

The Technology-Driven Resilience Paradox in MSMEs: The Case of Ecuador

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Abstract

This research aims to evaluate the impact of digital strategies related to technological learning on the resilience of Ecuadorian MSMEs. Based on theoretical frameworks that explain resilience mechanisms, four key factor groups are identified and then compared with empirical results (1. Technologies used, 2. Digitization strategies, 3. Technological barriers, and 4. Innovation strategies). To develop the statistical model, a Likert scale survey was administered to 2,042 Ecuadorian MSMEs during the period 2022–2023. A systematic structural equation modeling analysis was performed using mixed-methods techniques. The framework of variables (Digital Transformation Strategies Resilience) during disruptive environments is highlighted. However, this study reveals results that contradict intuition the Resilience Paradox. Although there is a general consensus on the benefits of digitalization for competitiveness, if SMEs assimilate technologies superficially due to reactive learning, this could impact their ability to be resilient. Furthermore, if digitalization and innovation strategies are implemented abruptly and without proper assimilation, transformation, and exploitation, companies suffer drastic disruptions and increased uncertainty. The paradox of business resilience is strongly influenced by digital maturity. Therefore, the findings indicate that the latent variable of Resilience is significantly and negatively affected by the study variables due to weak digital maturity. Only the Cybersecurity subfactor had a significant and positive impact. During and after the COVID-19 pandemic, organizations had to develop a series of strategies to survive in the market. This study, using a SEM model, focuses on evaluating the digitalization strategies of Ecuadorian micro, small, and medium-sized enterprises (MSMEs) to achieve resilience. After analyzing the results, a Resilience Paradox is identified, highlighting the importance of robust technological learning as an essential element for achieving resilience. The findings emphasize that for business strategies (technological, digitalization, and innovation-related) to be effective, adequate digital maturity is necessary to generate resilience.

JEL Codes: M14 - M21 - O33

Keywords: Digital Transformation, Business Resilience, Technological Learning, Structural Equation Modelling, Digital Maturity

Introduction

Micro, small and medium-sized enterprises (MSMEs) are the backbone of economies and job creation in emerging countries (Y. Wang, 2016). In Latin America, they represent more than 95% and up to 99% of all companies. According to the National Institute of Statistics and Censuses of Ecuador (INEC), in 2019, 99.5% of Ecuadorian companies were classified as MSMEs (Micro, Small, and Medium Enterprises). These companies create 60.4% of total jobs in the nation and account for 27.7% of total sales in the country. (UASB, 2020). For this reason, MSMEs are key representatives in the productive and social linkage of the Andean nations, since they are major generators of employment, employers of labor-intensive technology, and processors of mainly national resources (CA of N. CAN, 2025). The Superintendency of Companies of Ecuador considers three factors to categorize MSMEs: number of employees, gross value of annual sales, and volume of assets (SUPERCIAS, 2011).

Table 1 Classification of MSMEs according to the Superintendency of Companies

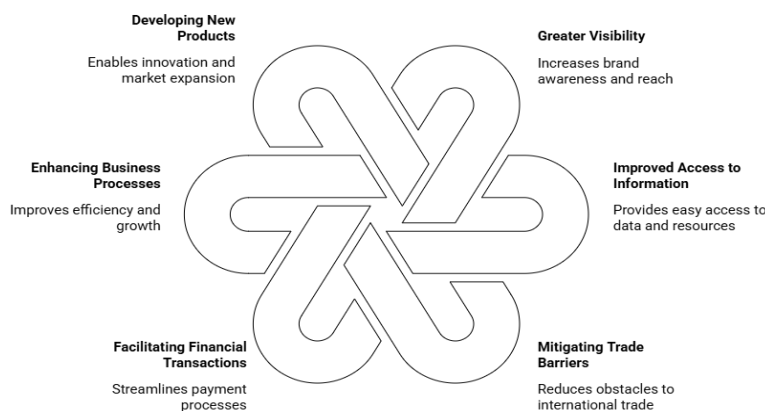
TYPE OF COMPANY	NUMBER OF WORKERS	GROSS ANNUAL SALES VALUE	ASSET AMOUNT
Microenterprises	1 to 9	≤ \$100,000	Up to \$100,000
Small Business	10 to 49	From \$100,001 to \$1,000,000	From \$100,001 to \$750,000
Medium-sized business	50 to 199	From 1,000,001 to 5,000,000	From \$750,001 to \$3,999,999
Large Company	≥ 200	Of more than 5,000,001	More than \$4,000,000

Note: Based on Resolution No. SC.Q.ICLCPAIFRS.11(SUPERCIAS, 2011).

It should be added that the Andean Community of Nations, in its Decision 702, maintains that MSMEs are a sector that needs to be monitored through statistical data, due to their contribution to the economic growth and development of the member countries (Andean System of SME Statistics) (TA CAN, 2019). Therefore, it is important to analyze the impact of the COVID-19 pandemic and post-pandemic period on micro, small and medium-sized enterprises (MSMEs) in Ecuador.

In Ecuador, as in the rest of the world, economic activity was disrupted by the health emergency caused by COVID-19, generating a deep recession (Araque & Argüello, 2022; Bustamante et al., 2022). This crisis amplified the macroeconomic imbalances that the country had been trying to correct since the end of the oil price boom. Furthermore, the crisis exposed some structural weaknesses, such as the lack of macroeconomic buffers and significant gaps in access to services (WB, 2023). Furthermore, MSMEs are emerging as an option to combat the effects of economic crises, particularly to reduce the repercussions of unemployment and poverty (Huilcapi Masacón et al., 2020). During the pandemic, some expanded into large organizations, while others maintained the same structure and, in the most adverse situation, failed to find a solution and dissolved (Rodríguez & Aviles, 2020). This research work seeks to determine the technological strategies that make SMEs resilient in these disruptive environments. The implementation of digital technologies in the business environment implies effective adoption that transcends simple tool use and is reflected in the restructuring of business models (Lestari et al., 2024). These new models seek a transformation and optimization of the operational and production processes of companies (Heredia, 2020). Technologies facilitate the expansion of companies, their networks of contacts, and the increase in their information capacity, both towards new cognitive fields and towards areas of specialization (Dini et al., 2021). Technology enables SMEs to access markets that they otherwise could not reach, precisely because of the restrictions these companies face due to their size, scarcity of resources, distance, or location (Ferrer-Dávalos, 2021). According to Dini et al., (2021); Kotturu & Mahanty, (2017)– ECLAC, the main benefits that technology and technological learning offer to MSMEs, are summarized in the following figure:

Figure 1 Factors that contribute to business growth



To reap these benefits, entrepreneurs must make a significant effort to secure the necessary financing, which will enable them to gain lasting competitive advantages through innovation activities supported by technological learning processes. This is a crucial element for the organization's economic growth (Ferrer-

Dávalos, 2021).

Therefore, there are companies that have the ability to react, adjust, and overcome critical circumstances (Salanova, 2009). These companies are known as resilient organizations; they possess resources and competencies that enable them to withstand environmental pressures and exhibit acceptable levels of performance and results (Duchek, 2020; Vera et al., 2017). However, resilience in organizations is a poorly studied factor in organizational literature, and there is little empirical evidence on the use of digital strategies to achieve it (Ndiege et al., 2023; Rodríguez-Sánchez et al., 2021).

This study investigates resilience in Ecuadorian micro, small, and medium-sized enterprises (MSMEs), considering that technological learning can be the key factor in achieving this capacity to react and maintain or develop organizational competitiveness. Therefore, it analyzes the effect of resilience resulting from the technologies and strategies adopted, as well as other digital tools and processes, which served to enhance the digital skills of MSMEs and enable them to remain competitive in the market.

The objective of this research is to develop a statistical model to determine the relationship between technological adoption, digital strategies, existing obstacles, and innovation with respect to resilience in SMEs (four hypotheses). To empirically support the above postulate, a survey was conducted as part of a project by FAEDPYME (Foundation for Strategic Analysis and Development of Small and Medium Enterprises), CLADEA (Latin American Council of Management Schools), and supported in Ecuador by the EPN (National Polytechnic School).

The novelty of this manuscript is that it has identified and empirically supported a Technology-Driven Resilience Paradox to MSMEs operating in an emergent economy setting. Although the prevailing literature largely presupposes that the digital transformation, technological adoption, and innovation automatically enhance the business resilience, this research disproves the linear assumption. With the help of a large scale sample of 2,042 Ecuadorian MSMEs gathered throughout the COVID-19 and post-pandemic era, the study proves, through structural equation modeling, that superficial or reactive digitalization, unaccompanied by sufficient digital maturity and absorptive capacity, may adversely impact resilience findings. In contrast to the earlier research that puts the emphasis on the developed economies or discusses the digitalization process as skewed to the positive effect, this study incorporates technological learning, the absorptive capacity theory, digital barriers, and innovation strategies into one comprehensive SEM framework. The results indicate that the majority of digital and innovation strategies demonstrate a statistically significant negative correlation with resilience in cases of weak digital maturity, detected to have cybersecurity as the sole positive predictor.

1. Literature Review

2.1 Technological Learning in Organizations

Technological learning (TL) can be described as a comprehensive process of consolidating knowledge and habits, such as the accumulated experience of a company and/or its staff Vega Mendoza & Castañeda Vega, 2019). It is closely linked to professional development within the organization and is considered an added value to human capital. This technological advancement is integrated into the company through various strategies and is associated with enterprise technology upgrades for the purchase and adaptation of technologies (MR Attarpour & Nasri, 2023). The second refers to the knowledge acquired by the organization for its operations and activities (Nozari et al., 2023; Vega Mendoza & Castañeda Vega, 2019).

2.2 Absorptive Capacity (AC) Theory in Disruptive Environments

According to Vargas Pérez & Malaver Rodríguez, (2022) the absorptive capacity in business environments follows a five-stage process: initial conditions, exploration, assimilation, exploitation, and absorptive performance. Therefore, the formal education of its members and the knowledge generated through collective experience must be taken into account (Roper & Love, 2018). Understanding this initial situation allows us to establish how much recent external knowledge can be understood, applied, and exploited (Vargas Pérez & Malaver Rodríguez, 2022). This knowledge can be absorbed without alteration or with minimal changes; in others, it must be merged with existing knowledge to generate learning and transformations in the company's processes and practices (Vargas Pérez & Malaver Rodríguez, 2022). This means that innovation and transformation adaptations within the organization should be used to address the shortcomings identified at the outset, ensuring that the suggested modifications are implemented to their full potential, for the benefit of the organization (Gao et al., 2017; Vargas Pérez & Malaver Rodríguez, 2022). Vargas Pérez & Malaver Rodríguez, (2022). They indicate that the final stage is verifying the new performance of the absorption process. It implies the implementation of formal elements for the evaluation of the previous stages, while maintaining the analysis in the assimilation of the processes (Nozari et al., 2023).

2.3 Absorptive Capacity (AC) Theory and Technological Learning (TL) in MSMEs

It is important to consider that technology is more than just objects (tools and machinery) and techniques (procedures), as it also includes information and knowledge accumulated in the processes, as well as individual and collective learning experiences (Casey, 2005). Additionally, technology consolidates technical aspects with those of the organization, in a socio-technical combination, which builds a network of actors for its performance (Miao et al., 2024). Along the same lines, the connection between absorptive capacity (AC) and technological learning (TL) has been of interest to scientists (M. Attarpour et al., 2023; Nozari et al., 2023; Vargas Pérez & Malaver Rodríguez, 2022). It has been recognized that skills enhanced through innovation activities and technological learning tactics can play a crucial role in responding to changing market or business environment opportunities (Figueiredo & Piana, 2021). Similarly, research, particularly in emerging nations, has revealed the importance of innovative actions by companies in terms of strategies and methods for technological learning (Ghazinoory et al., 2019).

Absorptive Capacity (AC) enables the company to adapt to fluctuating market conditions, with the goal of obtaining, understanding, modifying, and leveraging knowledge (Hassani & Mosconi, 2021). CA creates actions to monitor new trends, technologies, innovative products or processes, marketing strategies, etc., which, once established within the organization, can become a predictor of innovation and knowledge transfer (Demuner-Flores et al., 2021). CA is especially relevant for MSMEs, as it can assist them in creating and implementing survival strategies and in successfully managing the challenges of globalization (Hassani & Mosconi, 2021; Puetz & Werner, 2024). However, MSMEs have difficulty with technological learning (TL) and their absorptive capacity (AC) (Puetz & Werner, 2024). This is due to their scarce resources, insufficient digital management skills, and a traditional approach that can compromise their ability to adapt (Bouncken & Schmitt, 2022). However, companies can use collaborative alliances to acquire knowledge from their partners, which facilitates the exchange of knowledge and can increase the capacity for assimilation (Fredrich et al., 2019).

This research focuses on determining whether digitalization strategies supported by technology transfer (TT) implemented during periods of disruption (the COVID-19 pandemic and the post-pandemic period) achieve resilience in Ecuadorian SMEs. It should be noted that in the literature, TA has been studied from various perspectives (see table 2).

Table 2 Relevant studies of Technological Learning

AT	Authors
Based on organizations and their technological activities as a driver of economic development	(MR Attarpour & Nasri, 2023)
Focused on the capacity for innovation	(Ghazinoory et al., 2023)
Using its dimension as a learning process	(MR Attarpour & Nasri, 2023; Ghazinoory et al., 2023; Nelson, 1993)
As a learning strategy	(Figueiredo & Piana, 2021; Ghazinoori & Nozari, 2021)
Focused on its knowledge nature	(Goaill & Al-Hakimi, 2021; Kim, 2001)
As a collaboration platform	(Figueiredo, 2010; Tacla & Figueiredo, 2003)
As absorption capacity	(Goaill & Al-Hakimi, 2021; Kim, 1997; Vargas Pérez & Malaver Rodríguez, 2022)
Focused on its dynamic nature to gain a competitive advantage	(Lin, 2003; Vértesy, 2017)

NoteBased on research by (M. Attarpour et al., 2023).

2.4 Business Resilience (RE) in disruptive environments

Within business strategies to cope with disruptive events such as the pandemic and post-pandemic period, attention has been given to key competencies for effectively using new technologies, communication and collaboration skills, learning capacity (critical, technological and other thinking), individual autonomy (flexibility and decision-making ability) and digital skills (Joyne et al., 2019). While these transformations can represent an opportunity, they also pose a challenge, due to their potential disruptive effects on jobs and the skills in demand (Bensusán Areous & Florez Vaquiro, 2020).

The management of disruptions has been attracting considerable attention, both from academia and the industrial sector (Y. Li et al., 2020; Xu et al., 2020). Resilience is understood as the ability of a system to return to its initial state or even a more favorable condition after being disrupted (Shekarian & Mellat Parast, 2021). Proactive and reactive mitigation tactics are two fundamental methods for protecting against disruptions and enhancing resilience (Ivanov, 2018).

The literature underlines that resilience has a positive influence on the performance of companies (Brusset & Teller, 2017). However, explanations are lacking on how resilience affects different elements of performance (such as economic and non-economic outcomes). (Iftikhar et al., 2021; Sabouhi et al., 2018). Furthermore, even though business networks have become progressively more global and complex, most current research is linked to a single highly developed region (Iftikhar et al., 2021).

2.5 Business resilience is generated to achieve competitiveness in MSMEs

Resilience allows companies to adjust to change and recover quickly from adversity (Ortiz-Fajardo & Erazo-Álvarez, 2021). Resilience is a characteristic that indicates the ability to overcome, recover from, and even surpass obstacles and difficulties that arise in the environment (León-González et al., 2022). Resilience demonstrates that a business in good condition can reduce its vulnerability to unforeseen events, restoring its level of competitiveness in less time and at lower costs (Sanchis, 2017). This approach fosters knowledge and learning among the members of an organization (León-González et al., 2022). Therefore, the focus should be on resilience skills that enable companies to respond proactively to complex environments, capitalize on market opportunities, and thus distinguish themselves from rivals (Maican et al., 2023; Schaffer et al., 2022). This leads to the efficient use of resources to meet customer demands, thereby increasing performance (Teece, 2018).

However, the COVID-19 pandemic and its aftermath exacerbated resource constraints for SMEs, particularly impacting their research and development projects, while simultaneously demanding process and product innovation to meet fluctuating market demands (Cassiman & Golovko, 2011). Thus, organizations establish new business structures from within, generating learning spaces, constantly renewing their knowledge, and working in challenging environments; simultaneously attempting to leverage external elements, which promotes the growth of their skills (León-González et al., 2022). The evidence suggests that technological skills are crucial elements of resilience for the competitive success of SMEs, particularly in developing markets (Potjanajaruwit, 2023). Therefore, the objective is to adapt to the environment and cope with challenging circumstances in order to remain competitive in the market. The focus shifts to growth and competitiveness (Samán Chingay et al., 2022).

2.6 Resilience strategies in SMEs

Delving deeper into resilience strategies in VUCA environments, it is important to highlight the complex connection between market uncertainty and environmental fluctuations, which impacts business decisions and the operational functioning of companies (Cavusgil et al., 2004). It is clear that the volatility of the environment not only causes ambiguity, but also intensifies the effects that SMEs face in the face of new customer demands and the challenges of predicting market trends (Murugan et al., 2020). All these factors increase the challenge that companies face in managing resources and generating strategies to maintain or enhance their performance (Srisomwongse et al., 2025).

In circumstances of great market uncertainty, the ability to manage diverse platforms becomes especially useful, as it provides companies with the flexibility to modify their skills and benefit from various revenue streams (Srisomwongse et al., 2025). The survey conducted for this research, question 13 is emphasized regarding the use of digital platforms: What technologies do you use in your company and what is their level of importance?: 1. Website, 2. E-commerce portal, 3. E-commerce in Marketplace, 4. Social networks for commercial purposes, 5. Digital banking, 6. Teleworking, 7. ERPs, 8. Corporate intranet, 9. Services to cover cybersecurity, 10. Big data and data analysis software, 11. Robotics and sensors, 12. Location, Internet of Things.

Figure 2 Technologies in VUCA environments



Note Based on the survey, question 13

Micro, small, and medium-sized enterprises (MSMEs) face significant challenges in today's business landscape. For example, some of these companies struggle to survive the economic recession and technological advancements because their resources and managerial skills are limited (Gu et al., 2021). Learning is essential for organizations operating in these disruptive and competitive environments; since it involves several tasks, such as acquiring external knowledge, strengthening internal skills, and implementing cutting-edge practices and technologies (M. Attarpour et al., 2023).

To optimize the performance and productivity of SMEs, especially in managing crises such as the COVID-19 pandemic and post-pandemic period, digital technologies are essential (Khurana et al., 2022). De'a et al., (2020) stated that the pandemic caused an increase in the use of digital technologies within companies. The study by Xuan Trieu et al., (2023) discussed that 247 SMEs in Vietnam emphasizes that digital capabilities resulting from disruptive technologies are fundamental to promoting performance and resilience in these organizations. Bustinzá et al., (2019) discussed that 205 manufacturing companies in Spain indicates that digital skills through the use of cutting-edge technologies enable companies to protect themselves against various disruptive market circumstances and preserve their resilience.

However, according to the study of Papadopoulos et al., (2020) 30% of SMEs in the UK and 13% of those in Ireland see IT privacy and security as potential drawbacks when implementing digital technologies. Ritter & Pedersen, (2020); Warner & Wäger, (2019) stated that the adoption of digital technologies faces difficulties, primarily due to the inability of SMEs to quickly and effectively transition from outdated business models and technologies to new ones. They encourage research into how this adoption transforms SMEs' working methods and the consequences of this transformation, with the aim of supporting business continuity during crises (Papadopoulos et al., 2020).

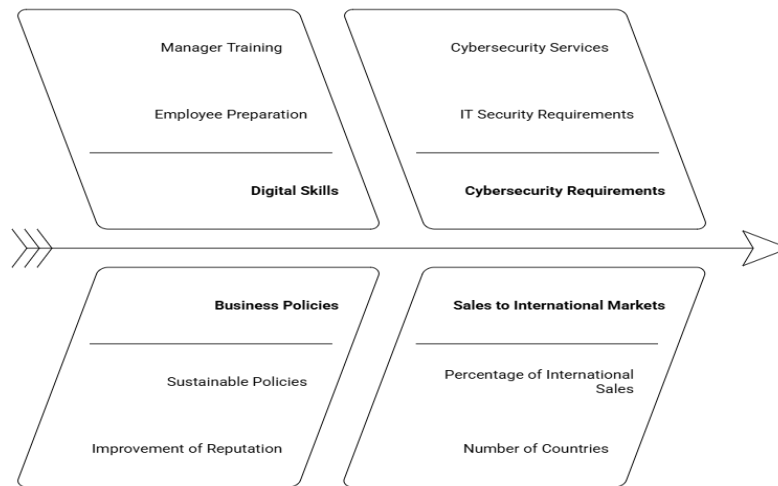
H1:The use of technologies in SMEs, as a result of technological learning, has a positive relationship with business resilience in disruptive environments.

Furthermore, the increasing digitalization of the global economy offers SMEs new and relevant growth opportunities (Stallkamp & Schotter, 2021; Westerlund, 2020). For example, SMEs that make use of these digitization strategies are expected to distinguish themselves through superior performance in: 1) the use of information systems, 2) the expansion of value networks, 3) the emphasis on essential internal resources, and 4) attention to cybersecurity issues (Westerlund, 2020).

Therefore, digitization involves the use of digital technologies to modify a company's business structure, in such a way that it provides new revenue streams and value creation opportunities (Ardito et al., 2021). Digital business models also facilitate scalability and rapid expansion of the organization (Holand et al., 2019). Regarding how digital transformation can help companies maintain their competitiveness, technology has always been considered a driver for managing the various challenges that emerge from complex business systems (Kowalkowski et al., 2013).

These technologies digitize and integrate the value creation process (Papadopoulos et al., 2020) and ensure that organizational boundaries remain fluid. This fosters agile and time-sensitive strategic action, and also facilitates the generation of new resource combinations for companies. Linde et al., (2021) discusses that SMEs to implement digital technologies and facilitate digital transformation. However, the digitalization of SMEs remains an understudied topic, particularly the specific methods by which digital technologies foster innovation and disruption in these businesses (Berger et al., 2021). During crises, companies face more difficult challenges; this requires decision-making under greater uncertainty, with greater time pressure, fewer options, and with very risky consequences for organizational survival (Vaaler & McNamara, 2004). For SMEs in particular, these challenges become even more critical due to mandatory operational limitations, the preparedness of human talent, and a lack of available resources. Therefore, when these organizations face disruption, they must try to rapidly develop their resilience (Khurana et al., 2022). Therefore, Linde et al., (2021) stated that accelerated technological development and digitization make it essential for ecosystems to constantly transform and innovate. Some of these are from other studies on digital transformation (Bresciani et al., 2021; Cherbib et al., 2021; Khurana et al., 2022; Matarazzo et al., 2021). They emphasize the importance of SME owners being aware of and promoting technological learning. Therefore, for the implementation of digital transformation, SMEs were asked about the importance, benefits, and advantages of digitalization strategies. The survey emphasized the following concerns and their degree of impact: 1. Q14 Improvement in digital skills, 2. Q17 Adopting sustainable policies to improve the company's image and reputation, 3. Q15_13 Cybersecurity requirements, 4. Q12 Sales to international markets.

Figure 3 Digitalization strategies in the company

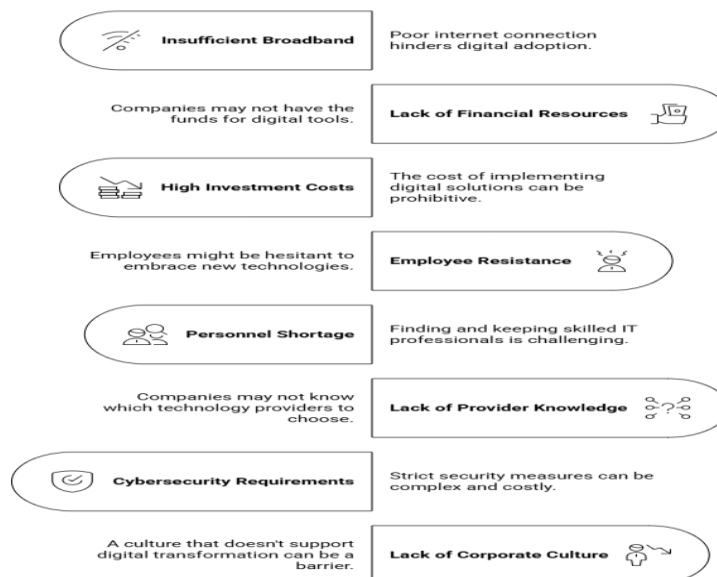


Note Annex 1 Survey, questions 12, 13, 14, 15 and P17.

In the case of the investigation of Troise et al., (2022) discussed a study of 204 innovative companies in Italy suggests that it could be essential for SMEs to reorient their corporate culture and adopt a long-term technological perspective. Companies have a responsibility to promote digital transformation and embrace a new organizational perspective focused on implementing, developing, and utilizing digital technologies (Schiuma et al., 2021). Li et al., (2018) demonstrated a study conducted with seven SMEs using the Alibaba platform indicates that digital transformation not only improves operational efficiency but also enables SMEs to innovate and develop new capabilities that are crucial in a changing business environment. However, the "black box" of digital technology adoption by SMEs, particularly during an external crisis, has been scarcely researched (Khurana et al., 2022; Ritter & Pedersen, 2020) Therefore, the following proposition is proposed to be verified; **H2: Digitalization strategies in SMEs, resulting from technological learning, have a positive perception relationship with business resilience in disruptive environments.** Warner & Wäger, (2019) demonstrated that companies encounter several obstacles when adopting digital technologies, including: 1. resistance from managers and senior leadership to implementing new business models; 2. reliance on established practices and over-reliance on existing models; 3. a preference for the known over the unknown; 4. a lack of digital expertise within the company; and 5. balancing the agility offered by new technologies with the stability of integrated models (Cannas et al., 2021; Matarazzo et al., 2021; Wuest et al., 2020).

Modernizing existing skills and co-developing assets are linked to transforming business capabilities. They are also related to decentralized decision-making and establishing an organizational culture focused on innovation and change. The role of organizational and technological learning and knowledge management is crucial (Khurana et al., 2022).

Figure 1
Figure 4 Barriers to the digitization strategy



Note: Annex 3 Survey 2, question 15.

To ensure digital transformation is successful, the organizations should also get rid of or at least reduce the major obstacles to digitalization. In Question 15 of the survey, SMEs have been requested to consider the effect of the major challenges on digital implementation. Those were: (1) lack of proper broadband connectivity, with infrastructure as the key enabling factor of digital strategy; (2) lack of financial resources, especially in the post-pandemic environment with the decrease of the investment capacity; (3) high start up costs of adopting digital technologies; (4) employee aggression to digitalization, which highlights the necessity of beginning training initiatives to support technological learning and manage the change process properly; (5) a mismatched corporate culture, which does not operate to foster or accommodate the digital transformation efforts; and (6) inadequate financing of digital transformation efforts.

Rafique et al., (2025) focuses on digitalization, revealing, for example, that e-commerce has experienced rapid growth since 2020 and how wireless communication technologies have helped mitigate the disruptions caused by the COVID-19 pandemic. The study of Vimal et al., (2023) supported by 15 experts from the manufacturing and automotive sectors, the report indicates that barriers must be addressed and eliminated as a priority for the successful adoption of digital technologies. Furthermore, it states that negative perceptions of technology are the most significant obstacle to the adoption of digital technologies in Industry 4.0 (Moeuf et al., 2020). Therefore, they suggest that managers should focus on avoiding system disruptions when implementing digitization (Vimal et al., 2023).

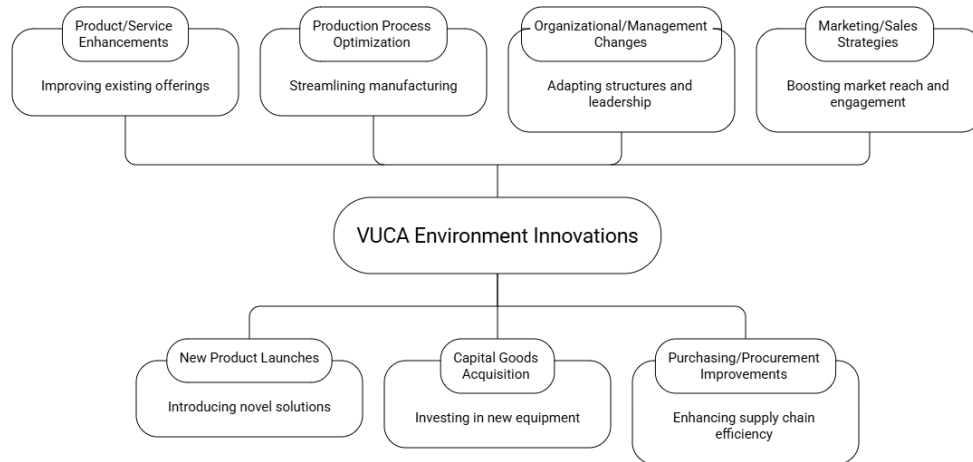
Indeed, barriers such as limited infrastructure, security issues, insufficient scalability, and unclear government policy are the reasons why many industries resist adopting these technologies and digitizing (Vimal et al., 2023).

H3:The perceived level of barriers to digitalization in SMEs is negatively related to their business resilience in disruptive contexts.

Furthermore, it is emphasized that for MSMEs to be able to innovate during periods of crisis such as the COVID-19 pandemic and post-pandemic, and to change their operations, the adoption of digital technologies has been essential (Khurana et al., 2022; Troise et al., 2022). Furthermore, according to the research of Troise et al., (2022) the resilience developed can be seen as a dynamic skill, arising from organizational and digital adaptation and transformation. Thus, within this technological shift, digitalization not only optimizes operational efficiency but also enables SMEs to adapt to market demands and become innovative (Hokmabadi et al., 2024). SMEs can access new resources and knowledge, which facilitates the implementation of relevant transformations in their business models (Tajpour et al., 2025). Furthermore, managing technological knowledge is essential to understanding innovation in organizations and optimizing decision-making in SMEs (Valencia-Arias et al., 2024). The research of Micek, (2019) discussed 215 Polish MSMEs in the IT services sector indicates that, in the context of digitalization and technology, knowledge sharing (technological learning) between companies has the potential to increase resilience, competitiveness, and sustainability.

According to the work of Roux et al., (2023) 375 managers from Vietnamese manufacturing companies, the study highlights the essential role of human capital in optimizing technological tools (e.g., AI) to achieve sustainability and resilience. This is achieved by conceptualizing innovative practices, optimizing current procedures, and strategically aligning them with business needs (S. Chowdhury et al., 2022; Roux et al., 2023; Suchek et al., 2021).

Figure 5 Innovations in VUCA environments



Note Annex 1 - Survey, question 20.

Thus, competitiveness is linked to innovations implemented in VUCA environments. Therefore, SMEs were asked to rate the degree of implementation of innovation strategies carried out during the crisis period. These new business modifications are: 1. Changes or improvements to existing products/services, 2. Launch of new products/services, 3. Changes or improvements to production processes, 4. Acquisition of new capital goods, 5. New changes or improvements in organization and/or management, 6. New changes or improvements in purchasing and/or procurement, 7. New changes or improvements in marketing and/or sales. See details in the previous figure. In today's fluctuating and complex environment, micro, small, and medium-sized enterprises (MSMEs) face continuous survival challenges. To survive, they must acquire the ability to recover quickly from setbacks and get back to work (Battisti et al., 2019; Conz et al., 2017; Zighan et al., 2022).

Innovation can manifest itself in different aspects and characteristics, such as service, technology, process, business model, product, and human capital (P. Chowdhury et al., 2024; S. Chowdhury et al., 2022).

H4:Innovation strategies in SMEs, resulting from technological learning, have a positive relationship with business resilience in disruptive environments.

Furthermore, identifying the factors that foster business resilience provides policy leaders, companies, and development stakeholders with guidance on the economic sectors where concentrated investment would enhance the resilience of MSMEs (Falconi et al., 2023). Therefore, data analysis helps us understand how to overcome the post-pandemic challenges. SMEs need to find innovative solutions to manage the crisis and steer their businesses toward the desired competitive future, which will become the new normal that could persist for several years (Zighan et al., 2022).

Methodology

Within the framework of the FAEDPYME project (Foundation for Strategic Analysis and Development of Small and Medium Enterprises), supported in Ecuador by the EPN - National Polytechnic School, a survey was conducted in the 2022-2023 survey: Digitalization and Sustainable Development of MSMEs in Ibero-America, encompassing 2,059 Ecuadorian MSMEs across nine major business sectors. This work focused on potential resilience strategies, such as digitalization and innovation in MSMEs, resulting from technological learning.

Of these MSMEs, missing data was removed to identify the companies that responded to the requested questions, resulting in 2042 organizations.

Table 3 Methodologies used in related research

Reference	Article	Methodology	Study
(Goaill & Al-Hakimi, 2021)	Does absorptive capacity moderate the relationship between business orientation and supply chain resilience?	Smart PLS	This study analyzes whether absorptive capacity (AC) moderates the relationship between business orientation (BO) and supply chain resilience (SCR). The sample consists of 171 small and medium-sized manufacturing enterprises in Yemen.
(Miao et al., 2024)	Innovation in business continuity in times of disruption: socio-technical systems, business analysis, virtual business and the mediating role of knowledge absorption capacity	Smart PLS	The model, based on 145 Indonesian companies, was empirically examined. From a technical perspective, the analysis of these companies has successfully enhanced innovation, business continuity, and the ability to absorb knowledge.
(Nozari et al., 2023)	A practical framework for technological learning in developing countries	Smart PLS	A mixed-methods research approach, based on a review of the literature and previous studies, led to the development of an interview protocol. The dimensions and elements of technological learning were established, derived from interviews with managers and specialists in the Iranian oil sector. The protocol incorporates 81 preliminary codes and 18 components, which were categorized and evaluated into 5 main categories.
(Falconi et al.,	Factors driving the resilience of SMEs in Southeast	Linear factor	Surveys were conducted with 400 and 514 companies in Cambodia and the Philippines, respectively. Of the 914

(2023)	Asia during COVID-19	analysis SEM	participants in the SME Competitiveness Survey, 726 also participated in the follow-up survey: 272 in Cambodia and 454 in the Philippines. The structural equation model merges these elements into a corporate-level resilience index, confirming that this index maintains a positive correlation with standard indicators of company performance during times of crisis, such as employee retention.
(Villena-Manzanares et al., 2021)	Organizational factors that drive BIM effectiveness: technological learning, collaborative culture, and senior management support	PLS	The information was collected from 92 AEC companies in Spain. Through partial least squares (PLS), this study finds evidence of the proposed relationships and the presence of partial mediation effects produced by technological learning and a collaborative culture in senior management support for the effectiveness of BIM technology.
(Ifrikhar et al., 2021)	Psychometric meta-analysis methodology. The basic purpose is to gain insight into a phenomenon by analyzing the effect size of independent variables on dependent variables.	Meta-analysis	This study investigates the relationship between resilience, its antecedents, and company performance. It analyzes the effect of three categories of Supply Chain capabilities (organizational capacity, supply chain flexibility, and supply chain integration) on company resilience (proactive, reactive, or dynamic) and the impact of this resilience on performance.
(Xuan Trieu et al., 2023)	The methodology consisted of collecting data from a sample of Vietnamese SMEs and then using PLS-SEM to model and analyze the relationships between the variables investigated.	PLS-SEM	The research used partial least squares structural equation modeling (PLS-SEM) to analyze the data. The data were collected from 247 SMEs located in Vietnam. The results indicate that IT capabilities are crucial for fostering organizational ambidexterity, organizational resilience, and overall performance in SMEs.
(Bustanza et al., 2019)	The Structural Equation Modeling (SEM) approach is used to test the relationships established in the model.	SEM	Structural equation modeling (SEM) is used with a baseline sample of 205 Spanish manufacturing companies. The findings support the relevance of human resource practices in fostering resilience, which helps companies adapt to change and subsequently increase their organizational effectiveness.
(Troise et al., 2022)	Using SmartPLS 3.3.3 software, the analysis for this research was carried out, employing the Partial Least Squares methodology to model structural equations.	Smart PLS	The adoption of the PLS-SEM technique proved beneficial, as it enables model analysis without sample limitations in the survey and contributes to achieving accurate results in exploratory research. This research, conducted in 204 Italian companies, indicates that digital technology skills, networking abilities, and the capacity for innovation are three key open-source factors.
(Vimal et al., 2023)	Matrix Multiplication Applied to Classification (MICMAC) analysis and Total Interpretive Structural Modeling (TISM) are two procedures that the study uses to detect potential obstacles to adopting digital technologies.	MICMAC and TISM	With 15 experts from the manufacturing and automotive sectors, it was determined that the barriers must be addressed and eliminated as a priority for the successful adoption of digital technologies. Other significant barriers affecting the implementation of Industry 4.0 are examined, such as a lack of knowledge and clarity regarding the benefits. These barriers, as key variables, interfere with the system and hinder its progress.

Results

Business resilience has been shown to be an essential element for the survival of MSMEs in volatile and complicated contexts, as was evident during the COVID-19 pandemic (Lestari et al., 2024; Trieu et al., 2025). Research indicates that adaptability and organizational resilience are linked, as the latter allows companies to innovate and recover from disruptions (Do et al., 2025; M. Li et al., 2024). It has been determined that the adoption of digital technologies is an essential factor for resilience, as it considers innovation strategies during periods of crisis (Cardoso et al., 2025; Sinha et al., 2025). Thus, digitization not only improves operational efficiency, but also enables companies to benefit from new opportunities in a volatile market environment (Qi et al., 2024; Sinha et al., 2025).

The following figures show the classifications of the MSMEs by: a) Type, b) Age, and c) Economic Activity. Figure 6 MSMEs according to their type

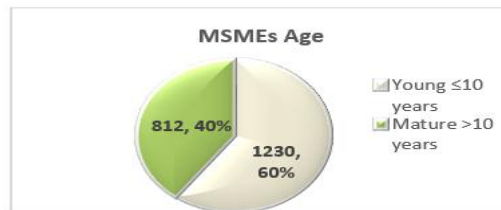
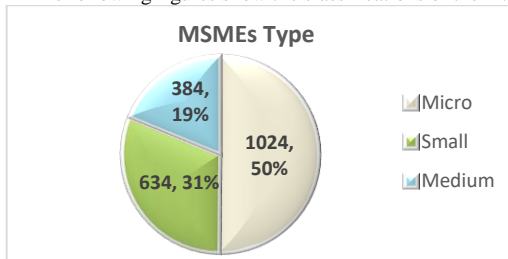
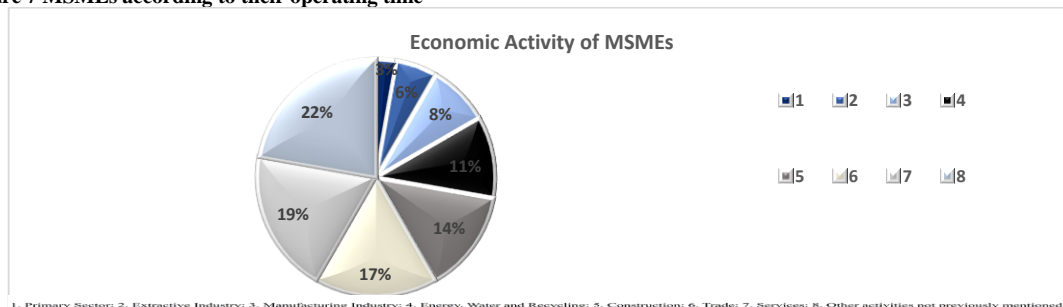


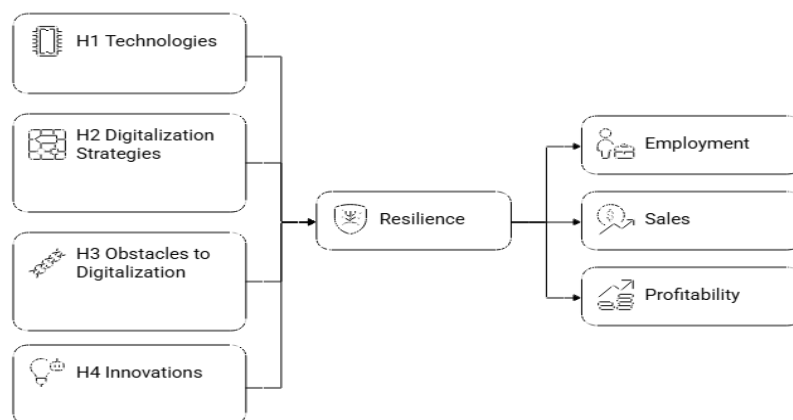
Figure 8 Economic activity of MSMEs

Figure 7 MSMEs according to their operating time



It should be noted that for this study, the dependent variable Resilience is composed of three components: 1. Employment: Average change in jobs between 2020, 2021, and 2022 (Question 8). 2. Sales: Company sales expectations for 2022 and 2023 (Question 11). 3. Profitability: Expected values for 2022 and 2023. Furthermore, it is considered that for Resilience to exist, each component must be maintained or increased. See the following figure.

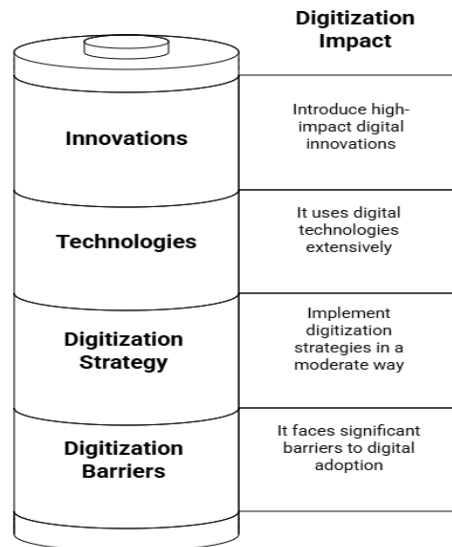
Figure 8 Composition of the Dependent and Independent Variables of the Model



On the other hand, the four independent variables analyzed were all measured using a Likert scale from 1 to 5, where 1 is not very important and 5 is very important. These variables are: 1. Technologies used in the MSME, related to their level of importance (Question 13). 2. Business digitization strategies (Question

14). 3. Level of importance of the obstacles or barriers to developing digitization in the company (Question 15). 4. Innovations in the last two years and their level of impact (Question 20). See the following figure.

Figure 9 Relationship between Independent Variables and the Hypotheses Proposed



Structural equation modeling (SEM) is used as the comprehensive statistical framework for the analysis and is applied to examine complex relationships between observed and latent variables. SEM is employed in a variety of areas and applications (Rappaport et al., 2020). SEM makes it possible to model not only directly observed variables, but also underlying constructs, which simplifies the analysis of complex interrelationships within the data (Ruiz et al., 2010; Stein et al., 2017). Therefore, it makes it flexible for different areas of research, including the behavioral and social sciences. SEM has the capacity to combine features of factor analysis, path analysis, and regression (Kline, 2023; Stein et al., 2017). Thus, the study framework allows the inclusion of latent variables, which have the capacity to represent unmeasured constructs, thereby optimizing the depth of the analysis (Grace & Bollen, 2008; Shafeeq & Muhamed, 2022). The following table includes studies related to this methodology.

Interpretation of the obtained model

Taking the above into account, this study proposes a model that, by fostering technological learning, utilizes disruptive technologies, digitization strategies, mitigating barriers to digital transformation, and innovation to mediate resilience. This would highlight the importance of developing these competencies to optimize business performance. The estimated parameters of the statistical model are reviewed in this section. It begins with the introduction of the regression coefficients, which determine and quantify the impact of the predictor variables on the Resilience variable. Subsequently, other important aspects of the model, such as the estimated variances and intercepts, will be addressed. First, the table of codes for the survey questions, which are related to the hypotheses formulated for the study, is presented.

Figure 10 Coding of the model variables

Hypothesis	Survey Questions	Survey Sub-Questions	General Code	Code
H1	P13 Improved sales conditions due to technological inclusion	1. Our own website	P13	P013_SQ001
		2. We sell through our own e-commerce portal		P013_SQ002
		3. E-commerce on marketplaces (Amazon or equivalent)		P013_SQ003
		4. Social media for business purposes		P013_SQ004
		5. Digital banking		P013_SQ005
H1	P13 Improvement in process conditions through technological inclusion	6. Teleworking	P13_2	P013_SQ006
		7. ERPs (Enterprise Resource Planning) systems		P013_SQ007
		8. Corporate intranet		P013_SQ008
		10. Big data and data analytics software		P013_SQ010
		11. Robotics, sensor technology		P013_SQ011
		12. Location-based automation, Internet of Things		P013_SQ012
		H2		P14 Improvement in digital skills
5. Our managers are well-trained in digitalization	P014_SQ005			
H2	P17 Business policies	3. Adopting sustainable policies improves the company's image and reputation	P017_SQ003	P017_SQ003
H2	P13 y P15 Cybersecurity Requirements	7. Demanding information technology security requirements (cybersecurity)	P15_13	P015_SQ007
		9. Services to cover cybersecurity		P013_SQ009
H2	P12 Ventas a mercados Internacionales	12.1. Of your total sales in 2021, what percentage of your sales came from international markets?:.....%	P12	P01201
		12.2. If it is greater than 0, to how many countries?.....		P01202
H3	P15 Minimize obstacles to business digitization	1. Insufficient broadband connection	P15	P015_SQ001
		2. Lack of financial resources in the company		P015_SQ002
		3. High investment costs		P015_SQ003
		4. Digitalization may be poorly received by employees		P015_SQ004
		5. Shortage of highly qualified personnel who are difficult to find and retain		P015_SQ005
		6. Lack of knowledge about technology providers		P015_SQ006
		8. Lack of a corporate culture to drive digital transformation		P015_SQ008
		H4		P20 Innovation
2. Launch of new products/services	P020_2			
3. Changes or improvements to production processes	P020_3			
4. Acquisition of new capital goods	P020_4			
5. New changes or improvements in organization and/or management	P020_5			
6. New changes or improvements in purchasing and/or procurement	P020_6			
7. New changes or improvements in sales and/or marketing	P020_7			

Additionally, the following table summarizes the unstandardized regression coefficients that link the predictor variables to the latent variable Resilience. Each row shows the relationship between a predictor variable and Resilience, specifying the magnitude of the estimate, the standard error, the critical ratio, and its statistical significance.

Table 4 Regression coefficients of the Resilience model

Predictor variable	HYPOTHESIS	Description	estimate	standard error	critical reason RC	p-value
P13	H1	Improved sales conditions due to technological inclusion	-0.005	0.002	-2,092	0.036
P13_2	H1	Improvement in process conditions through technological inclusion	-0.017	0.004	-4,288	< 0.001***
P14	H2	Business digitization strategies	-0.016	0.004	-3,734	< 0.001***
P017_sq003	H2	Adopting sustainable policies improves the company's image and reputation.	-0.006	0.003	-2,031	0.042
P15_13	H2	Cybersecurity Requirements	0.028	0.008	3,660	< 0.001***
p12	H2	Sales to International Markets	-0.001	0.000	-2,232	0.026
P15	H3	Minimize obstacles to business digitization	-0.016	0.005	-3,090	0.002
P20	H4	Innovation	-0.040	0.007	-5,919	< 0.001***

The interpretation of table 5 shows clear patterns regarding the elements that affect resilience

- Negative indicators: This means there is a statistically significant inverse relationship. In other words, resilience tends to decrease as the values of these variables increase. Variables P13_2, P14, and P20 are noteworthy due to their high statistical significance ($p < 0.001$).
- Positive indicators: P15_13 is the only one that appears as a positive predictor with statistical significance (Estimate = 0.028, $p < 0.001$). The positive coefficient indicates a direct relationship: when P15_13 increases, Resilience also increases.
- Magnitude of the coefficients: When examining the unstandardized coefficients, the highest negative regression coefficient corresponds to the variable P20 (-0.040). This indicates the expected changes in Resilience for each unit change in P20, leaving the other variables unchanged.

In addition to these regression values that established predictive relationships, the model calculated other relevant structural parameters, such as the intercepts of the observed variables and the variances of both the latent constructs and the measurement errors. The model intercepts represent the calculated means for each analyzed variable. The findings show that all calculated intercepts are statistically significant ($p < 0.001$). This implies that the means of all analyzed variables are significantly different from zero, which is a common and expected finding in variable modeling (Lestari et al., 2024).

Most of the error variances (denoted as e_1, e_2, e_3 , etc.) are also statistically significant. However, an anomaly was identified in the results: the error term e_{15} yielded a negative variance estimate of -0.165. This specific result, although not statistically significant ($p = 0.551$), constitutes an unacceptable solution, since variances cannot be negative by theoretical definition. (Rappaport et al., 2020) A value of this type, often called a Heywood case, is an indicator that may indicate poor specification of the variable, the presence of outliers, or empirical under-identification.

Discussion

Hypothesis 1 (H1) posits that higher business resilience is correlated with a higher level of digital tool utilization (Code: P13 (technologies to improve sales) and P13_2 (technologies to improve processes)). However, technology use is not the end goal itself, but rather the foundation for technological learning to develop competitiveness and resilience in organizations. In this context, the COVID-19 crisis reinforced the need for digital transformation (M. Attarpour et al., 2023; Khurana et al., 2022; Srisomwongse et al., 2025). This led a large number of SMEs to quickly adopt available technologies (De'a et al., 2020; Sinha et al., 2025; Srisomwongse et al., 2025). The purpose was to improve their ability to withstand and adapt to disruptions (Bustanza et al., 2019; Shekarian & Mellat Parast, 2021).

However, although there is a general agreement about the advantages that digitization can offer in order to be competitive (Hokmabadi et al., 2024; Troise et al., 2022). This study uncovers a counterintuitive hypothesis, essential for public policy. If SMEs in disruptive environments adopt technologies superficially or without a strategic approach, due to reactive technological learning, this could negatively impact their resilience. The aim is to break down this cause-and-effect relationship and demonstrate that the risk lies not in the technology itself, but in digital immaturity and structural elements that transform the investment into a rigid liability.

H1: The use of technologies in SMEs, as a result of technological learning, has a negative relationship with business resilience in disruptive environments.

It is important to mention that among the general barriers to implementing new technologies are: a lack of knowledge about them; a lack of digital skills; internal problems related to culture, habits, and resistance to change; and access to the necessary financing (Pozo-Benites et al., 2025); as well as insufficient connectivity infrastructure (Vélez & Morero, 2024). Furthermore, the process of technological adoption intensifies if the technological learning process has not been fully developed (Absorption theory: acquisition, assimilation, transformation, exploitation). (Garzón-Castrilló, 2016; Zahra & George, 2002) stated that SMEs pursue digitalization in order to survive, they risk failure if they do not use a comprehensive strategy for adoption and training (Campoverde Cajas & Guambaña Cárdenas, 2023). They become more vulnerable and risky when using technology, which should provide them with resilience, thus becoming trapped in a vicious cycle of disadvantage in the face of disruption.

According to the study of Fletcher & Griffiths, (2020) digitalization and the growth of an organization's digital maturity don't happen overnight. Moreover, simply acquiring a series of new systems isn't enough to succeed in this transformation. Implementing new technologies as a short-term response to disruption has proven to be the wrong approach (Symcox, 2020). In essence, technology acts as a catalyst that magnifies existing structural weaknesses, leading to a negative reaction (decline or exit from the business) when technology adoption lacks a solid strategic capability.

Hypothesis 2 (H2) maintains that higher business resilience is correlated with a higher level of perceived benefits from implementing digitalization strategies (Code: P14 (digital skills of human resources), P17 (business policies - image and reputation), P12 (international sales), and P15_13 (cybersecurity)). Again, according to the research (except for P15_13), there is a digital paradox, in which the expected benefits are sometimes not achieved in the short term (Alías Martín, 2024; C. Li & Wang, 2024). This may be because digital transformation is not simply about superficially implementing digital technologies in management or production (Fletcher & Griffiths, 2020; C. Li & Wang, 2024). It requires companies to base their decisions on their fundamental business needs and to incorporate, in a deep and strategic way, methods, concepts, and mechanisms aligned with technological learning (acquiring, assimilating, transforming, and exploiting new knowledge) (Do et al., 2025; Figueiredo & Piana, 2021; H. Li et al., 2021; Warner & Wäger, 2019).

The ability of traditional MSMEs (those with a low degree of digital maturity) to maintain their current practices is challenged by the effects of VUCA scenarios (vulnerable, uncertain, complex and ambiguous), such as the pandemic and post-pandemic (C. Li & Wang, 2024). This highlights the fragility of supply chain strategies and the inability to integrate business models and skills to adapt quickly to the market (Fletcher & Griffiths, 2020). The lack of robust infrastructure and skilled talent, along with operational and financial rigidity and increased risk from cyber threats, are the factors that contribute to this vulnerability (Hokmabadi et al., 2024).

The study of Ponies & Lada, (2021) discusses adoption of Digital Transformation during Covid-19 in Greek fashion companies, conducted with sixty executives in the sector, reveals this technological lag. It also presents results indicating the need for a more comprehensive, effective, organized, and less fragmented approach to developing a digital strategy and implementation roadmap. Under this VUCA scenario, the studies of Scholz et al., (2020). They also argue that superficial digitization strategies lead companies to experience drastic disruptions and increased uncertainty. These perceptions and results do not positively foster business resilience, so the first part of the hypothesis would be as follows:

H2a: Digitalization strategies in SMEs (digital skills of human resources, business policies - image and reputation and international sales), resulting from technological learning, have a negative perception relationship with business resilience in disruptive environments.

On the other hand, cyberattacks can paralyze a company, as they can eliminate access to communication and data systems, and potentially jeopardize confidential customer information or any other business information (ACIS, 2025). These are risks that are becoming more real for SMEs, and they must consider whether they are ready to face a crisis of this nature and how customers, employees, partners, and suppliers would be affected if information is permanently lost (Cobisa, 2021; USAID, 2021). Although most organizations allocate between 5% and 15% of their IT budget to cybersecurity, costly and complex incidents continue

to occur (ACIS, 2025). Hence, there is a positive perception of resilience and cybersecurity strategies in digital transformation. Therefore, the second part of the proposed hypothesis would be stated as follows:

H2b:Digitalization strategies in SMEs (cybersecurity), resulting from technological learning, have a positive perception relationship with business resilience in disruptive environments.

Hypothesis 3 suggests that SME managers perceive a high level of obstacles to digitalization as leading to lower business resilience. Therefore, they must develop the business skills to recognize, mitigate, or eliminate barriers to digital transformation (Cannas et al., 2021; Matarazzo et al., 2021; Mayor Ravines et al., 2025; Wuest et al., 2020). This capability will be a direct indicator of their agility and adaptability, and therefore, of their resilience (Vimal et al., 2023). Companies that successfully overcome these challenges demonstrate organizational maturity, enabling them to turn threats into opportunities (Cuevas-Gutierrez et al., 2024).

According to the survey, the most significant obstacles to adopting digitalization are: connectivity problems, limited financial resources, high costs related to initial investment, resistance to change from human talent, difficulties or lack of knowledge of technology providers, demands and complexities in the security requirements for information technologies (cybersecurity), and a lack of corporate culture that promotes digital transformation (Gutiérrez & Suárez Pedraza, 2023; Mayor Ravines et al., 2025).

It is observed that MSMEs already have an awareness of these barriers and their impacts. Regional studies, such as the one by Gutiérrez & Suárez Pedraza, (2023) Studies from Colombia demonstrate that internal obstacles related to organizational culture, human capital, and costs are considered more significant for technology adoption than physical infrastructure barriers, such as inadequate broadband connectivity. The obstacle lies not so much in the availability of technology or external infrastructure, but rather in the internal ability and willingness of SMEs to assimilate and manage digitalization. This is a task aimed at achieving digital resilience (Kahveci, 2025; Teece, 2007, 2018).

Research conducted during and after COVID-19 indicates that a robust technological infrastructure and the ability of companies to operate digitally reduce the impacts of the pandemic to some extent (CAF, 2020; Rafique et al., 2025; Vimal et al., 2023). Therefore, the existence of perceived barriers leads to a lack of strategic action or poor digitalization, which restricts the operational sustainability and performance of SMEs. This affects digital integration and resilience (Escobedo Cabello et al., 2025). Therefore, hypothesis H3, which states that the business resilience of SMEs in disruptive situations is negatively related to the perceived level of obstacles to digitization, is supported by a detailed analysis of empirical and academic evidence.

H3:The perceived level of barriers to digitalization in SMEs is negatively related to their business resilience in disruptive contexts.

Hypothesis 4 states that innovative activity is not limited to creating new products, but also represents a concrete expression of a company's ability to adapt, learn, and meet changing market demands (Valencia-Arias et al., 2024). Innovation, therefore, is a fundamental driver and a direct product of organizational resilience (Troise et al., 2022). The literature indicates that elements such as digital learning, the ability to innovate, and strategic management affect resilience (Do et al., 2025; J. Wang et al., 2025). Furthermore, it demonstrates the ability of SMEs to transform knowledge and technology into competitive value (Adelowo, 2020).

However, in a disruptive environment, such as the COVID-19 crisis, critical details are observed in the implementation of this capacity in Ecuadorian MSMEs (Duque-Espinoza et al., 2024). Regression models, both in the initial shock stage and in the subsequent adaptation/transformation phase, show that resilience has a significant predictive power over performance. However, innovation is also observed to be limited to a secondary dynamic capacity (Demuner Flores et al., 2025). This means that, when responding proactively to a crisis, the most important thing is survival; and if investments in innovation, which aim for long-term change, compete directly with liquidity, they may become less effective and even detrimental to keeping the organization afloat (Demuner Flores et al., 2025; Duque-Espinoza et al., 2024).

The conflict between financial prudence and capital investment in acquiring new equipment (P20_4) explains the empirical result obtained, which shows that these types of innovation strategies have a negative relationship with resilience. SMEs face severe cash flow constraints, and their primary strategic need is financial prudence to ensure their immediate survival (Bermeo Montalvo & Magal Royo, 2024). It is explained that investing in fixed capital represents a long-term financial commitment, which consumes the operating liquidity essential to cope with shocks, resulting in financial rigidity that reduces the company's ability to react to unforeseen situations (Duque-Espinoza et al., 2024; Pedroni, 2022). Therefore, investing limited resources in illiquid assets directly contradicts the resilience strategy and transforms this innovation into a vulnerability rather than a strength (Pedroni, 2022).

Additionally, if technological learning is insufficient, strategies for improving sales/commercial processes (P20_7) and changing production processes (P20_3) can negatively impact resilience. Empirical evidence on the failure of SMEs during the pandemic indicates that innovative responses without the necessary knowledge result in sunk costs and operational rigidity (Duque-Espinoza et al., 2024; Pedroni, 2022). Limited management and knowledge of information technologies (IT), as well as a lack of focus on the digitization of processes, were key factors that led to the closure of companies (Demuner Flores et al., 2025). This showed that imposed innovation without an adequate capacity to absorb technology (AC) becomes a factor producing internal failure rather than a driver of adaptation (Esparza-Aguilar et al., 2023; Estrada et al., 2018).

The strategy of launching new products to market (P20_2), which can be considered a radical innovation, usually has a negative correlation with short-term resilience, due to the high cost of research and development (R&D) and its uncertain return (Sánchez Pazmiño et al., 2023; Sánchez Pazmiño & Acosta Andino, 2020). In a disruptive environment that demands immediate results and low risk, pursuing this type of innovation diverts essential resources from core operations. Research on the performance of SMEs has determined that investing in profound transformations can be harmful or irrelevant if the goal is short-term survival (Molina-Sánchez et al., 2023; Patino-Galván et al., 2023).

Strategic management is fundamental, changes or improvements in terms of management and organization (P20_5) could have a negative correlation with the company's performance throughout the crisis. Innovation management has been found to have a considerable negative effect on perceived performance (product quality, customer satisfaction) due to the abrupt operational changes introduced to survive (Larios-Francia, 2023; Molina-Sánchez et al., 2023). The reason for this adverse relationship is that drastic organizational transformations, without a prior learning and maturation process, create internal instability and deteriorate service quality, while staff and customers struggle to adapt to new routines amidst the turbulence (Dalmutt Kruger et al., 2023). Therefore, the final hypothesis is stated as follows:

H4:Innovation strategies in SMEs, resulting from technological learning, have a negative relationship with business resilience in disruptive environments.

Conclusions and Recommendations

A structural equation model was used to evaluate the Business Digitalization Strategy for Resilience in a context of disruption in Ecuadorian SMEs. The regression weights indicate that the latent variable Resilience is significantly and negatively affected by several factors, including: technology use, digitalization strategies (digital skills of human resources, business policies image and reputation, and international sales), barriers to digitalization, and innovation strategies. However, the cybersecurity requirement had a significant and positive impact on resilience. These results highlight that, despite significant barriers to digitalization, such as high costs or employee resistance to change, it is essential to focus on specific elements of the digital strategy, such as the development of technological learning, to improve a company's responsiveness.

Business resilience in micro, small, and medium-sized enterprises (MSMEs) is undoubtedly affected by factors such as technological learning, organizational capabilities, and the adoption of digital technologies. The study highlights the importance of focusing on these criteria for companies to adapt and succeed in uncertain environments. Empirical research demonstrates that Ecuadorian micro, small, and medium-sized enterprises have a generally low level of digital maturity, particularly regarding technology implementation. Although business leaders acknowledge that digitalization is essential for survival and competitiveness in the wake of the pandemic, companies face significant challenges. The most significant obstacles are infrastructural and financial, with high investment costs and insufficient broadband connectivity being the most prominent.

Along the same lines, it is noted that when companies implement digitization strategies superficially, they are forced to confront drastic changes and increased uncertainty. Digital transformation requires cultural and organizational reconfiguration, in addition to a solid technological perspective. Resistance to transformation, low levels of digital literacy, and a lack of consistent implementation remain pervasive barriers that hinder the effective application of digital processes. It is suggested that future studies investigate standardized metrics on digital maturity in SMEs.

The innovation paradox, regarding the ability of SMEs to withstand periods of disruption, arises from the tension between capital investment and financial prudence. When innovation involves high investments, such as purchasing new equipment or developing radical products, an inverse relationship emerges with business resilience. In times of disruption, these illiquid investments clash with the need for financial caution, depleting the liquidity necessary for SMEs to survive

in the short term. Furthermore, a poor capacity for technological absorption is directly linked to the failure of innovative tactics. Implementing process changes or digitalization without the appropriate knowledge leads to rigidity and inefficiency, diminishing resilience rather than enhancing it. Resilient innovation must be agile and cost-effective.

Digital transformation projects have the potential to disrupt business operations, potentially leading to systemic changes that impact a company's resilience and necessitate risk management for informed decision-making. The practical lessons learned are that disruptive circumstances will always exist, making it essential to be prepared, incorporate agility into the organization, and become digitally enabled. Technological learning will foster digital maturity and enable the development of new approaches and planning, ultimately leading to more effective organizational responses to future crises.

Companies' ability to overcome crises is often discussed as a defensive response. However, this doesn't provide a long-term perspective. This limited view hinders our understanding of business resilience and our examination of how digital transformation incrementally impacts sustainability. We need to move beyond the digital paradox and strive for digital maturity, which encompasses growth from an organizational perspective that includes the development of technological learning.

Finally, the importance of resilience analysis in these organizations is confirmed, given that MSMEs constantly strive to promote new production, service, and marketing activities to increase their performance in the country's value chain. Furthermore, in contexts of change, this economic sector appears to adapt to new circumstances to remain competitive. However, gaps still exist, such as a lack of understanding of the long-term repercussions of digital transformation, the relationships between digital maturity, innovation, and sustainability, and the need for comparative studies across industrial sectors and geographic areas.

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1. Annexes

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	PLabel
Resiliencia <-- P13	-.005	.002	-2.092	.036
Resiliencia <-- P13_2	-.017	.004	-4.288	***
Resiliencia <-- P14	-.016	.004	-3.734	***
Resiliencia <-- P15	-.016	.005	-3.090	.002
Resiliencia <-- P20	-.040	.007	-5.919	***
Resiliencia <-- P017_SQ003	-.006	.003	-2.031	.042
Resiliencia <-- P15_13	.028	.008	3.660	***
Resiliencia <-- P12	-.001	.000	-2.232	.026
P00802_SQ001 <-- Resiliencia	1.000			
P010_SQ001 <-- Resiliencia	2.054	.405	5.067	***
P019_SQ006 <-- Resiliencia	-5.341	.921	-5.797	***
P013_SQ001 <-- P13	1.000			
P013_SQ002 <-- P13	1.097	.036	30.114	***
P013_SQ003 <-- P13	.793	.032	25.163	***
P013_SQ005 <-- P13	.694	.034	20.256	***
P013_SQ004 <-- P13	.846	.032	26.067	***
P013_SQ006 <-- P13_2	1.000			
P013_SQ007 <-- P13_2	1.433	.052	27.365	***
P013_SQ008 <-- P13_2	1.462	.053	27.526	***
P013_SQ010 <-- P13_2	1.503	.054	28.081	***
P013_SQ011 <-- P13_2	1.251	.046	27.119	***
P013_SQ012 <-- P13_2	1.302	.052	25.143	***
P014_SQ004 <-- P14	1.000			
P014_SQ005 <-- P14	.614	.096	6.399	***
P015_SQ001 <-- P15	1.000			
P015_SQ002 <-- P15	1.143	.051	22.393	***
P015_SQ003 <-- P15	1.117	.049	22.820	***
P015_SQ004 <-- P15	1.119	.052	21.626	***
P015_SQ005 <-- P15	1.280	.054	23.882	***
P015_SQ006 <-- P15	1.303	.054	24.153	***
P015_SQ008 <-- P15	1.225	.053	23.223	***
P020_1 <-- P20	1.000			
P020_2 <-- P20	.986	.020	48.793	***
P020_3 <-- P20	1.017	.018	55.211	***
P020_4 <-- P20	.974	.020	48.281	***
P020_5 <-- P20	1.017	.018	56.293	***
P020_6 <-- P20	1.023	.018	57.902	***
P020_7 <-- P20	1.027	.018	57.709	***
P015_SQ007 <-- P15_13	1.000			

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P013_SQ009 <-- P15_13	1.423	.327	4.357	***
P01201 <-- P12	1.000			
P01202 <-- P12	.161	.071	2.266	.023

Means: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	PLabel
P017_SQ003	4.057	.023	178.623	***

Intercepts: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	PLabel
P00802_SQ001	1.624	.018	90.292	***
P010_SQ001	1.722	.030	56.709	***
P019_SQ006	3.538	.068	52.347	***
P013_SQ001	2.737	.048	57.029	***
P013_SQ002	1.952	.046	42.772	***
P013_SQ003	1.481	.043	34.762	***
P013_SQ005	2.734	.047	58.147	***
P013_SQ004	3.273	.044	74.958	***
P013_SQ006	1.774	.044	40.547	***
P013_SQ007	1.793	.045	39.979	***
P013_SQ008	1.701	.045	37.566	***
P013_SQ010	1.742	.045	38.778	***
P013_SQ011	1.242	.040	31.240	***
P013_SQ012	2.180	.047	46.757	***
P014_SQ004	3.152	.028	111.723	***
P014_SQ005	3.386	.027	123.174	***
P015_SQ001	3.681	.029	127.896	***
P015_SQ002	3.659	.027	133.954	***
P015_SQ003	3.671	.026	141.784	***
P015_SQ004	3.011	.028	106.549	***
P015_SQ005	3.331	.027	121.497	***
P015_SQ006	3.324	.027	121.574	***
P015_SQ008	3.497	.028	126.814	***
P020_1	3.257	.042	77.519	***
P020_2	3.073	.044	70.412	***
P020_3	3.112	.042	73.781	***
P020_4	3.015	.043	69.517	***
P020_5	3.081	.042	73.692	***
P020_6	3.052	.041	73.598	***
P020_7	3.186	.042	76.365	***
P015_SQ007	3.325	.028	118.121	***
P013_SQ009	1.831	.046	39.919	***
P01201	7.926	.471	16.839	***
P01202	.737	.089	8.257	***

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Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	PLabel
P13	2.375	.141	16.845	***
P13_2	1.331	.096	13.902	***
P14	1.789	.280	6.379	***
P15	.526	.041	12.844	***
P20	2.705	.110	24.498	***
P15_13	.718	.169	4.236	***
P12	189.922	84.537	2.247	.025
P017_SQ003	1.053	.033	31.945	***
e1	.320	.010	31.817	***
e2	.546	.017	31.769	***
e3	.659	.021	30.717	***
e4	2.325	.094	24.752	***
e5	1.392	.078	17.838	***
e6	2.210	.081	27.307	***
e7	3.368	.114	29.673	***
e8	2.192	.082	26.590	***
e9	2.574	.085	30.317	***
e10	1.371	.054	25.538	***
e11	1.341	.053	25.123	***
e12	1.114	.048	23.244	***
e13	1.142	.044	26.091	***
e14	2.180	.076	28.659	***
e15	-.165	.276	-.597	.551
e16	.869	.107	8.095	***
e17	1.165	.039	29.746	***
e18	.837	.030	27.925	***
e19	.713	.026	27.425	***
e20	.972	.034	28.634	***
e21	.673	.026	25.640	***
e22	.633	.025	24.988	***
e23	.763	.028	26.859	***
e24	.897	.032	27.627	***
e25	1.260	.043	28.970	***
e26	.836	.031	27.151	***
e27	1.275	.044	29.076	***
e28	.768	.029	26.716	***
e29	.680	.026	25.965	***
e30	.697	.027	26.062	***
e31	.899	.166	5.402	***
e32	2.841	.344	8.260	***
e33	262.195	84.148	3.116	.002
e34	11.321	2.207	5.130	***

file:///C:/Users/00333595/Documents/Emprendimiento/Resiliencia%20v2.AmosOutput 13/6/2025