The determinants of blockchain adoption intention by Moroccan SMEs: a transaction cost theory perspective

MAKHROUT Samir [1], ERRASSAA Noureddine [2], EL HAMIDI Nabil [3],

and AIT HBIBI Amina[4]

[1] PhD, Cadi Ayyad University Marrakesh, Morocco

[2] PhD, Cadi Ayyad University Marrakesh, Morocco

[3] PhD, Cadi Ayyad University Marrakesh, Morocco

[4] PhD, Cadi Ayyad University Marrakesh, Morocco

Abstract: This paper analyzes the factors influencing blockchain adoption by Moroccan SMEs, using Everett Rogers' (1962) Diffusion of Innovations Theory. The study identifies six key determinants: perceived complexity, compatibility with existing practices, observability of results, cost, perceived risk, and the ability to test the technology before full adoption. An ordered Probit model is employed to assess these factors based on a survey of 302 Moroccan SMEs from various sectors. The results show that perceived complexity significantly hinders adoption, as companies struggle to master the technology without adequate expertise. Additionally, perceived cost and risks related to regulatory uncertainties present major obstacles. The study also highlights that compatibility with existing processes facilitates adoption by reducing adjustment costs. While the observability of results is not significant, the ability to test blockchain before full implementation encourages its integration. Control variables reveal that companies operating in technology-intensive sectors, such as finance and logistics, are more inclined to adopt blockchain, whereas firm size has no notable effect. Trust in the regulatory framework and access to funding emerge as important catalysts. The study concludes that accelerating adoption requires developing innovation ecosystems, promoting pilot projects, and establishing a clear regulatory framework. These measures would reduce the perception of risks and encourage Moroccan SMEs to adopt this promising technology.

1. Introduction

In a constantly evolving economic context, blockchain emerges as a disruptive technology capable of transforming business practices and organizational processes worldwide. Initially developed to support cryptocurrency transactions, this technology quickly established itself as an innovative solution across various sectors, particularly due to its characteristics of security, transparency, and decentralization. However, despite its potential benefits, blockchain adoption remains limited, especially among SMEs, which face several challenges in integrating this technology. In Morocco, in particular, the adoption of blockchain by SMEs remains low, hindered by structural, technological, and economic constraints. This situation raises the question of which specific factors influence the intention to adopt blockchain within this category of enterprises. Therefore, the objective of this research is to explore the determinants of blockchain adoption intention among Moroccan SMEs, relying on Everett Rogers' (1962) Diffusion of Innovations Theory. This theory helps explain why some innovations spread faster than others and identifies essential factors such as perceived complexity, compatibility with existing practices, observability of results, cost, perceived risk, and testability. These dimensions provide a relevant framework for examining the barriers and enablers specific to blockchain adoption within Morocco's entrepreneurial landscape.

In a competitive and uncertain environment, blockchain adoption could represent a strategic lever for SMEs by facilitating process improvement, securing transactions, and creating new business opportunities. However, these companies must overcome several challenges related to high implementation costs, regulatory uncertainties, and the lack of internal expertise. Furthermore, the absence of local pilot projects and clear regulatory frameworks adds an additional layer of complexity, hindering experimentation with this technology by SMEs. This study is based on a survey of 302 Moroccan SMEs to understand how factors perceived by managers influence their intention to adopt blockchain. By applying an ordered Probit model, we analyze the effects of various theoretical dimensions on the likelihood of adoption, while integrating control variables such as company size, sector of activity, and trust in the regulatory framework. The results will identify the main obstacles and potential catalysts for blockchain adoption in Morocco.

2. Literature review

Kshetri (2018) highlights the importance of blockchain in reducing information asymmetries between SMEs and banks, emphasizing its contribution to increased transparency and better access to credit. This idea is extended by Chen (2018), who asserts that blockchain, by facilitating transactions with fewer intermediaries, not only optimizes processes but also reduces production costs, creating a competitive environment favorable to SMEs. Both authors agree that blockchain acts as a lever to enhance the competitiveness of small businesses by lowering transactional barriers. In the same vein, Ilbiz and Durst (2019) emphasize that successful blockchain adoption depends on enhanced inter-organizational cooperation, allowing SMEs to improve resource management and build partnerships without relying on intermediaries. This perspective is complemented by Clohessy et al. (2019), who temper this optimism by identifying significant challenges, such as the lack of resources and specific technical expertise, which slow down blockchain adoption. In response to these challenges, SMEs often turn to cloud-based solutions to bypass infrastructure-related obstacles. However, the absence of clear use cases continues to slow their progress, a difficulty less encountered by larger companies.

Bracci et al. (2021) explore the psychological and demographic factors influencing blockchain adoption, highlighting the impact of age, gender, perceived usefulness, and ease of use on the decision to adopt the technology. They stress the importance of enhancing SMEs' knowledge of blockchain to promote the efficient and sustainable diffusion of this technology, complementing the previous

perspectives by emphasizing the human and organizational dimensions of this transformation. Mahyuni et al. (2020) explain that blockchain optimizes logistical and administrative processes, particularly by facilitating documentation and customs clearance for exports. Their analysis aligns with that of Chaithanapat and Rakthin (2021), who point out that blockchain's use extends beyond logistics, improving internal coordination in SMEs by streamlining knowledge management between departments. Both studies converge on the idea that the operational fluidity enabled by blockchain strengthens both the efficiency and overall competitiveness of businesses.

From a more technological perspective, Khan et al. (2023) introduce the B-SMEs framework, combining blockchain, artificial intelligence (AI), and the Internet of Things (IoT) to enhance the security, resilience, and transparency of SMEs. Their contribution builds on the work of Mahyuni et al. (2020) by demonstrating that blockchain can also reduce fraud risks through decentralization and the immutability of transactions, a topic that Mahyuni et al. primarily addressed from a logistical coordination perspective. Treiblmaier and Beck (2019) extend this discussion by showing that blockchain, through smart contracts, allows SMEs to reduce costs while increasing productivity. They also highlight the role of new financial infrastructures such as decentralized finance, which SMEs can now leverage thanks to this technology. These conclusions resonate with the findings of Khan et al. (2023), as both studies emphasize a reduction in operational costs associated with centralized management. Wang, Lin, and Luo (2018) focus on financing issues and demonstrate that integrating blockchain can address problems of information asymmetry and credit rationing. They emphasize that the decentralized sharing of financial information through blockchain fosters transparency and reduces incentives for data manipulation, aligning with Khan et al. (2023) on the topics of security and traceability. Furthermore, their risk-sharing model between banks, businesses, and the government allows SMEs to access credit without physical collateral, facilitating their financing. This idea complements the analysis of Treiblmaier and Beck (2019) by offering a perspective on access to non-traditional financial resources.

Nayak and Dhaigude (2019) and Wong et al. (2020) agree that blockchain improves transparency and traceability in SMEs' supply chains, facilitating better management of goods flows. Nayak and Dhaigude's approach focuses more on building trust-based relationships between business partners, promoting decentralized governance. In a complementary manner, Wong et al. emphasize the impact of this enhanced transparency on international transactions, helping to overcome transactional inefficiencies and strengthening trust. From a more strategic perspective, Vijayakumar (2021) highlights that blockchain, when combined with artificial intelligence, not only optimizes processes but also enables advanced risk and opportunity detection. He suggests that this technological synergy enhances SMEs' competitiveness by reducing fraud and improving financial performance, echoing the findings of Rejeb et al. (2022). The latter also emphasize the importance of smart contracts in managing financial flows, noting that this automation reduces SMEs' dependence on intermediaries while increasing investor confidence. This analysis by Rejeb et al. resonates with the conclusions of Dong et al. (2021), who show that the automatic execution of transactions through blockchain improves the overall efficiency of capital management.

However, Ozili (2022) tempers this enthusiasm, pointing out that despite its many potential benefits, blockchain adoption among SMEs remains limited due to the perceived complexity of the technology and high implementation costs. These economic barriers align with the findings of Blossey et al. (2020), who stress the role of blockchain in improving SMEs' resilience. According to them, decentralized data management enables SMEs to better adapt to market fluctuations and integrate into global supply chain networks despite the challenges of adoption. Marchesi, Lunesu, and Tonelli (2024) highlight that blockchain adoption enhances traceability and optimizes waste management, integrating the technology to promote sustainable management within SMEs. Tokenization and smart

contracts not only automate processes but also encourage greater environmental responsibility, aligning the economic and ecological objectives of businesses. Additionally, tax incentives for waste management help reduce operational costs, increasing SMEs' resilience in a competitive environment. This perspective aligns with the ideas of Senyo et al. (2019), who emphasize the broader contribution of digital ecosystems, including blockchain, to improving SMEs' operational efficiency. By reducing manual interventions and minimizing risks in transaction execution, SMEs enhance their internal processes and simultaneously improve their access to financing. Process optimization and risk reduction thus become pillars for enhancing competitiveness and overall performance.

Wang (2020) continues this reflection by exploring how blockchain improves SME credit assessment. He highlights the enhanced transparency and traceability of financial information, which facilitate access to financing. This transparency helps reduce auditing costs while minimizing errors, thus strengthening the efficiency of SMEs' internal financial processes. Together, these contributions show that integrating blockchain into different aspects of SME management not only optimizes their internal operations but also makes them more resilient to financial and operational challenges. Rakshit et al. (2022) emphasize how blockchain facilitates internationalization, particularly in technology-intensive sectors, by enabling SMEs to enhance their marketing capabilities and access new markets. Their study demonstrates that blockchain improves international collaboration by ensuring greater transparency and making transactions more reliable. From a complementary perspective, Chabani et al. (2021) highlight that blockchain also promotes organizational transparency and simplifies audit processes while reducing the costs associated with reconciliation operations. However, they point out the internal challenges companies face in adopting blockchain effectively, such as the need for internal reorganization and the lack of clearly established industry standards.

The relevance of blockchain in a crisis context is explored by Frizzo-Barker et al. (2020). They emphasize its importance in strengthening security and transparency—critical elements for SMEs that experienced the destabilizing effects of the COVID-19 pandemic. Blockchain helps these businesses resolve collaboration and cash flow management issues, demonstrating its supportive role during economic disruptions. Cocco et al. (2021) focus on applying blockchain in supply chain management within an agri-food SME. Their study shows that integrating blockchain with the Internet of Things (IoT) ensures transparent traceability, building trust among stakeholders without the need for a third party. By reducing input errors and mitigating risks of falsification, this technology provides visibility to consumers and authorities regarding product pathways, ensuring compliance with health standards. By connecting these contributions, it becomes clear that blockchain, beyond its individual benefits of transparency, security, and market access, offers a comprehensive response to SMEs' strategic needs.

The ideas of Rakshit et al. (2022) and Frizzo-Barker et al. (2020) converge on the impact of blockchain in supporting internationalization and collaboration, especially during times of economic uncertainty. Furthermore, the studies of Chabani et al. (2021) and Cocco et al. (2021) reveal the importance of blockchain in improving organizational efficiency and supply chain management, despite the internal challenges its adoption may impose. Drawing from these various contributions, blockchain plays a central role in reducing transaction costs by enhancing transparency and facilitating credit access for SMEs, thereby limiting expenses related to financial risk assessment and monitoring. By eliminating intermediaries, it simplifies processes and reduces transaction costs associated with coordination and production. Additionally, blockchain fosters decentralized governance, lowering transaction costs related to resource management and inter-organizational collaboration. In supply chains, blockchain strengthens trust among business partners by ensuring greater transparency, thereby reducing transaction costs linked to errors, disputes, and compliance checks. However, challenges remain due to high implementation costs and technical complexity, requiring SMEs to undergo

internal reorganization. By optimizing internal management and minimizing transaction costs, blockchain enhances the efficiency and resilience of SMEs in a competitive economic environment.

3. Methodology

3.1 Development of research hypotheses and model

The theory applied in this work is Everett Rogers' (1962) Diffusion of Innovations Theory. This theory examines how, why, and at what rate a new technology or innovation spreads through a social or organizational group. Rogers identifies several factors that influence the adoption of an innovation, including perceived complexity, compatibility with existing systems, observability of results, cost, perceived risk, and the ability to test the innovation before full implementation. The theory emphasizes the following elements:

- **Perceived complexity:** Blockchain is often regarded as difficult to understand and master. This perception is exacerbated by the lack of internal technical expertise, leading Moroccan SMEs to delay its adoption due to fears of implementation errors. The difficulty of recruiting or training specialized blockchain experts further complicates this challenge, contributing to slower adoption.
- **Compatibility with existing practices**: Integrating an innovation requires compatibility with existing systems and processes. However, Moroccan SMEs, often rooted in traditional structures, struggle to adapt their operational models to blockchain. This lack of compatibility results in additional adjustment costs and complicates the smooth integration of this technology.
- **Observability of results:** SMEs seek tangible proof of benefits before investing in a new technology. The absence of successful pilot projects or concrete examples of blockchain use in Morocco reduces the visibility of its potential advantages. This situation reinforces hesitation, especially as companies perceive the return on investment to be uncertain.
- **Perceived cost and economic uncertainties**: Implementing blockchain requires significant investments in training, development, and infrastructure. For SMEs operating in an unstable economic environment, these costs present a major barrier. The lack of funding or subsidies to support the adoption of this technology strengthens this perception.
- **Perceived risk and skepticism:** The unclear regulatory framework surrounding blockchain in Morocco fosters skepticism among SMEs. These businesses fear taking risks without legal guarantees or adequate protective frameworks, increasing their reluctance to adopt the technology. This regulatory uncertainty adds another layer of hesitation, discouraging investment.
- **Limited testability:** Rogers highlights that the ability to test an innovation before full adoption is essential. However, Moroccan SMEs rarely have access to experimental platforms that allow them to trial blockchain on a small scale. This lack of favorable conditions for experimentation limits their ability to understand the technology's advantages and constraints before committing to full adoption.

Based on these theoretical dimensions and their application to the Moroccan context, this research aims to identify the key factors influencing blockchain adoption and formulate testable hypotheses to guide the empirical study. In the case of Moroccan SMEs, the absence of successful pilot projects and the lack of clear demonstrations of benefits increase their cautious approach. Companies remain wary of this technology until they have tangible evidence to inform their investment decisions. From these considerations, the following research hypotheses are proposed:

- *H₁: The perceived complexity of blockchain has a negative effect on its adoption by Moroccan SMEs.*
- *H₂: A high perceived compatibility between blockchain and the company's current practices has a positive effect on its adoption.*
- *H₃: Increased observability of blockchain's benefits has a positive effect on its adoption by Moroccan SMEs.*
- *H₄: A high perceived cost of implementing blockchain has a negative effect on its adoption.*
- *H₅: A high perceived risk related to the use of blockchain has a negative effect on its adoption.*
- *H₆: The ability to test blockchain before full implementation has a positive effect on its adoption.*

After determining the research hypotheses, which help identify the barriers and enablers of blockchain adoption while guiding the empirical study, the formulation of the econometric model is as follows:

$$BLOCK = \alpha + \beta_1 COMP + \beta_2 COMPAT + \beta_3 OBSV + \beta_4 COST + \beta_5 RISK + \beta_6 TEST + \beta_7 SECT + \beta_8 SIZE + \beta_9 REGU + \beta_{10} FUND + \varepsilon$$

BLOCK represents blockchain adoption and is measured on a Likert scale from 1 to 5, thus assessing the level of SMEs' readiness to adopt this technology. COMP refers to perceived complexity, which evaluates companies' perception of the difficulty in understanding and implementing blockchain. COMPAT denotes perceived compatibility, measuring how well blockchain integrates with the existing systems and processes of SMEs. OBSV focuses on the observability of results, reflecting the ability of companies to perceive the tangible benefits of blockchain through pilot projects or concrete use cases. COST represents perceived cost, encompassing the evaluation of financial and human costs associated with adopting this technology. RISK refers to perceived risk, including the legal and technological uncertainties surrounding the implementation of blockchain. TEST concerns testability, measuring the possibility for SMEs to test blockchain on a small scale before full adoption. The six main dependent variables are measured using five relevant items on a Likert scale from 1 to 5, and the final variable is determined by calculating the average of the five items for each variable.

Regarding the control variables, SECT refers to the high-tech industry sector, measured as a binary variable. Certain industries, such as finance or logistics, are more inclined to adopt technologies like blockchain. SIZE represents the size of the company, with larger SMEs often having more resources to experiment with innovations. REGU assesses trust in the regulatory and legal framework, which plays a significant role in the adoption decision. An unclear or unstable regulatory environment can hinder the adoption of innovative technologies such as blockchain.

3.2 Justification for the use of ordered Probit

The choice of an ordered Probit model for this study is based on several considerations. This type of model is particularly suited to a dependent variable that is categorical and ordered, such as blockchain adoption measured on a Likert scale. Responses ranging from 1 to 5 illustrate different attitudes of SMEs toward this technology, making the model appropriate for capturing these distinctions. Moreover, this model effectively addresses issues of heterogeneity and endogeneity that may arise when evaluating the determinants of adoption. It accounts for the nonlinear effects of explanatory variables on the probability of belonging to a specific category of the dependent variable.

In addition, Probit models are distinguished by their robustness and ability to provide reliable estimates, especially when the conditions of an ordinary linear regression model are not met. These conditions include aspects such as normality of residuals and homoscedasticity, which are particularly relevant in the context of blockchain adoption, where company perceptions can vary significantly. Thus, the application of the ordered Probit model proves to be a sound choice for analyzing the factors

influencing blockchain adoption by Moroccan SMEs. It allows for a better understanding of the nuances in companies' attitudes toward this technology while considering the specificities of the data collected.

3.3   Data

The sample of this study consists of 302 Moroccan SMEs, selected to reflect the diversity of business sectors to ensure the representativeness of the results. The main objective is to understand how different factors influence the adoption of blockchain technology within these companies. The selection criteria for the companies first include the business sector. The sample comprises SMEs from various sectors, including technology, finance, logistics, and other high-tech industries. This sectoral diversity allows for the exploration of adoption variations based on the specific characteristics of each field. Next, company size was also considered. The sample includes SMEs of different sizes, ranging from micro-enterprises to medium-sized enterprises. This enables an analysis of how available resources can influence the ability to adopt new technologies.

Moreover, the location of the companies is an important factor. The selected SMEs come from various regions of Morocco, providing insight into blockchain adoption across different economic and social contexts. The data collection methodology is based on a questionnaire survey administered to the managers or heads of the SMEs. This questionnaire was designed to assess companies' perceptions of the key factors influencing blockchain adoption, including perceived complexity, compatibility, observability, cost, risk, and testability.

4.   Results

4.1   Robustness analysis

Unlike the Ramsey test used in traditional linear regressions, which assesses whether omitted powers of variables explain part of the variance not captured by the model, the recurrent coefficient approach offers an alternative for nonlinear models such as ordered Probit. Figure 1 shows that the coefficients gradually converge and do not undergo significant fluctuations as new data is added. This stability suggests that the model accurately captures the relationships between variables without requiring major transformations or revisions.

Figure 1: Specification test: stability of recursive coefficients in the ordered Probit model
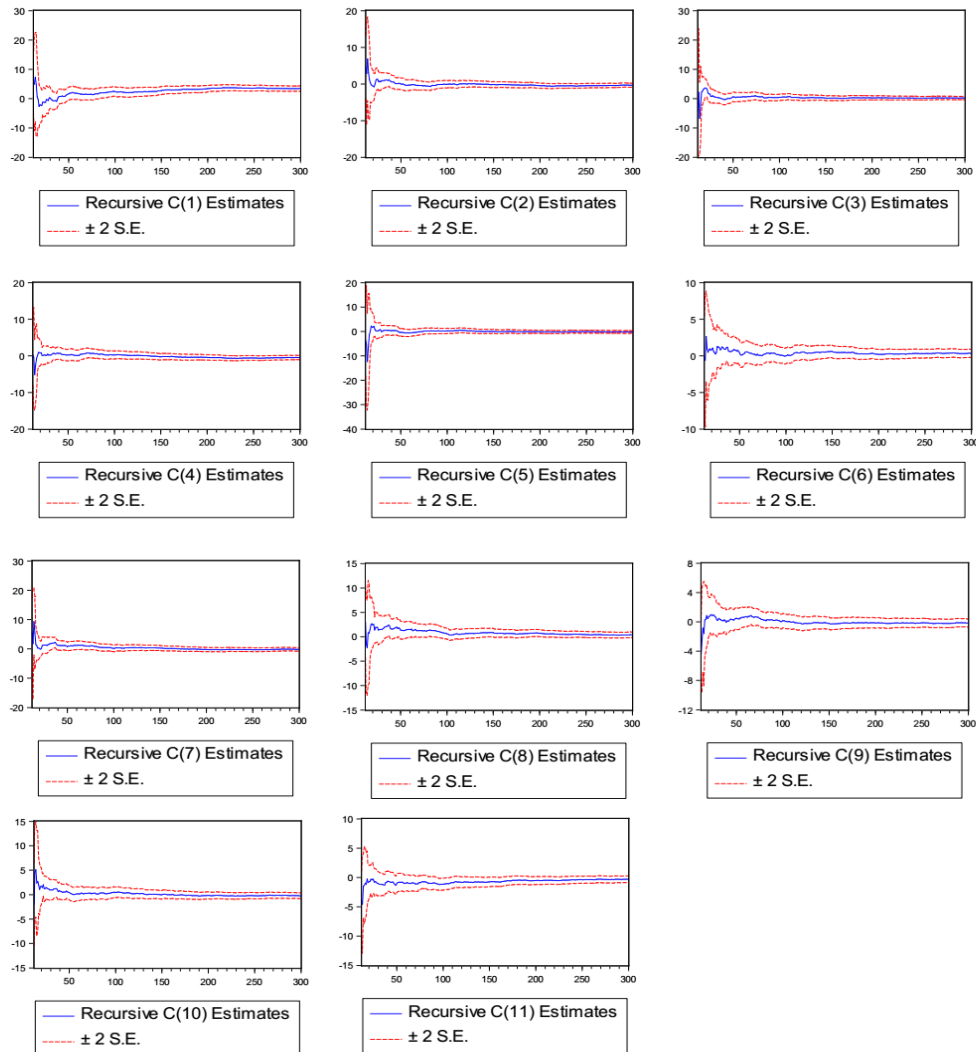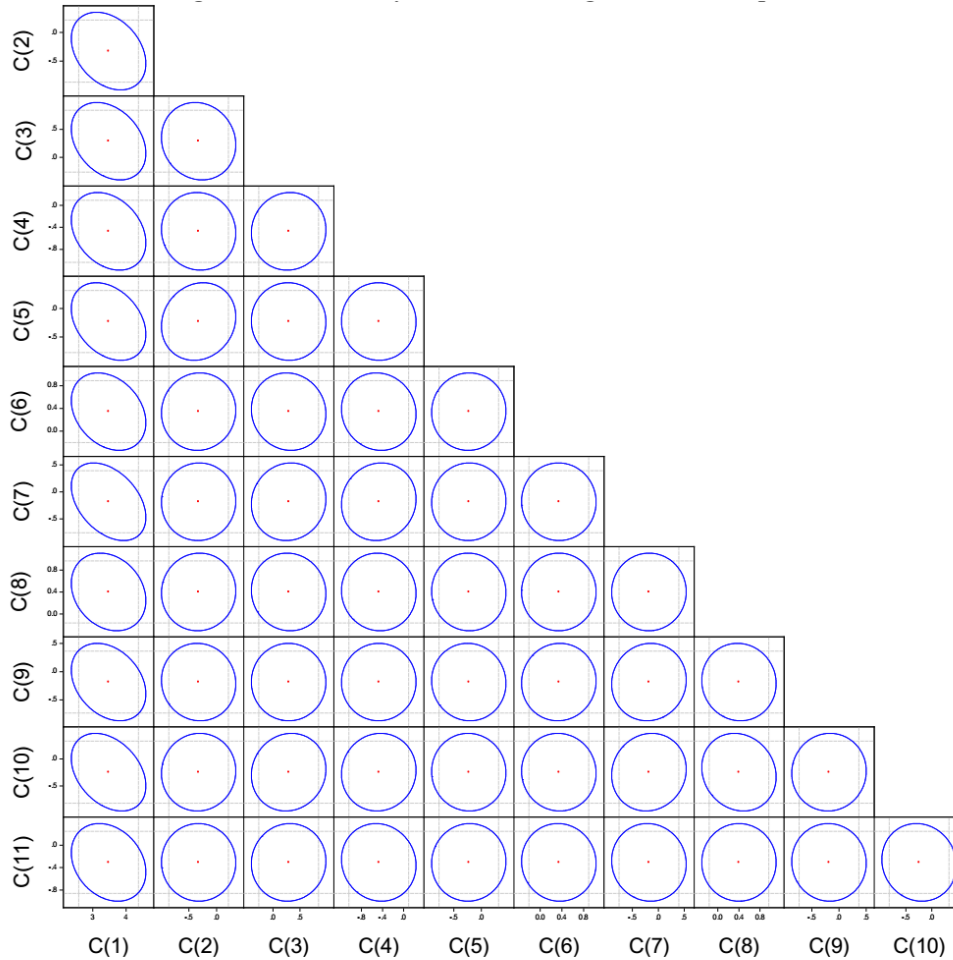

Source: authors

The absence of significant drift in the coefficients over iterations reflects the robustness of the specification and the relevance of the selected variables. Had substantial variations been detected, it would have indicated a specification error, suggesting the need to revise the model structure or include omitted variables. As it stands, the convergence observed in the figure reinforces the idea that the model is well-specified.

VIFs are not suitable for nonlinear models, such as ordered Probit, as they are specifically designed to assess multicollinearity in linear regressions. In these models, the nature of the relationships between variables does not allow for a straightforward interpretation of collinearity using VIFs. Consequently, alternative methods better suited for nonlinear models, such as confidence ellipses, are used to examine the relationships between the model's variables and identify potential strong correlations. Figure 2 shows a matrix of confidence ellipses that provides a visual assessment of collinearity between variables. Each ellipse represents the relationship between two variables. An elongated and flattened ellipse would indicate a strong correlation between these variables, while an ellipse closer to a circle suggests weaker or no correlation.

Figure 2: Collinearity assessment using confidence ellipses

Source: authors

The empirical points (in red) located within the ellipses confirm that the relationships between variables remain within expected limits, suggesting the absence of excessive collinearity. This approach is particularly useful for quickly detecting potential collinearity issues. Strong correlations between certain variables could affect the precision of estimates and reduce the quality of the model's results. In this figure, the ellipses are well-shaped and contain the empirical points, indicating that the relationships between variables are moderate and do not pose any major collinearity problem.

The White test is used here to detect heteroscedasticity, which refers to non-constant variance in the model's residual errors. Unlike other tests, such as the Breusch-Pagan test, which relies on more restrictive assumptions, the White test is non-parametric and offers greater flexibility by not assuming any specific form of heteroscedasticity. Its application aims to ensure the validity of the estimates, as the presence of heteroscedasticity can bias the standard errors of the coefficients and affect the statistical interpretation of the results.

Table 1: Heteroskedasticity Test: White Test

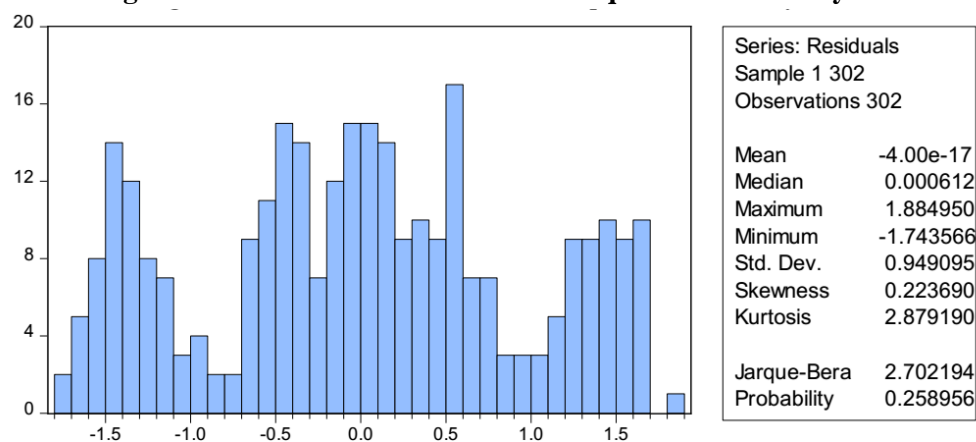| Statistic	Value	Probability
F-statistic	0.703790	Prob. F(65, 234) = 0.9527
Obs*R-squared	49.05841	Prob. Chi-Square(65) = 0.9296
Scaled Explained SS	20.60309	Prob. Chi-Square(65) = 1.0000

Source: authors

The results (Table 1) show that the probability associated with the F-statistic (0.9527), as well as with Obs*R-squared (0.9296) and Scaled Explained SS (1.0000), are all above the typical 0.05 threshold. These results indicate that the null hypothesis of homoscedasticity is not rejected, suggesting no evidence of significant heteroscedasticity in the model. The high probability values reported in the table suggest that the residuals do not exhibit abnormal variations, further reinforcing the relevance of the model used for this analysis.

The normality test is essential in ordered Probit models, as these models rely on the assumption that errors follow a standard normal distribution. If this assumption is violated, the estimates may become biased, leading to incorrect statistical inferences. Ensuring the normality of residuals helps maintain the robustness and validity of the estimated parameters and associated significance tests. Indeed, deviations from normality can affect the consistency and efficiency of estimators, making it crucial to detect and correct these issues when necessary.

Figure 3: Residuals distribution and Jarque-Bera normality test

Series: Residuals	
Sample 1 302	
Observations 302	
Mean	-4.00e-17
Median	0.000612
Maximum	1.884950
Minimum	-1.743566
Std. Dev.	0.949095
Skewness	0.223690
Kurtosis	2.879190
Jarque-Bera	2.702194
Probability	0.258956

Source: authors

Figure 3 shows a histogram of the model's residuals, accompanied by the results of the Jarque-Bera test for normality. The distribution of residuals is centered around zero, with slight irregularity but no significant skewness. The skewness is close to zero, and the kurtosis value is close to three, indicating a fairly balanced shape. The Jarque-Bera test yields a statistic of 2.702 and a probability of 0.259, well above the 0.05 threshold. This suggests that the null hypothesis of normality of residuals cannot be rejected. The results indicate that the errors do not exhibit significant bias.

Figure 4 presents the Hat Matrix, which allows for the evaluation of the influence and stability of observations in the model. Each point in the matrix corresponds to an observation, in this case, SMEs, with values indicating the relative weight or influence of each data point on the model's estimates. Model stability is assessed by verifying whether these values remain contained and do not exceed a critical threshold, usually indicated by a horizontal line, as shown in the graph. The Hat Matrix values appear to fluctuate between 0.03 and 0.04 without exceeding the limit. This suggests that no observation exerts excessive influence that could destabilize the model or introduce bias.

Figure 4: Hat Matrix: Assessing Observation Influence and Model Stability
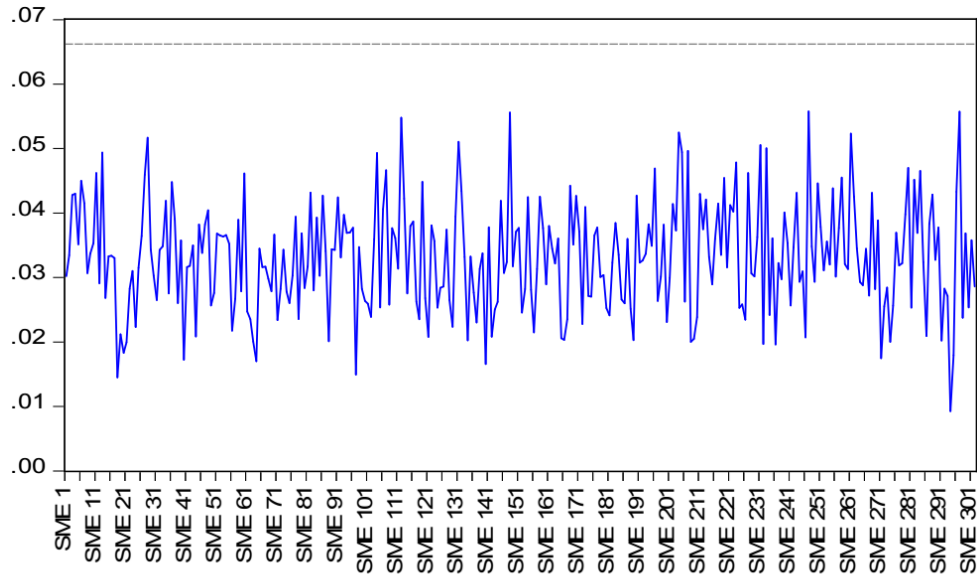
Source: authors

In other words, each SME in the sample contributes moderately to the final results, reinforcing the overall stability of the model. This absence of extreme points indicates that the model is robust to individual data points and is not dominated by a few influential observations. If some values had exceeded the critical threshold, it would have signaled a potential stability issue or influential outliers, requiring a revision of the model or a more in-depth analysis of the data in question.

4.2   Result of the Ordered Probit model

The empirical methodology of this study is based on Everett Rogers' (1962) Diffusion of Innovations Theory, applied to the context of blockchain adoption by Moroccan SMEs. The research hypotheses are formulated around several factors influencing this adoption: perceived complexity, compatibility with existing practices, observability of results, perceived cost, perceived risk, and testability. The study employs an ordered Probit model to analyze these factors, justified by the ordered nature of the dependent variable (blockchain adoption) measured on a Likert scale. A sample of 302 SMEs, selected based on sectoral, size, and location criteria, was studied through a questionnaire survey addressed to their managers. The results are analyzed while accounting for collinearity, heteroscedasticity, and the normality of residuals, ensuring the robustness of the estimates. Control variables, such as business sector and company size, enrich the model by considering the contextual specificities that influence adoption. The following table summarizes the results obtained:

Table 2: results of the ordered Probit model for blockchain adoption (dependent variable: BLOCK

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Dependent Variable: BLOCK				
Method: ML - Ordered Probit (Newton-Raphson / Marquardt steps)				
Sample: 1 302				
Included observations: 302				
Number of ordered indicator values: 5				
Convergence achieved after 4 iterations				
Coefficient covariance computed using observed Hessian				
C	***2.483841	0.816838	3.040800	0.0026
COMP	***-0.653865	0.215537	-3.033655	0.0026
COMPAT	**0.567660	0.219254	2.589053	0.0101
OBSV	-0.179876	0.209835	-0.857226	0.3920
COST	**-0.514660	0.212445	-2.422554	0.0160
RISK	***-0.616288	0.222699	-2.767359	0.0060
TEST	*0.399151	0.218959	1.822947	0.0693
SECT	**0.449249	0.223799	2.007379	0.0456
SIZE	0.184226	0.212653	0.866324	0.3870
REGU	**0.469466	0.213887	2.194925	0.0289
FUND	***2.483841	0.816838	3.040800	0.0026

Source: authors; ***Significant at 1%; **Significant at 5%; *Significant at 10%.

Perceived complexity (COMP) is significant at the 1% level, with a negative coefficient of -0.6539 and a p-value of 0.0026. This validates hypothesis H_1, indicating that the more blockchain is perceived as difficult to understand and implement, the less willing Moroccan SMEs are to adopt it. This result highlights the importance of simplifying integration processes and developing internal blockchain expertise to encourage adoption. Perceived compatibility (COMPAT) has a positive coefficient of 0.5677, with significance at the 5% level (p = 0.0101). This result confirms hypothesis H_2, suggesting that better compatibility between blockchain and existing systems or processes increases the likelihood of adoption. SMEs that perceive coherence between this technology and their current operations are more inclined to integrate it, thus reducing adjustment costs and internal resistance to change.

The observability of results (OBSV) is not significant, with a coefficient of -0.1799 and a p-value of 0.3920. Consequently, hypothesis H_3 is not accepted. This shows that visibility of results or success stories related to blockchain use does not appear to play a decisive role in adoption by Moroccan SMEs. This finding may indicate widespread skepticism or a lack of visible pilot projects in the local environment. Perceived cost (COST) is significant at the 5% level, with a negative coefficient of -0.5147 and a p-value of 0.0160. Hypothesis H_4 is thus validated, meaning that SMEs, particularly those with limited resources, are hindered by the high costs associated with training, infrastructure, and development necessary for blockchain implementation. This highlights the need for financial support mechanisms, such as grants or tax incentives, to encourage adoption.

Perceived risk (RISK) has a negative coefficient of -0.6163, with significance at the 1% level (p = 0.0060). Hypothesis H_5 is therefore accepted, confirming that technological or regulatory uncertainty discourages blockchain adoption. SMEs fear potential risks in the absence of solid legal guarantees or a clear regulatory framework, emphasizing the importance of appropriate regulation and risk management mechanisms. Testability (TEST) is significant at the 10% level, with a coefficient of 0.3992 and a p-value of 0.0693, validating hypothesis H_6. This positive relationship shows that SMEs with the opportunity to test blockchain on a small scale before full adoption are more inclined to adopt it. However, the lack of experimental platforms limits this ability, suggesting the need to create testing environments to overcome this barrier. The business sector (SECT) is significant at the 5% level, with a positive coefficient of 0.4492 and a p-value of 0.0456. SMEs operating in high-tech sectors, such as

finance or logistics, show a greater willingness to adopt blockchain. This indicates that the sectoral context plays a crucial role in openness to innovation.

Company size (SIZE) is not significant, with a p-value of 0.3870, suggesting that the size of SMEs does not have a notable influence on blockchain adoption in this study. This result may indicate that Moroccan companies, regardless of size, face similar challenges in adopting new technologies. Regulation (REGU) has a positive coefficient of 0.4695 and is significant at the 5% level (p = 0.0289). This result shows that trust in the regulatory framework encourages blockchain adoption. SMEs feel more secure when operating in a clearly regulated environment, reducing uncertainties related to innovation. Available funds (FUND) have a positive coefficient significant at the 1% level (p = 0.0026), highlighting that sufficient financial resources facilitate blockchain adoption. SMEs with adequate funding are better positioned to cover the costs associated with learning and infrastructure, enhancing their capacity to adopt this technology.

5. Discussion

The results show that perceived complexity hinders the adoption of blockchain by Moroccan SMEs. When companies consider this technology difficult to understand and implement, they are more reluctant to integrate it. This highlights the importance of strengthening internal blockchain skills and simplifying access to appropriate training. It also underlines the need for partnerships with external experts or training institutes to facilitate mastery of the technology and reduce the perception of complexity. Compatibility between blockchain and existing processes plays a positive role in its adoption. When companies perceive consistency between the new technology and their operational practices, they are more willing to adopt it. This suggests that blockchain integration should be designed to align with existing systems, which could reduce adjustment costs. Initiatives that encourage the gradual adaptation of processes, such as developing sectoral best practice guides, could accelerate adoption.

The lack of observability of results seems to limit blockchain adoption. Moroccan companies seek tangible proof of the benefits before committing to new technology. The absence of pilot projects or documented successes limits their ability to assess the return on investment. Policymakers and support institutions could encourage small-scale experiments or demonstrations across different sectors to enhance the visibility of this technology. The perceived cost of blockchain is a significant barrier to adoption. SMEs, often limited in resources, hesitate to invest in technologies that require high initial investments, particularly in infrastructure and training. This underscores the need for financial support mechanisms, such as grants, low-interest loans, or tax incentives. Such initiatives could ease the financial burden and make blockchain more accessible to smaller businesses. Perceived risk also hinders adoption. Moroccan SMEs are cautious about the uncertainty related to blockchain regulation and technical aspects. The lack of a clear legal framework reinforces this reluctance. Regulators have an important role in defining standards and protective frameworks suitable for the use of this technology. A predictable and secure regulatory environment could encourage companies to overcome their fears and adopt blockchain.

The ability to test blockchain before full adoption facilitates its integration. Companies are more willing to invest in technology when they can experiment with its advantages and limitations on a small scale. However, access to such testing platforms remains limited. Developing incubation programs and innovation labs could provide SMEs with a safe environment to test blockchain before committing to full adoption. Belonging to a high-tech sector also influences blockchain adoption. Companies in sectors such as finance or logistics, which are more receptive to technological innovations, show a greater willingness to adopt blockchain. This trend highlights the importance of fostering innovation ecosystems within these sectors to encourage the diffusion of blockchain to other

industries. On the other hand, company size does not seem to play a decisive role in adoption. This suggests that challenges related to blockchain, such as complexity or cost, are shared by companies of different sizes. While larger companies may have more resources, they are not necessarily more motivated to adopt the technology. Finally, trust in the regulatory framework positively influences blockchain adoption. Companies that perceive the regulatory environment as stable and predictable are more inclined to invest in innovations. This underscores the importance for policymakers to promote consistent and transparent regulation to reassure companies and stimulate innovation.

6.   Conclusion

This research has provided insights into the key determinants influencing blockchain adoption by Moroccan SMEs, drawing on Everett Rogers' Diffusion of Innovations Theory. The results show that several factors act as either barriers or drivers in companies' intentions to adopt this technology. Among the major obstacles identified, perceived complexity plays a significant deterrent role. SMEs often view blockchain as a technology that is difficult to understand and implement, highlighting the need for specialized training and partnerships with experts or training institutions. The ability of companies to overcome this obstacle will partly depend on their access to these skill development resources. Additionally, high costs related to infrastructure and training hinder adoption, especially in a context where SMEs often operate with limited financial resources. This underscores the necessity for financial support mechanisms, such as public grants, tax incentives, or low-interest loans, to make the technology more accessible. Perceived risk is another significant barrier, particularly due to the legal and regulatory uncertainties surrounding blockchain. This finding demonstrates that establishing a clear and predictable regulatory framework is crucial to reassuring businesses and encouraging investment in technological innovations.

On the other hand, some factors serve as key drivers for blockchain adoption. Compatibility with existing systems and processes is essential: when companies perceive alignment between the new technology and their current practices, they are more inclined to adopt it. The study suggests that support initiatives to help businesses gradually adapt their operations to blockchain can reduce resistance to change and lower adjustment costs. Furthermore, the ability to test the technology on a small scale before full adoption is a powerful enabler. However, the lack of experimental platforms in Morocco limits this opportunity. Establishing innovation labs or technological incubation programs would allow companies to explore the benefits and challenges of blockchain before fully committing. The study also shows that belonging to a technological sector, such as finance or logistics, increases SMEs' willingness to adopt blockchain. These sectors, being more sensitive to digital innovations, can act as catalysts, inspiring adoption across other industries. In contrast, company size does not have a significant impact on blockchain adoption, suggesting that technological and financial challenges are shared across SMEs of different sizes. Thus, beyond available resources, blockchain adoption appears to be more influenced by the perception of compatibility and risks.

This research highlights that blockchain adoption by Moroccan SMEs depends not only on internal factors, such as skills and process compatibility, but also on external factors, such as the regulatory environment and access to financing. Public policymakers have a key role to play by establishing consistent and transparent regulation and supporting businesses with financial incentives. At the same time, private sector actors can promote blockchain adoption by launching pilot projects and facilitating access to appropriate training programs. To overcome the identified barriers, it is recommended to develop innovation ecosystems capable of promoting this technology in a gradual and collaborative manner. The combination of a stable regulatory framework, suitable financing mechanisms, and a culture of experimentation will strengthen the resilience of Moroccan SMEs in the face of digital challenges and offer them opportunities for sustainable growth through blockchain adoption.

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