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437

# Barriers to innovation in Brazilian small- and medium-sized enterprises

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## Abstract

**Purpose** – This research investigates the barriers impeding innovation within small- and medium-sized enterprises (SMEs) in Brazil, exploring 54 innovation-related barriers categorized into six distinct groups to offer substantial insights and analyses pertinent to the decision-makers, researchers and SMEs.

**Design/methodology/approach** – This research employed a mixed quantitative and exploratory approach, utilizing fuzzy Delphi, fuzzy analytic hierarchy process (AHP) and fuzzy decision-making trial and evaluation laboratory (DEMATEL) methods. The fuzzy Delphi method confirmed the categories and barriers through quantitative analysis, the fuzzy AHP ranked the validated obstacles and the fuzzy DEMATEL method identified causal connections among the top-priority barriers.

**Findings** – Out of 54 barriers, 23 significantly impacted SMEs. The "Financing and Financial" category was the most significant barrier, with "Access to Financing" being the most critical impediment. The barrier with the most influence was "Instability of Fiscal Policies," and the highest causal priority was "Survival of the Priority Business," identifying the government's unstable fiscal policy as the principal barrier confronting SMEs in Brazil.

**Originality/value** – The primary challenges for Brazilian SMEs center on financing, fiscal policies and maintaining ongoing operations. By addressing these barriers and fostering a resilient business environment, SMEs' innovation capabilities and competitiveness can be enhanced, serving as key drivers for sustainable economic growth in fluctuating economic conditions. This study contributes to the literature by highlighting and validating the main barriers to SME innovation, providing highly relevant information about the innovation process.

**Keywords** Open innovation, Innovation process, Brazilian SMEs, Barriers to innovate, Market, Behavior

**Paper type** Research paper

## 1. Introduction

An organization's innovation process is relevant for obtaining a competitive advantage, causing new products and processes to be developed (Qin *et al.*, 2021; Gruenhagen *et al.*, 2022; Algarni *et al.*, 2023). From this perspective, different companies have sought to integrate different actors into their process as they understand that innovating benefits the organization. In this context, Morgan *et al.* (2021) shed light on the literature by verifying the

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strategy of opening the innovation process to customers, demonstrating that after adopting a more open innovation process, the organizations were able to reveal significant improvements, as in large organizations that have already employed this strategy (Ryszko and Szafraniec, 2022; Priyono and Hidayat, 2023).

Nevertheless, the innovation process may be differentiated for small and medium-sized enterprises (SMEs) as they often rely on limited resources and face economic and technological challenges (Rahman *et al*., 2020; Veiga *et al*., 2021). Authors such as Dossou-Yovo and Keen (2021) conceptualized the innovation process in SMEs as an interactive process involving idea generation and selection, transformation, learning, resource mobilization, commercialization, and coordination, as well as several key points of resource mobilization, requiring the interaction of business actors inside and outside the organization.

Rosenbusch *et al*. (2011) provided valuable insights into the influence of innovation on the performance of SMEs. The authors explained that when managers focus solely on the process of creating innovative employees. These elements are essential for realizing the value innovation can generate for the company.

Hence, it is known that the innovation process is indeed a market differentiation strategy, although entrepreneurs must be careful with this strategy not to become something harmful to their organization, thus becoming a barrier to innovation, even more so because innovation remains a high-risk activity (Slater *et al*., 2014; Roberts *et al*., 2021).

Barriers to innovation constitute a significant challenge for many organizations, particularly for SMEs. These entities are often more susceptible to such barriers than larger companies (Demirbas *et al*., 2011). Besides internal constraints, external factors like the COVID-19 pandemic can also adversely affect the innovation performance of SMEs. Bianchin and Pagnussat (2022) revealed that the impacts caused by the COVID-19 pandemic extend beyond health, profoundly affecting the economic landscape. The unemployment rate and inflation soared, leading to substantial economic losses, especially in emerging countries like Brazil. Data released by the Brazilian Institute of Geography and Statistics (IBGE) (2020) indicate that approximately 700,000 people were added to the unemployment figures in Brazil in the first two weeks of June alone. The National Household Sample Survey shows that, by the fourth week of July 2020, the unemployment rate in the country had reached 13.7%—one of the highest rates ever recorded, equating to 12.8 million unemployed individuals (PNAD, 2021). The services sector, particularly tourism, air transport, and events, was severely affected by the pandemic (Bianchin and Pagnussat, 2022).

Guimarães *et al*. (2022) reported that according to data released on September 1, 2020, Brazil's Gross Domestic Product (GDP) dropped by 9.7% in the second quarter of 2020 compared to the first quarter, marking the country's entry into a technical recession due to a significant slowdown in activity between March and April. When compared to the same period in 2019, the decrease was 11.4%. According to IBGE, the COVID-19 pandemic caused a reduction in the industrial sector by 18.8% compared to March. This plunge brought Brazil's production to 38.3% below its historical peak (Lima Neto *et al*., 2022).

In the context of Brazilian SMEs, there was a notable surge in entrepreneurship out of necessity, which arises when job opportunities are scarce and individuals, to ensure their survival and that of their families, turn to entrepreneurship. This situation significantly increased individual microentrepreneurs (SEBRAE, 2020; Guimarães *et al*., 2022). Hamilton (2020) and Van Auken *et al*. (2021) emphasize that SMEs were among the organizations hardest hit by the COVID-19 crisis, jeopardizing their market survival.

Moreover, SMEs play a critical role in Brazil, accounting for a significant share of the GDP, at 27% of the total (Da Silva Gumieiro and Sartori, 2023), and composing most businesses. In the first four months of 2024, SMEs accounted for approximately 93.6% of newly established companies in the country (Brasil, 2024).

In their literature review, Marcelino *et al*. (2020) emphasize the substantial role of SMEs in driving wealth creation and income generation within the Brazilian economy. Given their sheer volume and breadth of operations, these enterprises are pivotal to the country's economic

growth. They are crucial in fostering job creation, promoting social inclusion, and delivering economic benefits that enhance national resilience. SMEs are inherently dynamic entities, involving individuals, fulfilling specific roles, and operating based on accumulated knowledge and expertise.

The economic significance of SMEs in Brazil is undeniable. As of 2024, the sector comprised approximately 19 million establishments, contributing to over 900,000 new jobs that year alone (Brasil, 2024; Sebrae, 2024). This highlights the sector's critical role in employment generation and ensuring economic stability and growth.

In this context, innovation is a key driver for SME competitiveness, adaptability, and sustainable development. Prioritizing innovation allows these enterprises to enhance their market presence, offer diverse products and services, and remain resilient amid evolving economic challenges (Gupta, 2020; Carrasco-Carvajal *et al*., 2023; Zheng *et al*., 2023; Shi *et al*., 2024; Fawad Sharif *et al*., 2024; Ndzana and Mvogo, 2024; Vo *et al*., 2024). During recent economic turbulence, many Brazilian SMEs invested heavily in innovation, particularly in marketing and communication strategies, to maintain their operations and market relevance (Kruger *et al*., 2023).

However, Brazilian SMEs face significant barriers to innovation. The IBGE (2017) identifies excessive economic risks, high innovation costs, a lack of skilled personnel, and limited access to financing as significant challenges. Addressing these obstacles is essential for fostering an environment where SMEs can thrive and contribute meaningfully to Brazil's social development.

For Silva *et al*. (2021), financial barriers represent the most significant challenge for Brazilian SMEs aiming to innovate, leading them to seek support from universities and research institutes for this crucial capacity. However, some researchers have observed that limited efforts have been made to identify factors that hinder the innovation process in SMEs (Abbey and Adu-Danso, 2022). This situation is also evident in Brazil, as data on barriers to the innovation process for SMEs are still scarce (Serpe and Kaniak, 2021). Serpe and Kaniak (2021) indicated that, regarding innovation within SMEs, few efforts are made to comprehend their challenges and devise solutions for this demographic. This scenario underscores the need to understand how innovation unfolds in these companies.

Furthermore, when searching literature databases, no research was found that analyzes the barriers to innovation in SMEs during the COVID-19 pandemic. Similarly, few studies endeavor to understand and illuminate the primary barriers preventing Brazilian SMEs from achieving a more assertive innovation capacity despite numerous studies analyzing the pandemic's impact on the economy and various contexts.

Given the above and the importance of SMEs to the Brazilian economy, it is crucial to identify the main impediments these companies face in innovating. Hence, given the practical and managerial implications of this topic, our article sought to address the question: "What are the most significant barriers to the innovation process in Brazilian SMEs?"

To address this, we employed the fuzzy Delphi, fuzzy AHP, and fuzzy DEMATEL methods to identify and analyze innovation barriers specific to Brazilian SMEs. The innovation process is an essential factor for the survival of companies, particularly in the context of open innovation. Identifying these barriers is thus a crucial step in formulating strategies that can guide SME managers in their decision-making. It is widely acknowledged that such barriers can influence a company's willingness to innovate, the nature of their innovation, and their market competitiveness (Sama-Berrocal and Martínez-Azúa, 2022).

This research stands out for its originality in addressing a relatively unexplored topic in the scientific literature. Many studies have investigated the economic impacts of the pandemic and business resilience in a global context, although the specificity of focusing on Brazilian SMEs and their relationship with innovation provides an unprecedented and relevant contribution. This study fills a gap in the literature by examining the difficulties and challenges faced by this fundamental segment of the country's economy, offering a detailed and contextualized analysis of the specific obstacles imposed by the pandemic.

The relevance of this topic is underscored by the scarcity of research examining Brazilian SMEs from the perspective of innovation, in contrast to the abundance of studies on large corporations or more developed economies. The absence of studies focused on Brazilian SMEs during COVID-19 makes this article original and essential for policymakers, academics, and managers seeking to understand and mitigate the adverse impacts of the pandemic on these companies. By exploring this topic in an unprecedented manner, the article contributes significantly to the existing body of knowledge, offering valuable insights for economic recovery strategies and strengthening SMEs in Brazil.

This study is based on the premise that, by identifying barriers and their causal relationships, managers and decision-makers will be able to align efforts and establish strategic guidelines to mitigate these barriers, making Brazilian SMEs more competitive and innovative. The originality of this study lies in the comprehensive examination of the barriers to innovation faced by Brazilian SMEs, an area that has received limited attention in the existing literature. While numerous studies have addressed the innovation challenges in SMEs worldwide, few have focused on Brazil's unique economic, cultural, and regulatory environment. This research not only identifies and categorizes 54 barriers to innovation using a robust framework, which includes fuzzy Delphi, fuzzy AHP, and fuzzy DEMATEL techniques, but highlights the most critical barriers, including financial constraints and fiscal policy instability, which are particularly pertinent to the Brazilian context.

Furthermore, by providing empirical evidence and practical insights tailored to Brazilian SMEs, this study offers valuable contributions to policymakers and business leaders seeking to improve these companies' innovation capabilities and competitiveness. The integration of open innovation concepts with the specific challenges faced by Brazilian SMEs further underscores the novelty of this research, offering new perspectives and viable strategies to overcome these barriers.

The contribution to the literature lies in the fact that it highlights and validates the main barriers for SMEs, providing highly relevant information about the innovation process during a period of crisis. In terms of managerial contributions, this article explores information that can help better direct support strategies for SMEs, both by managers and formulators of public policies aimed at the innovation process of these organizations. Furthermore, it contributes in an empirical and evidence-based manner, bringing theory closer to the reality of organizations in this sector.

In today's global economy, SMEs face a variety of barriers that hinder their ability to innovate and compete in the market. While numerous studies have addressed the challenges of innovation in SMEs globally, few have focused on the specific economic, cultural, and regulatory environment of Brazil. This study addresses this gap in the literature by comprehensively examining the specific innovation barriers faced by Brazilian SMEs.

Hence, the rest of the article is structured as follows: the second section presents the theoretical foundation, the third one presents the methodological procedures, followed by the analysis of the results and, lastly, in the fifth section, the final considerations and recommendations.

## 2. Theoretical framework

### *2.1 Innovation process in the SME context*

Innovation activities include all developmental, financial, and commercial activities undertaken by a firm intended to result in innovation for the firm (OECD, 2018). According to the OECD, there are two main types of innovation: product innovation and process innovation. Product innovation consists of a new or improved good or service that differs significantly from the firm's previous goods or services and has been introduced to the market. Process innovation is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and is put to use by the firm (OECD, 2018).

Scozzi *et al*. (2005) described the innovation process as involving different factors, including cognitive, task, political, decision, strategic, creative, information flow, and communication; it must be a key process in an organization because innovation provides chances for success in the competitive market (Žižlavský, 2013).

From the perspective of SMEs, the innovation process is conceptualized as an interactive procedure involving sub-processes such as idea generation and selection, transformation, learning, resource mobilization, commercialization and coordination, and several key resource mobilization points, requiring the interaction of internal and external business actors (Rasheed *et al*., 2017; Dossou-Yovo and Keen, 2021).

Scozzi *et al*. (2005) and Purcarea *et al*. (2013) highlighted SMEs' relevant role in generating innovation, contributing effectively in recent decades, especially in emerging and developing countries, since innovation contributes to developing regions and economic growth. In addition to the external environment of SMEs, Terziovski (2010) emphasized that the innovation process of these companies directly influences their performance, in which the innovation strategy and formal structure are positive and significant predictors of SME performance. Networking is another determining factor for the successful innovation processes of SMEs (Zeng *et al*., 2010).

What is more, Ismanu *et al*. (2021) aimed to examine and analyze the effects that process and product innovation have on the performance of small and medium-sized enterprises by using a sample of 100 SMEs. The researchers demonstrated that innovation is positively related to business performance and demonstrated that government policies help in a relevant way in developing these companies.

### *2.2 Barriers to innovation and SMEs*

The barrier to innovation faced by firms is something that prevents them from adopting innovation initiatives and/or producing innovations (Valdés *et al*., 2020; Farjam *et al*., 2023). According to the authors, there are four main barriers listed in the literature: financial, knowledge, market, and regulatory. Pellegrino (2018), in turn, reported that other factors have been recently negatively influencing the innovation process: the lack of adequate skills, lack of adequate information about technologies and markets, and lack/uncertainty of demand. The author conducted an empirical study with Spanish companies from 2004 to 2011 and found that different types of obstacles are perceived differently by companies of different ages.

As demonstrated, SMEs encounter a variety of unique challenges when developing innovations within their activities. In Brazil, Serpe and Kaniak (2021) elucidate that factors such as the absence of external support and a lack of understanding of the dimensions involved in an innovation process constitute significant barriers that impede innovation in SMEs. In the research conducted by IBGE (2017), it was observed that the managers of the interviewed companies highlighted the main barriers to innovation as excessive economic risks, high innovation costs, a shortage of qualified personnel, and a scarcity of financing sources.

In their study, Feldens *et al*. (2012) identified the primary barriers to product innovation in small and medium-sized technology companies in Brazil. The barriers observed included: (1) difficulties related to legal barriers, costs, and availability of capital; (2) a lack of investors for the most advanced stages of development and a scarcity of exit modes, resulting in longer investment cycles compared to international averages; (3) involvement of investors who are close to entrepreneurs in business administration; (4) a challenge in finding qualified technical and management professionals willing to engage in new and uncertain ventures; (5) a cultural aversion to risk, leading businesspeople and investors to adopt a more conservative approach to decision-making; and (6) positive prospects, linked to the availability of capital.

Sanchez (2019), in his research, analyzed innovative SMEs in the manufacturing industry in Brazil and categorized the problems and obstacles to innovation into five groups: (1) economic-financial (high costs, risks, and limitations for financing); (2) knowledge (a lack of qualified personnel, a scarcity of market and technology information, and a low level of

cooperation with other companies and institutions); (3) research, development, and innovation (RD&I)—organizational rigidity and the centralization of innovative activities); (4) marketing (difficulties in accepting new products); and (5) regulatory (challenges in adapting to standards and regulations and limited access to specialized technical services). The author concluded that SMEs can significantly expand their understanding of the crucial nature of problems and obstacles to innovation as they engage in innovative activities, especially in open innovation models.

Mambrini *et al*. (2011) corroborate Sanchez (2019) findings that open innovation is a management practice promoting an innovative culture in Brazilian SMEs. They also introduced other practices, such as (1) operating in highly specialized niches and focusing intently on customer needs; (2) demonstrating speed and agility in the absorption and implementation of new knowledge and technologies; (3) retaining employees; (4) acting as an integrator by combining diverse knowledge and technologies; (5) managing the information of knowledge acquired by the company; (6) displaying little concern for patenting technology; (7) exhibiting flexibility and informal, fluid, and open communication among employees, which promotes agility in management; and (8) managing partnerships across the entire value chain, incorporating various functional areas.

Barboza *et al*. (2017) confirm the low autonomous propensity of small companies to innovate. They also emphasize the importance of public policy instruments and actors in facilitating the necessary conditions to promote innovation within the micro and small business segments. In this sense, the networked action of public policy actors can significantly contribute to overcoming barriers and resistance, facilitating the generation or incorporation of innovations by micro and small companies—both traditional and technological.

## 3. Method

In order to identify and analyze the barriers to the innovation process of Brazilian SMEs using the fuzzy Delphi, fuzzy AHP, and fuzzy DEMATEL methods, quantitative and exploratory research was conducted. To reach this goal, a double study was conducted, which was first done by searching in the Scopus and Web of Science databases for international publications using the following combination of keywords: "barriers to innovation" AND "small and medium enterprises" OR "SMEs." At this stage, approximately 60 documents were identified that met the selection criteria applied. These criteria included articles in English, and only articles and reviews were considered. Notably, this research was conducted on May 22, 2022, across both databases. After downloading data from these articles, duplicates were removed ($n = 28$) and the remaining documents were analyzed for thematic adherence, resulting in 11 documents deemed suitable for surveying barriers. Consequently, through the literature review, 54 barriers were identified (Supplementary material).

The barriers listed in Supplementary material, were systematized into six categories: the issues concerning "Resistance and Culture" explain barriers related to the organization's profile and strategy. In the "Infrastructure and Resources" category, the barriers deal with the size of the organization and the available infrastructure. The "Governmental" category shows barriers related to government support for organizations. The category "Knowledge" reveals barriers that include training, staffing, and knowledge about innovation. The "Collaboration and Cooperation" category is about barriers that consist of cooperating with other companies, universities, and collaborations. Finally, the category "Financing and Financial" lists barriers that deal with financing available to innovate and internal and external resources to the company.

The collected data underwent fuzzy data analysis to address the inherent uncertainties in the responses. The fuzzy Delphi method validated the identified barriers, while the fuzzy AHP method prioritized these barriers. The fuzzy DEMATEL method was then applied to establish causal relationships and offer insights into how each barrier influences the others. At this juncture, an online questionnaire was disseminated to a selected group of experts and

managers involved in the innovation processes within SMEs. The questionnaire was accessible from December 2021 to February 2023, garnering 70 valid responses for analysis. The number of responses is appropriate, considering that previous studies implemented methods with 15 respondents (Singh and Sakar, 2020); Khan *et al*. (2021) with 12 respondents, Dolatabad *et al*. (2022) and Guo and Wu (2023) with 16 respondents, and Elkadry *et al*. (2023) with 30 respondents. Table 1 presents data concerning the profile of the respondents.

Subsequent analysis revealed that the participants in the sample had an average of 17.5 years of experience as innovation specialists or managers directly engaged in innovation processes within Brazilian SMEs. These respondents included innovation directors, project managers, general directors of SMEs, and innovation analysts. Furthermore, the inclusion criteria for participating in the research stipulated that respondents must be directly linked to the management of the SME and have been involved in innovation projects, whether related to processes, products, or services, in the last five years.

Ethical considerations, such as obtaining informed consent from participants and ensuring data confidentiality, were meticulously followed throughout the research process. Despite these safeguards, the study may have limitations, including the reliance on self-reported data and the specific sampling method employed. These limitations were carefully accounted for during the data analysis and interpretation phases.

### *3.1 Fuzzy Delphi*

The fuzzy Delphi method was utilized to validate the barriers identified in the literature within the context of Brazilian SMEs. This method is frequently employed to provide systematic assistance in tool validation (Sulaiman *et al*., 2020), conceptual design and the development of new products (Baskar *et al*., 2020), the development of information and communication

**Table 1.** Profile of the study respondents ($n = 70$)

| Variable | | *n* | % |
|---|---|---|---|
| Sex | Female | 15 | 21 |
| | Male | 55 | 79 |
| Education | PhD | 29 | 41 |
| | MSc | 24 | 34 |
| | Complete higher education | 13 | 19 |
| | Incomplete higher education | 4 | 6 |
| Position held | CEO | 33 | 47 |
| | Director of innovation | 15 | 21 |
| | Project manager | 10 | 14 |
| | Innovation analyst | 12 | 17 |
| Brazilian state | Alagoas | 2 | 3 |
| | Espirito Santo | 2 | 3 |
| | Maranhão | 1 | 1 |
| | Minas Gerais | 8 | 11 |
| | Paraíba | 2 | 3 |
| | Paraná | 20 | 29 |
| | Rio Grande do Sul | 18 | 26 |
| | Rio Grande do Norte | 2 | 3 |
| | Santa Catarina | 8 | 11 |
| | São Paulo | 7 | 10 |
| Time in position | 0–4 years | 17 | 24 |
| | 4.1–8 years | 6 | 9 |
| | 8.1–12 years | 17 | 24 |
| | >12 years | 30 | 43 |

**Source(s):** Authors' own work

technology evaluation models (Sumrit, 2020), defining barriers to reverse logistics (Bouzon *et al*., 2016), and in defining performance indicators for scientific and technological parks (Da Silva *et al*., 2023). The method fuzzy Delphi was proposed with the intention in order to minimize the time, research costs, and uncertainties involved in expert evaluation (Ishikawa *et al*., 1993; Bui *et al*., 2020; Tsai *et al*., 2020; Wang and Peng, 2020; Da Silva *et al*., 2023).

The first step consists of identifying the barriers to the innovation process of small and medium-sized enterprises, which were made through a detailed review of the relevant literature on the subject (Supplementary material). After surveying the barriers, an $n$ number of experts were asked to define the importance of each of the barriers using linguistic variables (Table 2).

The fuzzy number is assumed to be $\widetilde{a_{ij}}$ if the $j^{th}$ importance of the barrier $i^{th}$ expert is given by $\widetilde{a_{ij}} = (a_{ij}, b_{ij}, c_{ij})$ for i = 1, 2, 3 . . ., $n$; j = 1, 2, 3, . . ., m. Then, the fuzzy weights of the barriers $(\widetilde{a}\_\ j)$ are described as follows: $\widetilde{a_{ij}} = (a_j, b_j, c_j)$, where $\_j = \min\{a_{ij}\}, b_j = (II_i^n\, b_{ij})^{1/n}$, $c_j = \max\{c_{ij}\}$.

The final step in applying the fuzzy Delphi method is to identify the barriers to the innovation process of small and medium-sized enterprises, which is done by comparing the weight of the criterion with the threshold $\widetilde{a}$, where the weight of $\widetilde{a}$ is calculated by the average weight of all barriers $\widetilde{a_j}$ in which the inclusion and exclusion principles are respectively by:

If $\widetilde{a_j} \geq \widetilde{a}$, then criterion $j$ is selected; if $\widetilde{a_j} < \widetilde{a}$, then the criterion $j$ is rejected.

It is emphasized that $\widetilde{a_j}$ and $\widetilde{a}$ are a combined fuzzy set, so it is necessary to transform them into crisp values to make the comparison, as in the study of Bouzon *et al*. (2016), the present paper used the center of gravity method to defuzzify the fuzzy values. Furthermore, it should be noted that $\widetilde{a_j}$ was calculated separately for each criterion, with the sub-criteria defined based on this decision value. This approach helped reduce the variability and oscillation of weights attributable to the number of barriers presented. The results obtained from the fuzzy Delphi method made it possible to progress to the fuzzy AHP method, aiming to analyze the importance of dimensions and barriers.

### *3.2 Fuzzy analytic hierarchy process*

After validating the barriers using the fuzzy Delphi method, it became possible to develop a questionnaire to analyze the importance of dimensions and barriers through pairwise comparison. This analysis was carried out with the assistance of experts and managers from companies based on the Saaty scale (Table 3). The weights were calculated using the fuzzy AHP method proposed by Chang (1996). The fuzzy AHP is an extension of the fuzzy analytic hierarchy process (AHP) developed by Saaty (1980), in which, by combining the fuzzy logic developed by Zadeh (1988), it was improved to be applied in environments that present degrees of uncertainty (Wegner *et al*., 2021; Serpa *et al*., 2023). The steps used to define the weights of the criteria determined by the method are as follows:

Step 1: a hierarchy was developed to transform a complicated problem into a fundamental form.

**Table 2.** Linguistic variables for evaluating the criteria using the fuzzy Delphi method

| Linguistic variable | Corresponding fuzzy numbers |
|---|---|
| Extremely unimportant | (0.1, 0.1, 0.3) |
| Unimportant | (0.1, 0.3, 0.5) |
| Normal | (0.3, 0.5, 0.7) |
| Important | (0.5, 0.7, 0.9) |
| Extremely important | (0.7, 0.9, 0.9) |

**Source(s):** Singh and Sakar (2020)

**Table 3.** Linguistic expressions for evaluating the criteria

| Linguistic expressions | Equivalent numbers | Triangular fuzzy number (l, m, u) |
|---|---|---|
| Equal importance | 1 | (1, 1, 1) |
| Low importance | 3 | (1, 3, 5) |
| Great importance | 5 | (3, 5, 7) |
| Very high importance | 7 | (5, 7, 9) |
| Extreme importance | 9 | (7, 9, 9) |

**Source(s):** Authors' own work

Step 2: The relative importance of each barrier is determined by the experts' evaluation, for which a comparison matrix was constructed. Hence, the resulting pairwise comparison matrix is defined by Equation (1).

$$Z = \begin{bmatrix} (1,1,1) & l_{12}m_{12}u_{12} & \cdots & l_{1n}m_{1n}u_{1n} \\ l_{21}m_{21}u_{21} & (1,1,1) & \ldots & l_{2n}m_{2n}u_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ l_{n1}m_{n1}u_{n1} & l_{n2}m_{n2}u_{n2} & \ldots & (1,1,1) \end{bmatrix} \tag{1}$$

All elements of the matrix $(Z, l_{ij}, m_{ij}, u_{ij})$ indicate the important values of the criteria. The values from the analysis of the $i$ our data for the target $m$ are found utilizing the following symbols. All of $(j : 1, 2, \ldots, m)$ $M^j_{gi}$ are triangular fuzzy numbers. In addition, $X = (X_1, X_2, \ldots, X_n)$ was the deciding set, and $T = (t_1, t_2, \ldots, t_n)$ was the target set of the matrix (see Equation (2)).

$$M^1_{gi}, M^2_{g2}, \ldots., M^m_{g3}, i = 1, 2, \ldots, n \tag{2}$$

To analyze the decision-makers, the scale containing linguistic expressions corresponding to the equivalent triangular fuzzy numbers was used, and it is here that each expert is invited to evaluate. Thus, Table 3 lists the expressions and corresponding fuzzy numbers.

Step 3: The diffused values across the entire target set for each criterion were summed separately, and the $\sum_{j=1}^{m} M^j_{gi}$ value was obtained (see Equation (3)).

$$\sum_{j=1}^{m} M^j_{gi} = \left( \sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{3}$$

Step 4: Each of the fuzzy values in the decision set is summed, and $\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{gi}$ is obtained. The inverse vector of $\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{gi}$ was then calculated, as shown in Equations (4) and (5).

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{gi} = \left( \sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{4}$$

$$\left[ \sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{gi} \right]^{-1} = \left( \frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{5}$$

Step 5: The value of the synthetic length $(S_i)$ for each criterion was calculated using Equation (6).

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[ \sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \tag{6}$$

Step 6: The degree of possibility of $M_1(l_1, m_1, u_1) \geq M_2(l_2, m_2, u_2)$ was given as Equation (7).

$$V(M_1 \geq M_2) = \sup x \geq y \left[ \min \left( \mu_{M_1}(x), \mu_{M_2}(y) \right) \right] \tag{7}$$

To calculate the ordinate of the highest intersection point, Equation (8) was used.

$$V\left( M_2 \geq M_1 = hgt(M_2 \cap M_1) = \left\{ 1 \; if m_2 \geq m_1 \; 0 \; if \geq u_2 \; \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \; otherwise \right\} \right. \tag{8}$$

Step 7: being evidenced by Equation (9), the degree of possibility of a convex fuzzy point to be greater than z convex fuzzy points $M_i (i = 1, 2, \ldots, z)$ was defined.

$$V(M \geq M_1, M_2, \ldots, M_z) = V[(M \geq M_1); \; (M \geq M_2); \; \ldots; \; (M \geq M_z)] = V\left(M \geq M_p\right), p = 1, 2, \ldots, z \tag{9}$$

Assuming that $z \neq p \; and \; z = 1, 2, \ldots$ and $n$ conditions are met, then Equation (10) is applied.

$$d'\left(A_p\right) = \min V\left(S_p \geq S_z\right) \tag{10}$$

If $A_p (p = 1, 2, \ldots, n)$ are $n$ elements, then Equation (11) was applied.

$$W = \left( d'(A_1); \; d'(A_2), \ldots, d'(A_n) \right)^T \tag{11}$$

Step 8: normalized weight vectors were obtained, as shown in Equation (12).

$$W = \left( d(A_1), d(A_2), \ldots, d(A_n) \right)^T \tag{12}$$

Following the process, the Consistency Index (CI) was calculated using λmax and obtained by CI = (λmax-$n$)/($n$ - 1) and to finalize the Consistency Ratio (CR) calculation in CR = CI/RI. The Random Index (RI) was obtained by simulation and summarized in Table 4 and, in general, with an acceptable consistency RC ≤ 0.10.

Thus, the weights were defined, performing a ranking of importance for the barriers evaluated. Moreover, the results obtained through the fuzzy AHP method allowed for the selection of the highest-priority barriers. These were then analyzed for their causal relationships using the fuzzy DEMATEL method.

**Table 4.** Random index

| $n$ | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|
| RI | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

**Source(s):** Authors' own work

*3.3 Fuzzy DEMATEL*

After prioritizing the barriers, the subsequent step involved verifying the causal relationships among those deemed most significant according to experts' assessments. To achieve this, an analysis was conducted using the fuzzy DEMATEL method.

The fuzzy DEMATEL method is an advanced extension of the original DEMATEL method proposed by the Battelle Memorial Institute through its Geneva Research Center (Chang *et al*., 2011). Regarding fuzzy DEMATEL, scholars such as Feldmann *et al*. (2022) contend that the method ameliorates the limitations associated with the uncertainty of expert-provided information by integrating fuzzy logic with the DEMATEL technique. It is worth noting that this method has been effectively employed in analyses involving relationships between various constructs. Instances include identifying factors that influence service innovation in manufacturing companies (Feng and Ma, 2020), determining critical success factors for implementing project safety programs (Chai *et al*., 2022), and analyzing barriers to the implementation of Education 4.0 (Gonzales *et al*., 2022). To implement the fuzzy DEMATEL method in our study, we followed the approach outlined by Wu and Lee (2007) and Si *et al*. (2018), which consists of the following steps:

Step 1: Form a decision-making committee to evaluate factors in alignment with the decision's objective. Subsequently, assess each barrier using the fuzzy values listed in Table 5.

Based on the experts' assessments $E = \{E_1, E_2, \ldots, E_l\}$, the fuzzy matrix of individual direct relationships is obtained $\widetilde{Z}_k = [\widetilde{Z}_{ij}^k]_{nxn}$, where $\widetilde{Z}_{ij}^k = (z_{ij1}^k, z_{ij2}^k, z_{ij3}^k)$ is the experts' fuzzy assessment and $E_k$ is the degree of influence between the barriers $B_i$ and $B_j$.

Step 2: After obtaining the individual decision matrices $\widetilde{Z}_k (k = 1, 2, \ldots, l)$, the diffuse matrix of direct influence of the group $\widetilde{Z} = [\widetilde{Z}_{ij}^k]_{nxn}$ aggregating the experts' assessments, where $\widetilde{z}_{ii}$ is seen as triangular fuzzy numbers and $\widetilde{z}_{ij}$ comes from Equation (13):

$$\widetilde{z}_{ij} = \left(\widetilde{Z}_{ij1}, \widetilde{Z}_{ij2}, \widetilde{Z}_{ij3}\right) = \left(\frac{1}{l}\sum_{k=1}^{l} z_{ij1}^k, \frac{1}{l}\sum_{k=1}^{l} z_{ij2}^k, \frac{1}{l}\sum_{k=1}^{l} z_{ij3}^k\right) \tag{13}$$

Step 3: After aggregating the fuzzy values using Equation (13), the values of the fuzzy matrix of direct influence of the group are defuzzified $\widetilde{Z} = [\widetilde{Z}_{ij}^k]_{nxn}$, obtaining a direct group evaluation matrix $Z$ with clear numbers. This is done using the method of area center (Hsieh *et al*., 2004), as shown in Equation (14).

$$x_{ij} = \frac{(u_{ij} - l_{ij}) + (m_{ij} - l_{ij})}{3} + l_{ij} \tag{14}$$

Step 4: Once the direct influence matrix of group Z has been obtained, the normalized direct influence matrix $X = [x_{ij}]_{nxn}$ is obtained through Equations (15) and (16).

**Table 5.** Fuzzy linguistic scale

| Linguistic expressions | Triangular fuzzy number (l, m, u) |
|---|---|
| No influence (No) | (0, 0, 0.25) |
| Very low influence (VL) | (0, 0.25, 0.5) |
| Low influence (L) | (0.25, 0.5, 0.75) |
| High influence (H) | (0.5, 0.75, 1.0) |
| Very high influence (VH) | (0.75, 1.0, 1.0) |

**Source(s):** Authors' own work

$$X = \frac{Z}{s}, \tag{15}$$

$$\max\left(\sum_{j=1}^{n} z_{ij}, \sum_{i=1}^{n} z_{ij}\right) \tag{16}$$

All the elements in the matrix $X$ conform to $0 \leq x_{ij} < 1, 0 \leq \sum_{j=1}^{n} x_{ij} \leq 1$, where there is at least one $i$, such that $\sum_{j=1}^{n} z_{ij} \leq s$.

Step 5: Using the normalized direct influence matrix $X$, the total influence matrix is calculated $T = [t_{ij}]_{nxn}$ using the sum of the direct effects and the indirect effects, where $I$ is denoted as an identity matrix according to Equation (17).

$$T = X + X^2 + X^3 + \ldots + X^h = X(I - X)^{-1}, when\, h \to \infty \tag{17}$$

Step 6: At this point, Equation (18) defines the vectors $R$ and $C$, which are the sum of the rows and the sum of the columns of the total influence matrix $T$.

$$R = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1}$$

$$, C = [c_j]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]^{T}_{1\times n} \tag{18}$$

Where $r_i$ is the sum of the matrix row $T$ and shows the sum of the direct and indirect effects of barrier $B_i$ to the other barriers. In addition, $c_j$ is the $j$ is the sum of the matrix column $T$ representing the sum of the direct and indirect effects that barrier $B_j$ received from the other barriers.

When $i = j$ and $i, j \in \{., 2, \ldots, n\}$, the vector of the horizontal axis $(R + C)$ is called the prominence, which shows the force given to and received from the barrier. This means that $(R + C)$ represents the degree to which the barrier plays a central role in the system. Similarly, the vertical axis vector $(R - C)$, called ratio, shows the net effect that the barrier contributes to the system. If $(r_j - c_j)$ is positive, barrier $B_j$ influences the other factors and is grouped into the group of causes. However, if $(r_j - c_j)$ is negative, then this barrier is influenced by the other factors and has to be grouped into the effects group. In this context, the map of influential relationships can be structured by mapping the set of data from $(R + C, R - C)$ that produces relevant information for the decision-making process (Si *et al.*, 2018).

After applying the methods, the results obtained through the complementary application of each are presented based on data provided by experts. The fuzzy Delphi method was instrumental in validating and verifying which barriers identified in the literature were relevant in the context of Brazilian SMEs. Furthermore, the fuzzy AHP method offered insights into which barriers were prioritized most by experts, facilitating the analysis of the cause-and-effect relationships of these priority barriers through the fuzzy DEMATEL method. Therefore, the following sections present the results of each method, demonstrating how they complement one another in achieving the study's objective.

## 4. Results

### *4.1 Barrier selection using the fuzzy Delphi method*

The results obtained with fuzzy Delphi are presented in Table 6, the threshold weight was stipulated by the average of the weights (0.546). Upon verifying Table 6, one can identify the barriers selected according to the evaluation given by experts, resulting in 23 barriers. It is possible to observe that the category with the highest number of accepted barriers was Cr4 - Knowledge, with 9 accepted barriers (Table 6). Next was "Cr5 - Collaboration and Cooperation," with 5 validated barriers; the third with the most validated barriers was "Cr1 - Resistance and Culture" and "Cr6 - Financing and Financial," both with 3 barriers. In fourth place was "Cr2 - Infrastructure and Resources" with two barriers and finally "Cr3 - Government," with only one accepted barrier. With these results, one can move on to the prioritization process using the fuzzy AHP method.

### *4.2 Ranking the categories and barriers using the fuzzy AHP*

After validating the barriers, experts evaluated the criteria and subcriteria using the linguistic variables (Table 3). Notably, 100% of the respondents at this stage were male from different regions of Brazil, which fits the legislation that governs the issue of company size, characterized as small or medium-sized enterprises. Thus, Table 6 presents the weights obtained for each category of barriers (i.e. the criteria) and sub-criteria.

**Table 6.** Weight of the criteria and subcriteria

| Criteria | Weight (%) | Subcriteria | Weight (%) |
|---|---|---|---|
| Cr1 - resistance and culture | 17.00 | *Scr1 - Survival of the priority business* | *54* |
| | | Scr2 - Resistance to change in organizational and operational routines | 15 |
| | | *Scr3- Supporting great challenges* | *31* |
| Cr2 - infrastructure and resources | 14.11 | *Scr4 - Company turnover* | *75* |
| | | *Scr5 - R&D intensity/per employee* | 25 |
| Cr3 - government | 16.95 | *Scr6 - Instability of fiscal policies* | 100 |
| Cr4 - knowledge | 14.52 | Scr7 - Education (training) for entrepreneurship | 8.83 |
| | | *Scr8 - Lack of qualified personnel* | *18.90* |
| | | Scr9 - Lack of information about technology | 7.89 |
| | | Scr10 - Lack of information about the markets | 11.70 |
| | | Scr11 - Uncertainty about the demand for innovative goods or services | 9.62 |
| | | Scr12 - Lack of diversified teams | 7.63 |
| | | Scr13 - Limited managerial skill or qualification | 11.66 |
| | | *Scr14 - Know-how needed for innovation* | 15.22 |
| | | Scr15 - External sources of deeper knowledge | 8.56 |
| Cr5 - collaboration and cooperation | 18.06 | Scr16 - Difficulty managing and maintaining collaborations | 18.81 |
| | | Scr17 - Difficulty in forming networks with companies | 18.72 |
| | | Scr18 - Cooperation and coordination among organizational units | 18.79 |
| | | *Scr19 - Integration between entrepreneurs' activities with R&D and universities* | *21.94* |
| | | *Scr20 - Lack of information about opportunities for university-industry collaboration* | 21.74 |
| *Cr6 - Financing and Financial* | *19.36* | *Scr21 - Lack of available financing within the company* | 39 |
| | | Scr22 - Lack of financial support for university-industry collaboration | 21 |
| | | *Scr23 - Access to finance* | *40* |

**Source(s):** Authors' own work

Table 6 shows the weights obtained for each category/criteria through the experts' evaluation. It is possible to note that the category with the highest weight was "Cr6 - Financing and Financial," with 19.36%, demonstrating that this was the primary barrier faced by the innovation process of Brazilian SMEs.

*4.3 Analysis of causal relationships using fuzzy DEMATEL*

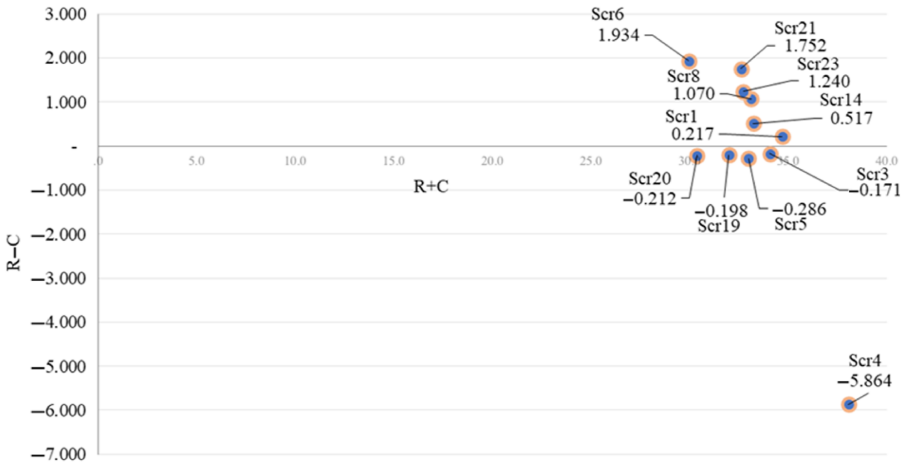
After establishing the criteria weights (Table 6), the causal relationships of the two most prioritized sub-criteria in each of the major barriers/dimensions were evaluated. Upon obtaining the expert assessments' data, Equation (13) was employed to aggregate the assigned weights. In this context, Table 7 presents the results obtained for the barriers using the fuzzy DEMATEL method, categorizing them into two groups, those of cause and those of effect.

Based on Table 7, it was possible to generate Figure 1, which shows the results of the relationships, as well as the classification of each barrier as a cause or effect. As a parameter, when the R-C is negative, the barrier is considered to be an effect barrier, which generally tends to be influenced by barriers with a positive value, classified as a cause, since they are capable of

**Table 7.** Cause and effect of barriers to the SME innovation process

| Barriers | Description of barriers | Group |
|---|---|---|
| Scr1 | Survival of the priority business | Cause |
| Scr6 | Instability of fiscal policies | Cause |
| Scr8 | Lack of qualified personnel | Cause |
| Scr14 | Know-how needed for innovation | Cause |
| Scr21 | Lack of available financing within the company | Cause |
| Scr23 | Access to finance | Cause |
| Scr3 | Supporting great challenges | Effect |
| Scr4 | Company turnover | Effect |
| Scr5 | R&D intensity/per employee | Effect |
| Scr19 | Integration between entrepreneurs' activities with R&D and universities | Effect |
| Scr20 | Lack of information about opportunities for university-industry collaboration | Effect |

**Source(s):** Authors' own work




**Source(s):** Authors' own work

**Figure 1.** Causal diagram of the barriers found

affecting and even giving rise to the other barriers (Wu and Lee, 2007; Zhou *et al*., 2011; Si *et al*., 2018; Addae *et al*., 2019; Khan *et al*., 2019; Schaefer *et al*., 2021). Figure 1 illustrates the causal diagram of the barriers.

Figure 1 shows that there are two groups. The vertical axis shows the R-C values, and the horizontal axis shows the R + C values. According to the results, in the group of barriers considered causes, the barrier with the most significant influence was "Scr6 - Instability of fiscal policies" since it had the highest R−C. Nonetheless, the most important barrier in the cause group was "Scr1 - Survival of the priority business," with the highest R + C. For the effect group, the most important barrier was Scr4 - Company turnover since it had the highest R + C value. Based on this premise, the cause barriers are the ones that affect the other barriers. In this context, SME decision-makers are advised to check these barriers more closely in order to leverage their innovation process (Bongo and Seva, 2023).

## 5. Discussion and implications

Our research findings provide several significant insights into the barriers affecting the innovation processes of Brazilian SMEs. The main barriers faced by Brazilian SMEs are categorized into six distinct groups: "Resistance and Culture," "Infrastructure and Resources," "Governmental," "Knowledge," "Collaboration and Cooperation," and "Financing and Financial." Resistance and organizational culture are critical barriers for SMEs. Resistance to change can inhibit the development of innovations essential for market competitiveness (Lopes *et al*., 2012; Ziviani and Ferreira, 2013). Inadequate infrastructure and high staff turnover also pose significant barriers to innovation in SMEs. The absence of a formal structure and an innovation strategy negatively impacts the performance of these companies (Ziviani and Ferreira, 2013; Massuga *et al*., 2019).

Governmental challenges, represented by fiscal policy instabilities, stand as one of the biggest challenges faced by Brazilian SMEs. Unstable fiscal policies hinder business protection and economic recovery, especially during times of crisis (Martini *et al*., 2013; Cassiolato, 2015).

The lack of qualified personnel and information about technologies and markets, which represent the knowledge category, significantly impedes innovation in SMEs. This knowledge deficit limits these companies' ability to develop new and innovative products and processes (Pacheco *et al*., 2018; Álvarez Jaramillo *et al*., 2019).

The difficulty in managing and maintaining collaborations and forming networks with other companies, small, medium, and large, but also with research institutions, technology, and the public sector in Brazil, as highlighted by Zuniga *et al*. (2016), underlines the importance of collaboration and cooperation between the different players in the market for the success of SMEs' innovation processes. The propensity to collaborate is much weaker in SMEs, with only five percent of innovative companies collaborating with higher education institutes or research organizations, compared to 23% in large companies. The struggle to form and sustain these collaborative networks restricts access to new knowledge and technologies, harming the innovative capacity of SMEs (Zuniga *et al*., 2016; Reinaldo and Pinto, 2023).

For example, Ngugi *et al*. (2010) revealed that relational capabilities are crucial for collaborations between SMEs and their customers, as they facilitate the support and dissemination of innovations. Furthermore, these capabilities assist in implementing actions that result in mutual benefits and, consequently, the co-creation of value. Our analysis revealed that the most influential barrier was "Cr6 - Financing and Financial," as determined through the fuzzy AHP method (Table 6). This finding aligns with prior studies highlighting the substantial resource constraints SMEs face, particularly those in their nascent stages, especially during volatile or unfavorable financial market conditions (Bakhtiari *et al*., 2020). Given the pivotal role that finance plays in the survival and growth of SMEs (Mutsonziwa and Fanta, 2021), it is evident that adequate financial backing is essential for creating an environment conducive to innovation. A decline in financial resource inflow, such as during

the COVID-19 pandemic, can make SMEs vulnerable to market survival (Hossain *et al*., 2022).

The primary challenge for SMEs in Brazil lies in securing sufficient financial resources, particularly in volatile or unfavorable market conditions. Financing plays a crucial role in the survival and growth of SMEs, a fact underscored by their vulnerability during the COVID-19 pandemic (Walter *et al*., 2021; Mer and Virdi, 2024). In the Brazilian context, without significant changes in investments in R&D, the country is poised to continue grappling with severe issues related to innovation, productivity, and economic growth (Leal and Figueiredo, 2021).

Based on the fuzzy DEMATEL method analysis, "Scr6 - Instability of fiscal policies" had the most substantial influence on other barriers. Fiscal policies play a vital role in protecting businesses, stabilizing demand, and facilitating economic recovery (Padhan and Prabheesh, 2021). The study suggests that government support through stable tax policies, investment subsidies, and public investment programs is essential to promote innovation in SMEs in challenging times. Nevertheless, the results also highlighted the scarcity of government stimulus packages as a significant challenge faced by SMEs (Cowling *et al*., 2020; Hossain *et al*., 2022). For Padhan and Prabheesh (2021), fiscal policy can effectively protect people, stabilize demand, and facilitate economic recovery and should support businesses to take care of the informality of the economy. In addition, employment support measures can help encourage a safe return to work and facilitate structural changes for its rapid recovery. Furthermore, studies such as those by Albis Salas *et al*. (2023) suggest that investment in innovation and development can boost the productivity of SMEs more significantly than in large companies. This demonstrates the crucial role that access to adequate investments plays in developing companies of this size.

In Brazil, despite incentives for innovation and development, there is a low production of patents and investments in R&D, particularly in SMEs. Often, existing resources are absorbed by a few large companies with more robust structures, making it difficult for smaller companies to compete for this financing (Menezes Filho *et al*., 2014).

Arenhardt and Simonetto (2023) highlight in their study the importance of access to financing, especially public, in the innovation process of Brazilian SMEs. They found that companies that were finalists for the National Innovation Award use or have used public financing, underlining its importance for developing innovative projects. Additionally, the findings presented by Leal and Figueiredo (2021) suggest that Brazilian fiscal policies must be restructured, as they currently hinder innovation and return on investments due to ineffective structures in the implementation process.

Based on this, it is clear that reform and restructuring are necessary. The results of these research efforts show that the instability of fiscal policies is the biggest barrier to innovation for SMEs in the country. Consequently, fiscal instability creates an environment of uncertainty that discourages investments in new technologies and processes, affecting the innovation drive among Brazilian SMEs due to the perennial fear associated with the risk of investing in innovation.

Moreover, with regard to companies in Brazil, there is a strong dependence on the public sector for innovation, especially regarding financial subsidies. In developed countries, the reality is different, with companies depending less on the state to carry out R&D projects and, consequently, innovate (Memória and Caminha, 2021). As demonstrated in this study, unstable fiscal policies in Brazil strongly affect SMEs, promoting the emergence and exacerbation of other barriers.

Furthermore, it is observed that Brazilian companies tend to purchase more technology than they develop through R&D and make little use of intellectual property mechanisms. Public policies have been ineffective in solving systemic problems and promoting the diffusion of innovation (Nogueira and Oliveira, 2023).

A mechanism created by the federal government in 2005, Law No. 11,196/2005, known as Lei do Bem, offers tax incentives that legal entities can automatically benefit from,

provided they carry out technological research and development of technological innovation in the country. While the tax incentives promoted by the law have increased beneficiary companies' innovative capacity and productivity, improvements are needed. These include the possibility of accumulating R&D incentives for future use and including small companies, which are currently excluded for not adopting the Real Profit regime. Although the effectiveness of the Lei do Bem is recognized, with a continuous increase in benefiting companies, the lack of information and dissemination still prevents wider adoption, especially among small entrepreneurs, contributing to the low innovation rate in SMEs (Nogueira and Oliveira, 2023).

Among the causal barriers identified, "Scr1 - Priority business survival" emerged as the most critical factor. Crises, such as the COVID-19 pandemic, can significantly impact the existence of SMEs, weakening their growth prospects and threatening their projects, thus limiting innovation (O'Reilly and Tushman, 2011; Dhochak and Sharma, 2015). During the COVID-19 pandemic, more than 44% of SMEs went bankrupt in the first month of lockdown, and only 6% had cash reserves to survive a twelve-month period (Assefa, 2023).

To mitigate these challenges, various strategies were identified, including special loans, payment suspensions, release of restricted funds, and tax and penalty exemptions by the government to support the survival of SMEs during crises. Successful responses to crises have also involved strategic innovation in accessing new markets and agile methods, such as changing product offerings or sales channels (Kadenic and Tambo, 2023).

These findings are consistent with the research of Roloff (2023), which identified different patterns of response to crises among entrepreneurs, including strategic innovation and social innovation. Strategic innovation to access new markets can be a successful response to circumvent barriers (Roloff, 2023), as well as the use of agile methods as an instrument to ensure business survival, for example, by changing the market, products, or sales channels (Kadenic and Tambo, 2023).

In Brazil, the quest for survival becomes a paramount concern amidst crises such as the one experienced during COVID-19. Critical factors for SMEs in this context include management and human resource considerations (Pereira and Feitosa, 2022). This preoccupation with survival often causes companies to shy away from the idea of innovating their products, processes, or services. There is a prevalent belief that maintaining the status quo and avoiding change, and by extension, the risks associated with innovation, is the safer route (Al Halbusi *et al*., 2024). This mindset is exacerbated by the high rate of business failures in Brazil, compelling many to focus solely on survival (Bogers *et al*., 2019).

However, managers need to recognize that innovation is a key contributor to an organization's survival. They should remain vigilant for entrepreneurial opportunities that can help them navigate and potentially overcome crises (Mello *et al*., 2010; Alves *et al*., 2023; Cucino *et al*., 2024).

The main effect barrier resulting from the causal barriers in the innovation process of Brazilian SMEs was identified as "Scr4 - Company Turnover." This implies that lower-than-planned sales and operations hinder innovation, even for digital businesses dependent on the sharing economy (Gruia *et al*., 2022). Moreover, our findings demonstrate the importance of maintaining a stable and prosperous business environment to support SMEs' innovation efforts. The economic impact of the COVID-19 pandemic has been evident, with a significant decrease in the number of employers in Brazil during the crisis period (Silva and Moreira, 2022). To overcome such barriers, a robust innovation management strategy is essential, and SMEs can benefit from adopting various tools and methods to foster innovation in their organizations (Zammar *et al*., 2023).

Rezende *et al*. (2020) revealed that companies were compelled to reinvent themselves during the pandemic period to sustain their business volume. In this context, an above-average growth in new e-commerce users was identified, along with the employment of collaborative strategies between small business owners and large virtual retail chains to enhance both sales during the pandemic.

Torres (2021) analyzed the impact of the pandemic on small and medium-sized companies in Brazil and Portugal. Their findings reveal that all companies experienced impacts on their activities and results in various ways. Each one had to adjust its business and operational strategies, with operational activities—particularly logistics and production—being the most affected, necessitating restructuring to adapt to restrictions and changes in demand. To overcome challenges related to business volume, the primary adaptations involved innovation, primarily through the adoption of technological tools, such as online sales and teleworking. The pandemic also spurred technological development due to shifts in the population's consumption patterns.

It is important to note that, among the responses obtained, it is possible to conclude that operational activities were the most impacted for companies. Most interviewees cited the challenges that the pandemic presented to logistics and production activities. These activities were negatively impacted by the need for restructuring to adapt to restriction measures and changes in demand, thus highlighting shifts in operational strategies. The main changes in business and operations strategies were adopting technological tools to aid in executing essential company activities. These changes primarily involved selling to customers through online channels. Another significant point was the adoption of teleworking by most companies. It was also found that the COVID-19 pandemic encouraged companies to pursue technological development due to the alteration in the population's consumption patterns.

This study sheds light on the critical barriers to the innovation process of Brazilian SMEs and provides valuable insights for managers and policymakers. The results underline the importance of eliminating financial obstacles, ensuring stable fiscal policies, and supporting the survival of SMEs during crises in order to promote a conducive innovation environment. In addition, the study emphasizes the need for strategic innovation approaches to access new markets and agile methods to adapt to changing business conditions. Overcoming these barriers can lead to sustainable growth and increased competitiveness for Brazilian SMEs. However, it is essential to consider the unique challenges and opportunities in the Brazilian context to effectively tailor the proposed strategies.

Analyzing various findings, we observe that economies share common challenges among SMEs, as Karadag (2015) demonstrates in his study on Turkish SMEs. Karadag notes several key hurdles, including management capabilities, financial and human resources, and innovation capacity, which significantly hamper the fundamental role these companies play in the economy. A primary issue identified is the lack of innovation due to elevated R&D costs, thus limiting the adoption of modern technologies in SMEs. This finding aligns with those of our study, which suggests high R&D intensity per employee as a core challenge (Scr5).

Moreover, Karadag highlights the obstacles of funding challenges that impede cooperation between the industry and universities (Scr19), a shortage of financial resources within companies (Scr21), and limited access to external finance (Scr23). According to Karadag (2015), a widespread lack of funding is reported in non-OECD economies for small businesses. Additionally, bureaucratic hurdles, such as the complexity and costs of establishing new businesses, remain significant. Therefore, reducing bureaucracy is crucial for fostering entrepreneurship and establishing new ventures (Scr6). Another major obstacle is the deficiency in entrepreneurship and technical skills (Scr14).

Ndiaye *et al*. (2018) found in their analysis of SMEs across 206 economies that policymakers can enhance the growth of SMEs by recognizing that performance determinants vary with the economy's developmental stage. They advocate for tailored approaches rather than a one-size-fits-all policy, emphasizing the need for improved access to finance and enhanced institutional support to allow small businesses and local economies to independently prosper. Policies encouraging formal SME registrations should also be implemented.

Tawakol and Ibrahim (2021) note the long-term necessity of enacting regulations and legal amendments to facilitate SMEs' access to financing and promote liquidity and market growth, especially to mitigate future economic downturns. They stress the importance of simplifying regulations and taxation, suggesting that training on these topics could enlighten entrepreneurs

and enhance performance. Moreover, they recommend that governments foster technology and innovation through increased R&D investment. Countries are encouraged to conduct tailored studies to identify specific informational and support mechanisms for SME growth, ensuring that policies are adapted to the local business environment.

This analysis underscores that understanding and addressing these shared challenges can offer valuable insights for countries aiming to bolster their SME sectors.

## 6. Final considerations

In this research, we explored the challenges facing the innovation journey of Brazilian SMEs, utilizing fuzzy Delphi, fuzzy AHP, and fuzzy DEMATEL techniques. Our contribution to the literature encompasses a comprehensive assessment of 54 innovation-related barriers, structured into six distinct categories. Using the fuzzy Delphi method, we substantiated these categories and barriers through a rigorous quantitative analysis. Following this, the fuzzy AHP method facilitated the ranking of these validated obstacles, while the fuzzy DEMATEL approach identified causative interconnections among the top-priority barriers. This investigation sheds light on pivotal hurdles stalling SME innovation, proffering significant insights for both scholarly and practical domains.

Our analysis underscores that Brazilian SMEs' most significant barrier to innovation is in the "Cr6 - Financing and Finance" category. This finding highlights SMEs' substantial hurdles in securing adequate financial resources, particularly under volatile or unfavorable financial market conditions. To surmount this barrier, SMEs should explore alternative financing avenues, capitalize on digital marketplace opportunities, and embrace smart technologies to reduce costs and bolster innovation potential. This category identified the primary influencing barrier as "Scr23 - Access to Finance."

Turning to the fuzzy DEMATEL analysis results, the barrier exerting the most influence on others was "Scr6 - Instability of Fiscal Policies." However, according to entrepreneurs, the barrier with the highest causal priority was "Scr1 - Survival of the Priority Business." The main barrier identified as having an effect was "Scr4 - Company Turnover." Thus, the findings suggest that the principal barrier confronting SMEs in Brazil is the government's unstable fiscal policy. Conversely, the primary causal factor among the barriers to innovation was maintaining the ongoing operations of the business.

### *6.1 Theoretical, policy, and managerial contributions*

This study offers theoretical and managerial contributions to the field of SMEs by illuminating the challenges Brazilian SMEs face concerning the innovation process. Theoretically, the study provides a comprehensive list of barriers to SME innovation, along with their categorization, thus significantly advancing the literature that explores obstacles to organizational innovation. From a managerial and practical standpoint, the study supplies crucial information to aid decision-making processes.

Regarding the political implications, it is clear that SMEs in Brazil encounter numerous obstacles that impede their innovation processes. Excessive bureaucracy stands as a primary barrier, with the complex tax system and regulatory burdens rendering starting and sustaining a business extremely cumbersome. Additionally, political instability and the absence of consistent, effective public policies supporting innovation create an environment of uncertainty, discouraging investment in new technologies and processes. Corruption and inefficiency within the government further divert resources that could otherwise promote research and development. These factors combined create a scenario where SMEs struggle to compete and innovate, detrimentally affecting the country's economic development.

From an economic development standpoint, the barriers hindering innovation in Brazilian SMEs are critical to the nation's economic health. SMEs constitute a significant portion of the GDP and are key drivers of job creation. When these enterprises encounter innovation

obstacles, their growth is stunted, diminishing competitiveness and productivity. This scenario adversely affects the national economy by limiting the potential for creating new products and services, expanding into new markets, and adapting to global technological advancements. Therefore, eliminating these barriers is vital for fostering a dynamic, resilient business environment to sustain long-term economic growth.

This article is pivotal in addressing the barriers impeding innovation in small and medium-sized enterprises, considering political implications and their impact on economic development in Brazil. Highlighting issues such as bureaucracy, tax burdens, and the lack of effective public policies that create an adverse environment for innovation, the article contributes to a deeper understanding of the challenges faced by SMEs. This insight is crucial for developing more effective governmental programs aligned with the realities of these enterprises, enhancing their growth and, consequently, bolstering the country's economic development. Moreover, the article underscores the necessity for structural reforms that can decrease government inefficiency and foster a more favorable, stimulating business environment for innovation.

Hence, it is clear that the practical implications involving the barriers to innovation faced by SMEs in Brazil are profound, widespread, and significantly impact society by discouraging entrepreneurship and preventing the emergence of new, innovative companies. Consequently, these enterprises struggle to compete in domestic and international markets, negatively impacting the nation's economy. Indeed, public managers must address these challenges, for instance, by implementing structural reforms that simplify bureaucracy, lessen the tax burden, and advocate for effective public policies supporting innovation. These measures would not only enhance the competitiveness and productivity of SMEs but also boost Brazil's economic development sustainably in the long term.

Regarding managerial contributions, the most significant obstacle identified is securing adequate financial resources, especially in volatile financial markets. Managers are encouraged to explore alternative financing options, such as digital marketplaces, crowdfunding, and smart technologies, to reduce costs and enhance innovation capabilities. Fiscal policy instability also presents a considerable challenge. SMEs must engage with policymakers to advocate for stable and supportive fiscal policies. Furthermore, managers should remain informed about regulatory changes and leverage available government support programs to reduce the impact of fiscal instability.

Survival and operational challenges, particularly during economic downturns, are also critical. Strategic innovations, such as accessing new markets, diversifying product offerings, and employing agile methods to adapt to changing conditions, are advisable. Implementing robust risk management practices can aid in navigating through crises. Resistance to change within the organization can significantly hinder innovation; thus, managers should cultivate a culture of continuous improvement and openness to change by promoting employee involvement in innovation and training on new technologies and methodologies.

Inadequate infrastructure and resource constraints also limit innovation potential. Managers should prioritize investments in infrastructure that support innovation, such as modern IT systems and R&D facilities. Collaborating with external partners can help overcome resource limitations. Significant barriers are the absence of qualified personnel and limited knowledge about new technologies. Managers should invest in ongoing training and development programs for their staff and forge partnerships with educational institutions to access the latest knowledge and expertise.

Collaboration with other companies, universities, and research institutions fosters innovation. Managers should actively seek and participate in industry networks, innovation clusters, and collaborative projects to enhance their innovation capabilities. By addressing these barriers with targeted strategies, managers can significantly improve the innovation potential of their SMEs, leading to sustainable growth and increased market competitiveness.

Understanding the causal relationships among barriers can help develop strategies to mitigate them, fostering increasingly innovative products, services, and processes. This, in

turn, contributes to advancing entrepreneurship and innovation across various sectors. The insights generated can also guide public managers and policymakers in formulating strategic investment guidelines to foster innovation and entrepreneurship within SMEs.

The results indicate that the significant barriers identified in this study align with those experienced by other emerging economies, such as Turkey (Karadag, 2015), particularly in terms of accessing investments, streamlining regulations and policies, and encouraging R&D. This finding expands the understanding and contributions of this research.

### *6.2 Limitations*

Despite the promising findings, this study has several limitations. First, it focuses solely on Brazilian SMEs, limiting the generalizability of the findings to different economic, cultural, and regulatory contexts. Second, despite employing robust analytical methods like fuzzy Delphi, fuzzy AHP, and fuzzy DEMATEL, subjectivity in expert opinions could still influence the prioritization of barriers. Third, the study does not explore specific strategies to overcome the identified barriers, leaving room for future research on practical implementation methods.

Fourth, the self-reported data may introduce biases. Although we employed methods to address subjectivity in the evaluation process, it is important to acknowledge the potential for recall and social desirability biases. Fifth, the sample size of respondents may be considered small, which represents a limitation.

Future research avenues are plentiful and could expand upon the current study's findings. In-depth case studies, longitudinal analyses, and comparative studies could provide invaluable insights into the dynamic nature of innovation barriers. Qualitative research methods like interviews and focus groups could offer a deeper understanding of SMEs' experiences and strategies for overcoming innovation obstacles. Moreover, future studies could examine the role of governmental policies in creating a conducive environment for SME innovation, especially in crises. Furthermore, since this research was conducted during the pandemic, it is suggested that it be replicated today to compare the results obtained during and after the pandemic. This comparison could yield valuable insights into the changes following this period. In addition, future research should incorporate data collection and analysis methods that consider the biases mentioned above and try to increase the sample size, which could improve this study.

In conclusion, while the barriers to innovation in Brazilian SMEs pose significant challenges, they also present opportunities for growth and development. By addressing financial constraints, ensuring stable fiscal policies, and fostering a resilient business environment, SMEs can enhance their open innovation capabilities and become more competitive. As Brazil navigates fluctuating economic conditions, investment in innovation and support for SMEs are key drivers for sustainable economic growth. Further research in this area will continue to enrich our understanding, serving as a valuable resource for policymakers, managers, and entrepreneurs looking to bolster the innovation potential of SMEs.

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**Further reading**

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**Supplementary material**

**Table A1.** Barriers to the innovation process

| Barriers | Sources |
|---|---|
| *Cr1- resistance and culture* | |
| 1 - Survival of the priority business | O'Dwyer (2021) |
| 2 - Lack of ambition | Deschryvere *et al.* (2020) |
| 3 - Resistance to change in organizational and operational routines | Gruenhagen *et al*. (2022) |
| 4 - Failure of previous attempts to find a solution | Gruenhagen *et al*. (2022) |
| 5 - Lack of supportive organizational culture | Van Auken *et al*. (2021) |
| 6 - Market dominated by incumbent firms | Valdès *et al*. (2020) |
| 7 - No need for innovation due to previous innovations | Valdès *et al*. (2020) |
| 8 - No need for innovation due to lack of demand | Gruenhagen *et al*. (2022) |
| 9 - Market dominated by established companies | Pellegrino (2018), Radicic (2021) |
| 10 - Increasing innovation disparities | Deschryvere *et al.* (2020) |
| 11 - Supporting great challenges | Deschryvere *et al.* (2020) |
| 12 - Cultural attitudes towards bribery (corruption) | Demirbas *et al*. (2011) |
| 13 - Lack of transparency | Demirbas *et al*. (2011) |
| *Cr2 - infrastructure and resources* | |
| 14 - Company turnover | Demirbas *et al*. (2011) |
| 15 - Company size | Van Auken *et al*. (2021), Demirbas *et al*. (2011) |
| 16 - Limited innovation options | O'Dwyer (2021) |
| 17 - Infrastructure | Kalkvik (2021) |
| 18 - Inadequate standards | Demirbas *et al*. (2011) |
| 19 - R&D intensity/per employee | Demirbas *et al*. (2011) |
| 20 - Insufficient property rights | Demirbas *et al*. (2011) |
| 21 - Support gaps | Deschryvere *et al.* (2020) |
| 22 - Support system complexity | Deschryvere *et al.* (2020) |
| *Cr3 - government* | |
| 23 - Lack of government R&D and technology policy | Deschryvere *et al.* (2020), Demirbas *et al*. (2011) |
| 24 - Excessive government regulation | Gruenhagen *et al*. (2022), Demirbas *et al*. (2011), Valdès *et al*. (2020) |
| 25 - Lack of government support | O'Dwyer (2021), Van Auken *et al*. (2021) |
| 26 - Instability of fiscal policies | Demirbas *et al*. (2011) |
| *Cr4 - knowledge* | |
| 27 - Education (training) for entrepreneurship | Van Auken *et al*. (2021), Demirbas *et al*. (2011) |
| 28 - Lack of qualified personnel | Valdès *et al*. (2020), Pellegrino (2018), Oliveira *et al.* (2022) |
| 29 - Lack of information about technology | Raposo *et al*. (2014), Valdès *et al*. (2020), Pellegrino (2018), Thukral (2021) |
| 30 - Lack of information about the markets | Valdès *et al*. (2020), Pellegrino (2018), Radicic (2021), De Oliveira *et al.* (2022) |
| 31 - Uncertainty about the demand for innovative goods or services | Valdès *et al*. (2020), Pellegrino (2018) |
| 32 - Lack of diversified teams | Deschryvere *et al.* (2020) |
| 33 - Development of skills lagging in the support ecosystem | Deschryvere *et al.* (2020) |
| 34 - Limited managerial skill or qualification | Raposo *et al*. (2014), Thukral (2021) |
| 35 - Know-how needed for innovation | Raposo *et al*. (2014), Thukral (2021) |
| 36 - External sources of deeper knowledge | De Oliveira *et al.* (2022) |

(*continued*)

**Table A1.** Continued

| Barriers | Sources |
|---|---|
| *Cr5 - collaboration and cooperation* | |
| 37 - Difficulty in managing and maintaining collaborations | Gruenhagen *et al*. (2022), Kleiner-Schaefer and Schaefer (2022) |
| 38 - Difficulty in forming networks with companies | Gruenhagen *et al*. (2022) |
| 39 - Cooperation and coordination among organizational units | Van Auken *et al*. (2021) |
| 40 - Sectorial conservatism | O'Dwyer (2021) |
| 41 - Difficulty in finding partners to cooperate in innovation | Valdès *et al*. (2020), Pellegrino (2018) |
| 42 - Integration between entrepreneurs' activities with R&D and universities | Van Auken *et al*. (2021) |
| 43 - Lack of information about opportunities for university-industry collaboration (UIC) | Kleiner-Schaefer and Schaefer (2022) |
| *Cr6 - financing and financial* | |
| 44 - Lack of financial resources | Valdès *et al*. (2020), Thukral (2021), Radicic (2021) |
| 45 - Lack of external financing for the company | Valdès *et al*. (2020), Pellegrino (2018), Oliveira *et al*. (2022) |
| 46 - Lack of available financing within the company | Pellegrino (2018) |
| 47 - Lack of matching private funding | Deschryvere *et al*. (2020) |
| 48 - Lack of financial support for UICs | Kleiner-Schaefer and Schaefer (2022) |
| 49 - Access to financing | Kalkvik (2021) |
| 50 - The cost of innovation is too high | Valdès *et al*. (2020), Pellegrino (2018) |
| 51- Lack of resources for policy implementation | Deschryvere *et al*. (2020) |
| 52 - Specialized venture capital | Oliveira *et al*. (2022) |
| 53 - Better risk analysis of the financial system | Oliveira *et al*. (2022) |
| 54 - The impact of the informal economy on the investment | Demirbas *et al*. (2011) |

**Source(s):** Prepared by the authors

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