country's economy and entrepreneurs. In Latin America, the issue of informality among micro, small, and medium-sized enterprises (MSMEs) persists, mired in regulatory chaos, limited state capacity, and low levels of institutional trust. According to Perry et al. (2007), informality is conceptualized as a highly heterogeneous phenomenon, ranging from very small businesses merely seeking to survive to larger companies with significant investments that use informality as a strategic mechanism to evade formal regulation. This context helps us understand why countries that implement measures to reduce registration costs fail to achieve results, and moreover, why this is not a sustainable long-term solution (Bruhn & McKenzie, 2014).

Formalization is currently understood as a multifactorial phenomenon that integrates initial registration, tax compliance, and access to formal entities. Several empirical studies have observed a very interesting phenomenon: factors that contribute to reducing the informality rate include lower registration fees, effective communication between institutions and entrepreneurs, and traceability of the entire process from beginning to end to ensure that requirements are met and formalization is achieved (Bruhn & McKenzie, 2014; Andrade et al., 2016). In this context, providing clear information and digital channels for paying registration fees and completing other procedures, without requiring in-person visits to establishments, promotes financial inclusion. Furthermore, real-time tracking of the process improves the perceived cost-benefit ratio of informal MSMEs, fostering a more positive attitude (Pomeranz, 2015; Naritomi, 2019)

This perspective provides the conceptual basis for analyzing how digital financial inclusion and electronic invoicing can jointly contribute to the formalization of MSMEs, particularly in non-metropolitan contexts

2.2 Digital Financial Inclusion and MSMEs

Financial inclusion is vital in today's landscape, as it involves using digital platforms and channels to conduct banking transactions and bringing financial services closer to customers through mobile devices (Demirgüç et al., 2022). Of particular note are the micro, small, and medium-sized enterprises (MSMEs) that have adopted digital payment methods and accessed financial products through digital platforms, strengthening their internal processes and becoming more efficient in their resource utilization (Mustapha et al., 2025; Callupe et al., 2025). Numerous empirical studies have shown that businesses that regularly use financial products from formal institutions experience a greater impact on their productivity. Having a loan allows for improvements to merchandise and staffing, thus strengthening the institution and increasing its goals, enabling the company to achieve consistent growth (Beck et al., 2007; Flores et al., 2021). Similarly, Suri and Jack (2016) assert that small businesses, such as corner stores, benefit the most, provided they utilize digital payment methods to reduce cash use and improve the flow of transactions between seller and buyer, resulting in greater efficiency and higher quality purchases.

In developing countries, it has been shown that using digital payment methods improves the management of company income and expenses, as well as the efficiency of transactions. Furthermore, informal micro and small enterprises (MSEs) benefit from this advantage, which helps them reassess their options for becoming formal businesses; that is, gaining access to financial products through digital platforms, saving time and resources. Therefore, digital transactions improve the daily operational efficiency of businesses, increasing buying and selling activity, moving more economic flow, and offering greater flexibility compared to traditional methods (Suri and Jack, 2016). Moreover, as Klapper and Singer (2017) point out, digital payment methods increase efficiency and transparency, allowing micro and small enterprises to access formal financial products and services more efficiently, and in some cases, breaking the paradigm of necessarily having a credit history. Financial inclusion consequently has a positive impact on the rate at which businesses transition to formalization, benefiting the country's economy. When micro and small business transactions shift to digital means, changing the traditional way of receiving physical money, the buying and selling process is streamlined. This means consumers save time, and businesses do as well. Furthermore, the visibility of economic flows in a digital environment improves, allowing businesses to track the exact date of receipt or disbursement, which encourages many to formalize their operations (Pomeranz, 2015). In turn, having this financial history of the organization on a mobile phone (for example) encourages formal banking institutions to grant credit or loans to formal businesses, based on their knowledge of digital transactions (Björkegren & Grissen, 2020). However, like all forms of inclusion, it is not yet fully achieved. There are still areas where improvements are needed to make it truly beneficial for everyone. A clear example is that even in remote areas with limited technological and government support, people still cling to outdated paradigms such as using physical money and always visiting banks in person for inquiries or services. This, coupled with a low level of familiarity with technology and distrust in digital systems, due to concerns about fraud or theft, contributes to the fact that financial inclusion is not yet effective for all. To overcome this, not only is technology needed, but also government-run programs to educate and reinforce digital systems, reaching even the most remote areas of the country

In conclusion, the literature states that inclusion promotes the formalization of MSMEs, primarily through invoicing and the efficiency of payment methods. This allows financial institutions to establish a credit history and support formal businesses with financial services, while also strengthening the ability to quickly monitor their income and expenses through digitalization

2.3 *Electronic invoicing and tax compliance*

An important tool to mention is electronic invoicing, which facilitates the traceability of transactions for micro and small enterprises (MSEs) and for tax collection agencies; in the case of Peru, SUNAT. This supports the formalization of MSEs and simplifies their accounting. By connecting the company's invoicing software with the tax authority, the latter can view the company's daily transactions, ensuring transparency and improving trust between businesses and the government (OECD, 2020). Thus, electronic invoicing benefits both the state's tax collection agency and tax auditing by consolidating and reconciling balance sheets in real time, resulting in better control. According to Pomeranz (2015), monitoring and accessing real-time information improves tax collection compliance. Similarly, Naritomi (2019) states that having control through digital platforms and even by customers compels companies to pay taxes correctly and more effectively, guaranteeing tax compliance for the state.

In Latin America, specifically in developing economies, various studies have concluded that electronic invoicing improves formalization rates and tax collection. Furthermore, electronic invoicing promotes best practices, as it makes tax evasion more difficult, encouraging businesses to adhere to proper accounting practices (OECD, 2020; Dabla et al., 2021). Therefore, for micro and small enterprises (MSEs), having electronic invoicing is essential because it improves the company's financial structure, making it more organized and detailed. This facilitates access to formal credit from financial institutions and government contracts, thereby increasing revenue and enhancing their reputation. However, the adoption of this technology must be evaluated by the company, considering three factors: first, whether it is viable or profitable; second, whether sufficient technology is available; and third, whether the company has the skills or training to implement it. Therefore, the premise is that SMEs, specifically those lacking the aforementioned resources, will have a more limited perspective; that is, they may perceive it as more cumbersome than beneficial, and ultimately, they will not adapt it to their systems (Dabla et al., 2021). Consequently, the benefits of electronic invoicing will vary depending on the company's context and financial situation. Furthermore, combining electronic invoicing with digital tools such as mobile transactions increases the advantages for businesses. When combined with digital payments, it strengthens and better organizes daily balances and, in turn, formal revenue collection (Pomeranz, 2015). Therefore, the challenge is to integrate financial inclusion with electronic invoicing, understand the contexts of businesses, and adapt to them in order to improve rates of effective formalization in micro and small enterprises (MSEs).

2.4 *Technology adoption in MSMEs*

The main turning point is having the technological infrastructure and the ability to adapt the necessary tools for the business, such as electronic invoicing, among others, and focusing on becoming a formal, higher-performing company. In any case, it is necessary to review the different theories of digital adoption for businesses and see how it plays out in SMEs, drawing conclusions that will help increase their formalization. We will begin by explaining the Technology Acceptance Model (TAM), which states that a company will adopt technology in its internal processes only if it is perceived as useful, that is, if it adds value, and profitable (Davis, 1989). Furthermore, TAM2 theory suggests that usefulness is closely linked to group opinion, particularly in company meetings, and perhaps to social pressure (Venkatesh and Davis, 2000). Therefore, if the micro, small, or medium-sized enterprise (MSME) perceives the usefulness, that is, the benefits, of adopting the technology, it will be easier to understand it and improve performance. Similarly, the Unified Theory of Technology Acceptance and Use clearly indicates that social pressure, perceived performance improvements, and ease of implementation can lead to technology adoption within companies (Venkatesh et al., 2003). A World Bank study (2016) states that in developing economies, specifically among micro and small enterprises (MSEs) with enabling factors such as technological know-how, secure infrastructure, internet access, and trained personnel, it is easier to adapt new technologies and improve performance. On the other hand, the literature states that the adoption of these technologies is linked to government incentives and their costs, as they are not very viable for micro and small enterprises (MSEs). Formalization depends on the clear implementation of digital tools, because if businesses perceive the value and incentives, thus improving their performance, then only then will they be willing to cooperate with the government (OECD, 2020). Therefore, financial inclusion and electronic invoicing are interdependent in order to achieve improvements in the formalization of MSEs.

2.5 *Theoretical contribution and conceptual framework*

The present study contributes to the literature in three ways: the first from a theoretical approach; that is, topics such as informality and institutional economy, tax auditing based on information and technological adoption, to finally explain how financial inclusion is linked to electronic invoicing and supports the formalization of MSMEs (Syed, 2024).

Secondly, from an institutional perspective, if the cost of formalization is perceived as higher without receiving the necessary incentives, then MSMEs will continue to operate outside the law (North, 1990; La Porta and Shleifer, 2014). Therefore, the formalization process must be understood holistically, including incentives and a robust network to facilitate registration and formalization through digital platforms for MSMEs to achieve their formalization

Third, from an empirical perspective, electronic invoicing requires businesses to be transparent with tax authorities on a daily basis, preventing errors and improving transparency in the formalization of accounts and taxes (Pomeranz, 2015; Naritomi, 2019). By generating a transaction history through digital tools, it's important to consider that physical cash will no longer be necessary,

as this inherently promotes financial inclusion, especially for micro and small enterprises (MSEs) located far from city centers, bringing financial services closer to them (Wei et al., 2025; Demirgüç et al., 2022). Finally, it should be noted that only those companies that adopt some type of digital financial tool will be included within the national financial system and gain full access to the services discussed in this research (Davis, 1989; Venkatesh et al., 2003)

The central theoretical contribution of this paper lies in proposing complementarity between digital financial inclusion and electronic invoicing. While each tool may independently support formalization, their joint adoption is expected to generate synergistic effects: digital payments increase the feasibility of recorded transactions, while electronic invoicing increases the value of maintaining a transparent transaction history.

Based on this framework, the study advances the following propositions:

P1: Digital financial inclusion positively influences MSME formalization by enhancing operational capabilities.

P2: Electronic invoicing positively influences MSME formalization by strengthening transaction traceability and compliance incentives.

P3: The combined adoption of digital financial inclusion and electronic invoicing has a stronger effect on formalization than either mechanism in isolation.

This integrated framework directly informs the empirical strategy used to test these relationships.

3. Methodology

3.1. Approach, design and type of research

The research was carried out using a quantitative, non-experimental, cross-sectional design approach, and explanatory design. This approach allows for the analysis of causal relationships between variables without directly manipulating them, while the cross-sectional nature will allow for the collection of data at a single point in time. The main objective is to examine the combined effect of two independent variables, digital financial inclusion and electronic invoicing, on a dependent variable: the level of formalization of MSMEs. To this end, a multiple linear regression model is used, which is suitable for multivariate studies, as it allows for the evaluation of the simultaneous and relative influence of several predictors on a single outcome variable. The multivariate nature of the study is justified by the interest in estimating not only the individual effect of each dimension of the independent variables, but also their combined effect, controlling for possible overlaps or collinearities. Furthermore, the analysis is organized using a hierarchical block model, which allows for the evaluation of the incremental contribution of each group of predictors to the overall model, and the establishment of the relative explanatory weight of each in predicting business formalization.

3.2. Population, sample, and sampling technique

The target population consists of micro and small businesses operating in the central region of Peru, specifically in the provinces of Huancayo, Chanchamayo, Tarma, and Satipo, and operating under formal regulations. A proportional stratified probability sampling method is used, based on economic sector (commerce, services, or production) and registration status (formal), to ensure territorial and sectoral representativeness. A minimum sample size of 381 units of analysis is estimated, calculated with a 95% confidence level and a 5% margin of error, which will guarantee the statistical robustness of the proposed analysis.

Table 1

Main financial variables

Variable	Dimension	Item
Digital financial inclusion	Access to digital financial services	Availability of online payment platforms
		Mobile banking adoption
	Use of digital financial tools	Frequency of use of mobile apps
		Internet banking, and e-wallets
Digital financial education	Participation in financial literacy programs	
Electronic invoicing	Technological implementation	Use of invoicing software, digital platforms for invoicing
	Regulatory knowledge	Understanding of tax compliance, e-invoice regulations
	Perception of usefulness	Business perception of efficiency and benefits of electronic invoicing
Business formalization	Registration and legal compliance	Legal entity registration, tax registration
		Compliance with regulations
	Formal corporate culture	Corporate governance, professional organizational practices
	Economic and organizational impact	Increased sales, improved financial transparency
		Organizational growth

Table 1 presents a detailed structure of the key financial variables that influence digital financial inclusion, electronic invoicing, and the formalization of MSMEs. Within digital financial inclusion, three fundamental dimensions are identified: access to digital financial services, use of digital financial tools, and digital financial education. The first dimension, access

to digital financial services, focuses on the availability of online payment platforms and the adoption of mobile banking, facilitating MSMEs' access to essential banking services. The second dimension, use of digital financial tools, refers to the frequency of use of mobile applications and online banking services, reflecting the integration of MSMEs into the digital economy. Finally, digital financial education addresses businesses' participation in educational programs on digital finance, which increases entrepreneurs' financial management capacity. Regarding electronic invoicing, the table distinguishes three essential dimensions: technological implementation, regulatory knowledge, and perceived usefulness. Technological implementation assesses the use of software and digital platforms for issuing electronic invoices, which is key to improving the operational efficiency of SMEs. Regulatory knowledge refers to the understanding of legal requirements related to tax compliance and regulations on electronic invoicing, a crucial dimension for tax formalization. Finally, perceived usefulness reflects how SMEs perceive the efficiency and benefits of electronic invoicing, which can influence their willingness to adopt this technology. Finally, business formalization is addressed through three dimensions: registration and legal compliance, formal corporate culture, and economic and organizational impact. The registration and legal compliance dimension analyzes adherence to legal requirements such as legal entity registration and tax registration, essential elements for business formalization. Formal corporate culture highlights the importance of governance and professional organizational practices to ensure business sustainability. Finally, the economic and organizational impact addresses how formalization contributes to increased sales, improved financial transparency, and fosters organizational growth, factors that are crucial for the stability and expansion of MSMEs.

3.3. Data collection technique and instrument

The data collection technique consists of a structured questionnaire, designed based on the findings of the theoretical review and validated through expert judgment. The instrument is composed of items distributed across three sections, corresponding to the study variables: digital financial inclusion, electronic invoicing, and level of formalization. For financial inclusion, information is collected on the use of digital banking services, the frequency of use of electronic wallets, and participation in digital financial education programs. Regarding electronic invoicing, its implementation, frequency of use, access to technological platforms, and regulatory knowledge are considered. Finally, for the dependent variable, it is assessed whether the MSMEs are registered with SUNAT (the Peruvian tax authority), whether they file taxes regularly, and whether they access government benefits aimed at formal businesses. Each dimension has indicators that have been previously operationalized and measured using ordinal, nominal, and discrete scales. Content validity is verified using Aiken's V coefficient, and internal reliability is estimated using Cronbach's alpha coefficient, with expected values greater than 0.80.

3.4. Statistical and econometric procedure and analysis

Data are collected during the second quarter of 2025, using both in-person and digital methods, depending on connectivity and access conditions in each geographic area. Once collected, the data are coded and processed using IBM SPSS Statistics version 28. The process begins with descriptive statistical analyses to characterize the sample and verify the internal consistency of the instruments. Subsequently, a multiple linear regression model is applied, verifying the main assumptions associated with the analysis: normality of residuals, linearity of relationships, independence of errors (measured using the Durbin-Watson test), homoscedasticity of variances, and absence of multicollinearity, assessed using the tolerance index and the variance inflation factor (VIF).

$$y_j = \beta_{j,0} + \beta_{j,1}x_1 + \beta_{j,2}x_2 + \beta_{j,3}x_3 + v_{jt}, \quad \text{for } j = 1, 2, 3 \quad (1)$$

where

y_1 : Access to digital financial services
 y_2 : Use of digital financial tools
 y_3 : Digital financial education
 x_1 : Technological implementation
 x_2 : Regulatory knowledge
 x_3 : Perception of usefulness
 x_4 : Registration and legal compliance
 x_5 : Formal corporate culture
 x_6 : Economic and organizational impact
 v_{jt} : Disturbance term, $v_{jt} \sim \text{iid}(0, \sigma^2)$

The formula shown shows the estimation by linear regression, which is to minimize the Sum of Squared Residuals (SSR):

$$\text{SSR} = (y_j^T - \beta_j^T X^T)(y_j - X\beta_j) \quad (2)$$

where SSR is sum square of residuals, $\beta_j = [\beta_{0,1}, \beta_{1,1}, \beta_{2,2}, \beta_{3,3}, \beta_{4,4}, \beta_{5,5}, \beta_{6,6}]^T$ and $X = [1, x_1, x_2, x_3, x_4, x_5, x_6]^T$.

$$\beta_j = (X^T X)^{-1} X^T y_j \quad (3)$$

The explanatory power of the model is assessed using the adjusted coefficient of determination (R^2), the F-test for overall significance, and the standardized beta coefficients (β) for each individual predictor. In addition, a statistical significance level of $p < 0.05$ is considered to confirm the existence of significant relationships between the variables. This approach aims to develop a robust predictive model that allows for an understanding of the impact of digital factors on the formalization of MSMEs in the central region of the country.

3.5. Research hypothesis

The objective of this research is to analyze the impact of digital financial inclusion (represented by the variables x_1, x_2, x_3) and the adoption of electronic invoicing (represented by the variables x_4, x_5, x_6) on the level of formalization of MSMEs (dependent variable y).

Null hypothesis (H_0): There is no significant relationship between digital financial inclusion, electronic invoicing, and the level of formalization of MSMEs.

Alternative hypothesis (H_1): There is a significant relationship between digital financial inclusion, electronic invoicing, and the level of formalization of MSMEs. This is expressed mathematically as:

$$H_1: \exists \text{ at least } \beta_j \neq 0 \text{ for } j = 1, 2, 3, 4, 5, 6$$

This formulation states that the null hypothesis assumes the absence of effects, while the alternative hypothesis indicates that there is a significant relationship between the variables. The results of the hypothesis test are based on the estimation of the coefficients β_j and their significance through statistical tests (e.g., the t-test).

4. Results

4.1. Descriptive statistics

Table 2
Descriptive statistics

Stats	y_1	y_2	y_3	x_1	x_2	x_3	x_4	x_5	x_6
N	381	381	381	381	381	381	381	381	381
Max	15	15	15	15	15	15	15	15	15
Min	6	6	7	6	7	8	6	7	6
Mean	12.131	12.087	11.934	11.829	11.790	11.940	11.948	11.940	11.903
SD	1.499	1.549	1.452	1.651	1.523	1.557	1.555	1.589	1.605
Variance	2.246	2.400	2.109	2.726	2.319	2.425	2.418	2.525	2.577
P_{50}	12	12	12	12	12	12	12	12	12
Skewness	-0.309	-0.374	-0.268	-0.556	-0.252	-0.331	-0.392	-0.401	-0.652
Kurtosis	3.010	3.122	2.794	3.324	2.872	2.674	3.106	2.925	3.690

Table 2 presents descriptive statistics for the variables involved in the analysis. The values of N (number of observations) are consistent across all variables, with a total of 381 observations. The mean for each variable, as indicated in the Mean column, varies slightly among the variables, with variable y_3 reaching a mean of 11.934, while y_1 has a mean of 12.131. The SD (Standard Deviation) values range from 1.452 to 1.661, indicating moderate variability within each variable. The variance, presented in the next column, shows a similar pattern of dispersion, with x_3 having the highest variance (2.726), indicating greater dispersion in the values of that variable compared to others.

In terms of the median (P_{50}), most variables have a value of 12, suggesting that the distribution of observations is centered around this value. Skewness and kurtosis provide information about the shape of each variable's distribution. Skewness ranges from -0.268 to -0.556, indicating that the distributions tend to be slightly skewed to the left (longer tail at the bottom). Kurtosis values range from 2.674 to 3.690, suggesting distributions with slightly thicker tails than normal distributions, especially for the x -squared (χ^2) distribution, which has the highest kurtosis (3.690), indicating a distribution more concentrated at its extremes. This may reflect a greater presence of outliers or extreme events in this variable.

4.2. Statistical analysis

Table 3 shows the correlation matrix between the variables included in the study. The values presented indicate linear relationships between the variables, with 1.000 on the main diagonal, reflecting the relationship of each variable with itself. Most of the correlations between the variables are low, suggesting a weak linear relationship between the majority of them.

For example, the correlation between y_1 and y_2 is almost zero (0.003), indicating that there is no significant relationship between these two variables. Similarly, y_3 and the variables x_1 , x_2 , x_4 , x_5 , and x_6 have small correlations, implying that there is no strong linear association between these variables. However, some correlations are more notable. The variable x_4 shows a moderate positive correlation with x_1 (0.022) and x_5 (0.047), suggesting that these variables might share certain behaviors or trends in their distribution. Furthermore, the correlation between x_5 and x_6 is quite weak (0.016), confirming that there is no significant relationship between these two variables. The highest correlations occur in the pairs x_3 and x_4 (0.063) and y_3 and x_6 (0.058), although all of these remain low, suggesting that the variables in the model are relatively independent of each other. In summary, the correlation matrix reflects weak relationships between the variables studied, which is important when considering multicollinearity in regression models.

Table 3
Correlation matrix

	y_1	y_2	y_3	x_1	x_2	x_3	x_4	x_5	x_6
y_1	1.000	-	-	-	-	-	-	-	-
y_2	0.003	1.000	-	-	-	-	-	-	-
y_3	-0.021	-0.127	1.000	-	-	-	-	-	-
x_1	-0.028	-0.014	-0.030	1.000	-	-	-	-	-
x_2	-0.023	0.114	0.046	-0.047	1.000	-	-	-	-
x_3	-0.008	-0.088	-0.009	0.001	-0.004	1.000	-	-	-
x_4	0.106	-0.006	-0.005	0.022	-0.022	0.047	1.000	-	-
x_5	-0.010	0.083	-0.035	-0.070	0.079	0.063	0.016	1.000	-
x_6	-0.054	-0.078	0.058	-0.005	0.020	-0.030	-0.061	-0.057	1.000

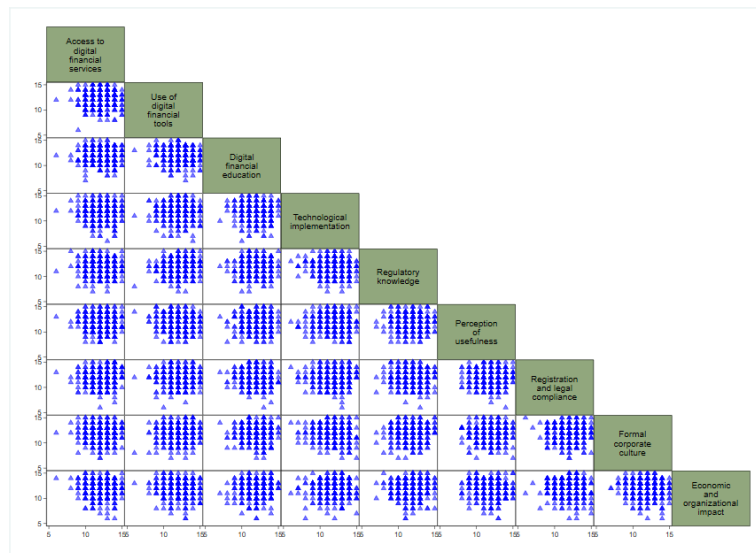


Fig. 1. Scatterplot matrix of financial dimensions

Fig. 1 shows a scatter plot of the main dimensions studied in the research, facilitating the visualization of the bivariate relationships between each pair of dimensions. Each scatter plot reflects how the observations of the different dimensions are distributed. In particular, it can be observed that most pairs of dimensions have a scattered distribution without a clear or significant relationship between them. This may indicate that there are no strong correlations between the variables being analyzed, suggesting that each dimension has considerable variability that may not be linearly related.

However, some plots appear to show slightly more defined patterns. For example, the dimensions related to "technology implementation" and "perceived usefulness" show a slight tendency for points to cluster along the diagonal, which could indicate a moderate relationship between these variables. Similarly, "formal corporate culture" and "economic and organizational impact" show a slight alignment in their distributions, suggesting that companies with a more formal corporate culture tend to have a greater economic and organizational impact. Despite these observations, the dispersion patterns remain relatively scattered, reflecting moderate independence between the dimensions studied.

4.3. OLS Regressions results

Table 4 reports the OLS regression results examining the relationship between digital financial inclusion, electronic invoicing adoption, and MSME formalization across three model specifications. The baseline model includes core firm characteristics and digital financial inclusion, while the extended and full models sequentially incorporate electronic invoicing adoption and additional contextual control variables. Coefficients are reported with t-statistics in parentheses, allowing for

heteroskedasticity-robust inference. The results indicate that digital financial inclusion is positively and significantly associated with MSME formalization in the baseline model, supporting the capability-enhancing mechanism proposed in the theoretical framework. Electronic invoicing adoption exhibits a positive and statistically significant effect in the extended and full models, suggesting that transaction traceability and compliance incentives play an important role in formalization outcomes. Control variables display limited explanatory power across specifications, which is consistent with prior empirical evidence in firm-level formalization studies. All estimated models are jointly significant according to the F-statistics reported, indicating that the included explanatory variables provide meaningful explanatory power despite relatively modest adjusted R-squared values (Flores-Vilcapoma et al., 2021, 2025).

Table 4

OLS Regressions results: digital financial inclusion, electronic invoicing, and MSME formalization

	(1) y ₁ MSME Formalization Baseline model	(2) y ₂ MSME Formalization Extended model	(3) y ₃ MSME Formalization Full model
x ₁ Firm Age	-0.279 (-0.60)	-	-
x ₂ Digital financial inclusion	0.0997* (2.02)	-	-
x ₃ Firm size	-0.0444 (-0.93)	-0.0759 (-1.55)	-
x ₄ Electronic invoicing adoption	-	0.111* (2.14)	0.159* (2.40)
x ₅ Sector (dummy or categorical control)	-	-0.946 (-1.87)	-0.0954 (-1.47)
x ₆ Region (dummy or location control)	-	0.0745 (1.50)	-
Constant	11.80*** (11.75)	11.93*** (10.15)	23.28*** (21.03)
F statistic			
Adjusted R-squared	0.07	0.23	0.15

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

Table 5 presents the p-values of several diagnostic tests used to verify model specification in the financial regressions. These tests are fundamental for evaluating the regression model assumptions, such as heteroscedasticity, autocorrelation, normality of the residuals, and model identification. Regarding heteroscedasticity, the p-values for all three models (Models 1, 2, and 3) are greater than 0.05, indicating that the null hypothesis of homoscedasticity is not rejected; that is, there is no significant evidence of heteroscedasticity in any of the models. This result suggests that the variance of the residuals is constant, fulfilling one of the key assumptions of regression.

Table 5

Model specification by financial regression models p-values

Test	Heteroscedasticity	Autocorrelation		Normality	Identification
	White	Durbin-Watson	Breusch-Godfrey	Jarque-Bera	Ramsey RESET
Model 1	0.5158	1.9331	0.4068	0.1353	0.5663
Model 2	0.1042	1.9335	0.5496	0.1394	0.2170
Model 3	0.4644	2.163789	0.3455	0.0701	0.3634

With respect to autocorrelation, the Durbin-Watson value is close to 2 for all models, indicating that there are no significant autocorrelation problems in the regression residuals. In the normality test (Jarque-Bera), the p-values are greater than 0.05 for all three models, suggesting that the null hypothesis of normality of the residuals is not rejected. This is a good indication that the residuals follow a normal distribution, as required by the OLS estimation. Finally, in the identification test (Ramsey RESET), all p-values are also greater than 0.05, indicating that there are no specification problems in the models; that is, it is not necessary to add additional terms to improve the model specification. In summary, the diagnostics suggest that the three models adequately meet the assumptions of standard regression, thus validating their reliability for making inferences.

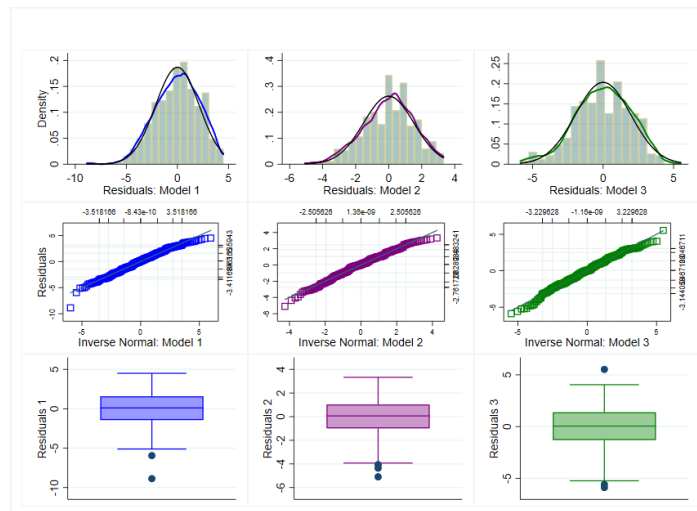


Fig. 2. The graphical analysis is based on Kernel densities, Q-Q charts and box plots, where predefined percentiles were used as references and a black line was used to represent the normal distribution

Fig. 2 shows a series of diagnostic plots that allow for the evaluation of the residual distribution for the three regression models: the estimated density plot, the Q-Q (Quantile-Quantile) plots, and the box plots. At the top of the figure, the estimated density plots of the residuals for the three models are presented, where the black line represents the normal distribution. The density plot for Model 1 shows a slight asymmetry, as the residual curve does not perfectly follow the shape of the normal distribution. In contrast, Model 2 and Model 3 exhibit a residual distribution closer to normal, although they also show slight deviations in the tails of the distribution.

The Q-Q plots in the second row of the figure plot quantiles of residuals against quantiles from a normal distribution. In all three plots, the dots are close to the straight line which seems to indicate that the residuals are approximately normally distributed. Nevertheless, we can see some discrepancies in the tails for Model 1, which could suggest that the residuals in this model have fatter tails than those of a normal distribution. Model 2 and Model 3 also exhibit small deviations at the tails, but the residuals approximately follow a normal distribution.

At the bottom of the figure, we find box plots representing the distribution of residuals for each model. There seems to be no significant bias in the residuals in all three models with most of the datums being located inside the boxes, with a small number of outliers. Model 3 has a slightly more scattered distribution than the rest of the models, yet in general there is no large outlier or substantial skewness, indicating there are no serious bias or dispersion problems in the models. These plots collectively indicate that although there is some scatter, the residuals of all three models follow a fairly good normality fit; this can be considered as an important proof for the legitimacy of the estimates.

5. Conclusions

The main objective of this study was to analyze the impact of digital financial inclusion and the adoption of electronic invoicing on the formalization of MSMEs in the central region of Peru. This study contributes to the literature by providing empirical evidence on the complementary role of digital financial inclusion and electronic invoicing in promoting MSME formalization in non-metropolitan contexts of a developing economy. The results obtained from the multiple linear regression analysis provide valuable information on the relationship between these two factors and their contribution to MSE formalization. The findings reveal that both digital financial inclusion and electronic invoicing play a significant role in MSE formalization, although the impact varies depending on the specific variables involved.

One of the main conclusions of the study is that digital financial inclusion, especially through the use of mobile banking and e-wallets, has a key effect on MSE formalization. Businesses that adopt digital payment systems such as Yape and Plin tend to be more formalized. This phenomenon is particularly visible in regions where digital literacy and access to financial technologies have improved, underscoring the growing importance of financial inclusion within Peru's broader economic context.

Furthermore, the adoption of electronic invoicing has emerged as a crucial factor in increasing formalization. MSMEs that implement electronic invoicing systems demonstrate greater compliance with tax regulations, better management of their financial records, and increased access to formal financing. The use of invoicing software, combined with knowledge of the regulatory framework, not only improves operational efficiency but also allows businesses to build a solid tax and financial record that facilitates their growth.

However, despite the observed benefits, several obstacles exist to the full adoption of digital tools and electronic invoicing. Low digital literacy, distrust of the tax system, and the logistical challenges inherent in rural and intermediate regions hinder widespread adoption. These obstacles slow the formalization process in these areas, and overcoming them requires collaboration between the government and the private sector to improve digital education and increase trust in formal systems.

This study highlights that digital financial inclusion and electronic invoicing should not be considered isolated tools, but rather complementary elements that, when implemented together, can significantly boost formalization. It is essential to adopt a comprehensive approach that combines both dimensions in a holistic strategy for the growth and formalization of MSMEs. Policymakers and financial institutions are encouraged to support the development of interoperable digital payment platforms and ensure that electronic invoicing systems are accessible to all businesses, regardless of their size or location.

The results presented in this paper provide a solid foundation for formulating public policies that promote the adoption of digital financial tools and improve the regulatory framework for electronic invoicing. The study underscores the importance of continuing to promote financial inclusion and digital education as essential components of MSME formalization strategies in Peru. By improving access to digital tools, MSMEs can transition more efficiently to the formal economy, enabling them to grow, access financing, and participate more actively in the national economy.

In conclusion, although significant progress has been made in digital financial inclusion and electronic invoicing, barriers to widespread adoption remain. It is recommended that further research explore the effects of digital education in greater depth campaigns in rural areas, as well as the role of government incentives in promoting business formalization through digital tools. These actions will strengthen policies designed to foster economic inclusion and the growth of the MSMEs sector in Peru.

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