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## Innovation and sustainability in the SMEs industries in Brazil

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**Abstract:** This study investigates innovation and sustainability barriers in manufacturing SMEs in Western Paraná State, Brazil. Data were collected via Likert-scale questionnaires from 25 companies across seven sectors and analysed using descriptive statistics and a correlation matrix. Findings reveal that political/economic uncertainty and high initial costs are the primary innovation barriers. Sustainability efforts are mainly hindered by difficulties in measuring financial return and regulatory challenges. Notably, barriers fluctuate based on sector and company size; for instance, micro-enterprises are more sensitive to costs, while medium-sized firms struggle with regulations. The analysis identifies significant correlations between financial constraints in both areas. These results contribute to regional literature and provide a basis for public policies and private strategies aiming at mitigating the obstacles, ultimately supporting the competitive and sustainable development of the regional manufacturing industry.

**Keywords:** innovation barriers; sustainability barriers; small and medium-sized enterprises (SMEs); transformation industry.

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### 1 Introduction

The primary challenge outlined by the 2030 Agenda for Sustainable Development is to eradicate poverty, protect the environment, and promote prosperity and peace. The Agenda establishes the Sustainable Development Goals (SDGs), among which SDG 9 focuses on "industry, innovation, and infrastructure," aiming to build resilient

infrastructures, foster inclusive industrialisation, and drive innovation. The target specifically emphasises the need to modernise industries to make them more sustainable and underscores the importance of strengthening scientific research and increasing the technological capacity of industrial sectors (United Nations [UN], 2015).

In Brazil, industry contributes approximately 24% of the Gross Domestic Product (GDP), with the manufacturing sector alone contributing nearly 13%. Although the industrial sector is of significant economic importance, more than 90% of it is composed of small and medium-sized enterprises (SMEs) (Wu, 2017). These enterprises play a crucial role in the economy, being responsible for 60% of jobs and 20% of the national gross domestic product (GDP) (Pacheco, 2020). In the state of Paraná, about 23% of GDP is generated by the industrial sector (Paraná Institute of Economic and Social Development [IPARDES], 2020), with the West region contributing approximately 15% of the entire state (IPARDES, 2021) and generating almost 12% of all industrial jobs (Federation of Industries of the State of Paraná [FIEP], 2016).

Several studies relate the resilience and growth of SMEs with actions aimed at innovation and sustainability (Brunhera et al., 2015; Fernandes et al., 2023; Franklin et al., 2021; Menezes et al., 2012). However, these enterprises face significant barriers that hinder the implementation of such practices. Identifying and understanding these barriers is vital to developing strategies that can help SMEs implement innovative and sustainable practices (Beyer, 2022).

In the environmental sphere, there is a consensus in the literature on the impact of SMEs on global pollution, resource consumption, and waste generation (Jabbour et al., 2020; Madrid-Guijarro & Duréndez, 2023). The environmental impact of SMEs varies between 60% and 70% (Organisation for Economic Cooperation and Development [OECD], 2018), presenting the need to develop studies around sustainability in this sector.

In innovation, there is a need for studies in the sense of what could discourage and prevent investments or actions aimed at this topic (Martinez-Azúa & Sama-Berrocal, 2022). Even more categorically, considering the points of some authors, is the need for future studies to understand the main barriers to innovation and sustainability faced by companies in Brazil and whether there are relationships between SMEs and these barriers (Jaramillo et al., 2019; Siqueira & Kodama, 2023).

Therefore, considering the financial and economic impact that SMEs have on the global industrial situation, it becomes relevant to understand the main barriers found in these businesses and to provide private and governmental organisations with this information, aiming at channelling efforts to support continuous development.

Considering all the importance of the exposed context, and as a way of directing the study, this research goal is to analyse the barriers to innovation and sustainability in small and medium-sized manufacturing industries in Western Paraná/Brazil

## **2 Theoretical frameworks**

The barriers to innovation can be caused by various situations or reasons (Cordeiro & Vieira, 2012) and can be any factor that negatively influences the innovation process (Hadjimanolis, 2003). The OECD includes economic factors, such as lack of demand and

high costs; specific conditions of companies and sectors, such as difficulty finding qualified personnel; and legislative or legal factors, such as laws and tax burdens (OECD, 2005).

Several other authors also observe types of barriers to innovation (Alshwayat et al., 2022; Cordeiro & Vieira, 2012; Hadjimanolis, 2003; Holzl & Janger, 2014; Maia & Cabral, 2015; Martínez-Azúa & Sama-Berrocal, 2022; Piatier, 1984; Rawindaran et al., 2023; Roldan et al., 2013; Siqueira & Kodama, 2023), however, in general, they tend to be similar those identified by the OECD.

A useful classification is one that, based on the firm, differentiates the barriers between internal and external (Hadjimanolis, 2003). External barriers related to the market refer to the focus on the short term, the low level of ability of companies to account for the possible profits generated by innovations, and the difficulties in obtaining financing. Those related to the government are the bureaucracy, laws and regulations that confuse and hinder the performance of organisations. Finally, the other sources are determined by the lack of cooperation between suppliers, technology obsolescence, corporate and insufficient capital scale (Hadjimanolis, 2005).

On the other hand, internal barriers are related to human management, lack of motivation, lack of skills, personal goals different from those sought by the or, fear of change, among others. Barriers related to structure are characterised by the way management is conducted, especially in relation to the centralisation of power, resistance to change, inadequate communication and failure to seek external knowledge. In the end, those related to strategy refer to a lack of budget, absence of focus on the long term and lack of master plan or strategic planning (Hadjimanolis, 2005).

Barriers to sustainability are classified in four dimensions: structural, political, human, and cultural. The structural dimensions are the organisation's architecture, that is, the way in which the units and branches are designed and managed, as well as their functions, rules, objectives and operating policy. The human dimensions are focused on understanding people, therefore their strengths and weaknesses, their thoughts and emotions, and their fears and anxieties. The political dimensions, and perhaps the most sensitive of them, are related in the way scarce resources are directed, in the competition between internal interests and in the search for advantages and powers. Finally, the cultural dimension, which is beliefs and the ambiguous and chaotic sense with which human beings conduct their lives (Bolman, & Terrence, 2008).

### *Conceptualising the main barriers*

Considering the conditions of business size and cash flow volume of SMEs, the lack of financial resources is widely found as the main barrier to innovation (Auer & Jarmai, 2018; Beyer, 2022) and sustainability (Costache et al., 2021; Mahmood et al., 2019), in all literature. With the lack of financial resources, it is difficult to invest in these practices, in addition to other barriers such as a lack of human resources, lack of a specific area for these activities, among others (Hadjimanolis, 2003).

The lack of technical knowledge or qualification of the workforce is another barrier commonly identified in organisations (Alayón et al., 2022; Auer & Jarmai 2018; Jaramillo et al., 2018; Roldan et al., 2013). In a study carried out in India, Pachouri and

Sharma (2016) concluded that 85% of Indian SMEs understand that their teams are not prepared with adequate knowledge to innovate. They also found that most organisations have less than 10 employees with a technical level on some topic and more than 50% reported not having any scientists or engineers in their business. Considering that it is an emerging country, it is possible that these same conditions are found in its peers (Raghuvanshi & Agrawal 2020).

Considering the size of the business, the reduced number of human resources, and the volume of work that each employee ends up covering in their activities, lack of time becomes a significant barrier for SMEs. Several studies present this barrier as one of its main ones, regardless of the country, the sector or the type of business involved (Baz et al., 2016; Cantele & Zardini, 2019; Neri et al., 2021).

The bureaucracy is a barrier commonly found in emerging countries that are still in full development. These are government laws and regulations that, due to high bureaucracy in place, end up making it difficult for SMEs to invest their resources in innovation and sustainability (Beyer, 2022).

Another barrier found is the high cost of sustainability and innovation, which is the difficulty related to the financial amount to be spent on the development of actions or investments for innovation. It is the perception that the owner or partners have, and that can be an impediment to including the topic in internal discussions or in the strategic planning of companies (Beyer, 2022).

Uncertainties about the future and the economy are also barriers commonly found in companies. Uncertainties that permeate from the institution's own financial health in relation to the future, as well as changes in the political situation, agreements and disagreements of the world economic blocs, wars, among others (Cabral, 2015; Cordeiro & Vieira, 2012).

Resistance to change is also an impediment to investments in innovation and sustainability. This resistance may come not only from company employees, but also from managers and owners, who may not believe that investments in these areas are important, or that they can improve institutional processes, and hinder progress on these issues (Alshwayat et al., 2022; Roldan et al., 2013).

Another barrier identified in this theoretical framework is characterised by the difficulty of measuring the return on investments in innovation and sustainability. Some studies have pointed out that managers stop investing in these topics because they understand that the financial return has a low guarantee or is difficult to quantify (Auer & Jarmai, 2018; Bakos et al. 2019).

Some other barriers commonly found in studies, although less frequently than the previous ones, are: lack of institutional support, lack of profitability, perception of high risk involved, lack of credit availability, highly competitive pressure, lack of information about technologies, lack of research and development, lack of innovative ideas, and lack of demand (Neri et al., 2021; Raghuvanshi & Agrawal, 2019).

All the studies found in the literature review presented an extensive range of barriers to innovation and sustainability, even having a certain similarity despite the differences between the characteristics of these types of investments. Table 1 presents a summarised

scheme of the barriers that were most frequently identified in the results of these articles, as well as the authors and the description of each of them.

**Table 1** Summary scheme of barriers and authors

<i>Barrier</i>	<i>Authors</i>	<i>Description</i>
Lack of financial resources	Alayón et al., 2022; Auer & Jarmai, 2018; Bakos et al., 2019; Beyer, 2022; Caldera et al., 2019; Cantele & Zardini 2019; Costache et al., 2021; Cordeiro & Vieira, 2012; Jaramillo et al., 2018; Madrid-Guijarro & Duréndez 2023; Mahmood et al., 2019; Neri et al., 2021; Oliveira Junior et al., 2021; Steur et al., 2019	Low volume in cash flow generates a conflict of available resources between areas and prevents investment in innovation and sustainability
Lack of technical knowledge or qualification of the workforce	Alayón et al., 2022; Antonioli et al., 2017; Auer & Jarmai, 2018; Beyer, 2022; Cabral, 2015; Caldera et al., 2019; Jaramillo et al., 2018; Mahmood et al., 2019; Oliveira Junior et al., 2021; Roldan et al., 2013	Employees are not prepared to conduct or participate in innovative and sustainable projects
Lack of time	Alshwayat et al., 2022; Caldera et al., 2019; Cantele & Zardini 2019; Madrid-Guijarro & Duréndez 2023; Neri et al., 2021; Steur et al., 2019	Small and medium-sized businesses have a reduced number of employees, who develop activities in several areas with a high volume of work, making it impossible to advance in other topics
Bureaucracy or difficulty with laws and regulations	Auer & Jarmai, 2018; Beyer, 2022; Caldera et al., 2019; Neri et al., 2021; Steur et al., 2019	The difficulty in understanding laws and regulations makes it difficult to invest in the areas of innovation and sustainability
High cost	Antonioli et al., 2017; Beyer, 2022; Cabral, 2015; Cordeiro & Vieira, 2012; Jaramillo et al., 2018;	Company owners understand that investments in innovation and sustainability demand high financial value, so they do not discuss these issues
Uncertainty about the future and economy	Cabral, 2015; Cordeiro & Vieira, 2012;	Political changes, global economic volatility and unpredictability about the future prevent investments in innovation and sustainability
Resistance to change	Alshwayat et al., 2022; Cordeiro & Vieira, 2012; Oliveira Junior et al., 2021; Souza & Faria, 2013; Roldan et al., 2013	Pragmatic employees, managers and/or owners hinder changes in companies and sectors
Difficulty in measuring the return	Auer & Jarmai, 2018; Bakos et al., 2019	The lack of guarantee of return or the inability to quantify it are barriers that prevent investment in innovation and sustainability

Source: Prepared by the author (2024).

The criterion used for the elaboration of this summary was the identification of barriers with frequencies in at least two studies. For example, the "difficulty in measuring return" was a barrier found in the studies by Auer and Jarmai (2018) and Bakos et al. (2019), unlike "lack of profitability", which was identified by only one author among the several verified and, therefore, was not used. This criterion was established due to the need to synthesise the barriers to the construction of the questionnaire, which would be too extensive if this artifice were not performed.

### 3 Research methods

This study adopts a quantitative approach that focuses on descriptive statistical analysis of the data and the verification of correlations between two variables (Eisenhardt, 1989), and is classified as applied research, aiming to identify and address concrete problems (Zanella, 2009). The research is descriptive, aiming to record and describe the characteristics of a phenomenon without directly interfering with it (Prodanov & Freitas, 2013). A survey technique was used to gather data directly from industries.

The research carried out accessibility or convenience sampling. Sampling of this type is characterised by the selection of elements to which the researcher has access, assuming that these elements may be representative of the universe (Gideon, 2012). The sample was selected through convenience sampling from an initial group of 63 industries in Western Paraná/Brazil, served by SEBRAE (Brazilian Micro and Small Business Support Service), representing various cities and industrial sectors.

The choice of 25 industries for analysis was justified based on the regional representativeness and the variety of locations, company sizes, and industrial sectors, for the purpose of the regional context. Similar procedures were conducted in studies in Italy and Germany, which used a sample of 26 industries from the chemical and metallurgy sectors to represent SMEs to identify barriers to sustainability (Neri et al., 2021), and in Australia, which researched the barriers to sustainability with 20 SMEs representing the Queensland region of Australia (Caldeira et al., 2019).

Table 2 shows the 25 companies participating in the survey, as well as the city in which it is established, the respondents' position and the sector in which it operates.

**Table 2** Summary table of sampling

<i>ID</i>	City	Respondent Job Title	Industry
1	Cafelândia	Supervisor	Foods
2	Marechal Cândido Rondon	Supervisor	Foods
3	Marechal Cândido Rondon	Supervisor	Drugs
4	Marechal Cândido Rondon	Owner	Metallurgy
5	Cascavel	Owner	Furniture
6	Cascavel	Owner	Furniture
7	Céu Azul	Supervisor	Foods
8	Céu Azul	Supervisor	Foods
9	Cascavel	Owner	Chemists
10	Toledo	Manager	Foods
11	Toledo	Owner	Foods

12	Toledo	Manager	Metallurgy
13	Foz do Iguaçu	Owner	Hygiene and cleanliness
14	Cascavel	Owner	Metallurgy
15	Cascavel	Owner	Metallurgy
16	Marechal Cândido Rondon	Owner	Furniture
17	Cascavel	Owner	Metallurgy
18	Cascavel	Owner	Furniture
19	Cascavel	Owner	Chemists
20	Toledo	Manager	Metallurgy
21	Cascavel	Manager	Chemists
22	Cascavel	Supervisor	Chemists
23	Cascavel	Owner	Hygiene and cleanliness
24	Toledo	Manager	Metallurgy
25	Cascavel	Owner	Textile

Source: Survey data.

### Questionnaire

The research technique used was direct observation through the application of a questionnaire without the presence of the researcher. The questionnaire is sent directly to the informant who, agreeing with the terms provided, responds to the investigator (Marconi & Lakatos, 2010). Table 3 shows the data collection instrument used and the appropriate references. The barriers to innovation were grouped according to the classification of Hadjimanolis (2003), while the barriers to sustainability were grouped according to the classification of Bolman and Terrance (2008), both previously detailed, and described according to studies from the literature review as follows.

**Table 3** Aspects covered and references

<i>Introductory questions</i>		
Sectorization	City, position and sector of activity	
Company size	Number of employees and management	
<i>Barriers to innovation (Hadjimanolis, 2003)</i>		
Strategy-related	Lack of financial resources	Antonioli et al.,2017; Auer & Jarmai, 2018;
	High initial cost	Beyer, 2022; Cordeiro, & Vieira, 2012;
Structure-related	Lack of time	Alshwayat et al.,2022; Antonioli et al.,2017; Auer & Jarmai, 2018;
		Beyer, 2022; Cabral, 2015; Roldan et al.,2013;
Related to people	Lack of technical knowledge or qualification	Alshwayat et al., 2022; Antonioli et al.,2017;
	Resistance to change	Auer & Jarmai, 2018; Beyer, 2022; Cabral, 2015; Roldan et al.,2013;
Government-related	Laws and regulations	Auer & Jarmai, 2018; Beyer, 2022; Martínez-

		Azúa, & Sama-Berrocal, 2022; Khani et al., 2023
Market-Related	Difficulty in measuring the return	Auer & Jarmai, 2018;
	Uncertainties about the future and/or economy	Cabral, 2015; Cordeiro & Vieira, 2012;
<i>Barriers to sustainability (Bolman and Terrance, 2008)</i>		
Political dimensions	Lack of financial resources	Alayón et al.,2022; Bakos et al.,2019; Caldera et al.,2019; Cantele & Zardini, 2019; Costache et al.,2021; Steur et al.,2019; Jaramillo et al.,2018; Madrid-Guijarro & Duréndez, 2023; Mahmood et al.,2019; Neri et al.,2021; Oliveira Junior et al.,2021;
	High initial cost	Jaramillo et al.,2018;
	Lack of time	Caldera et al.,2019; Cantele & Zardini, 2019; Steur et al.,2019; Madrid-Guijarro & Duréndez, 2023; Neri et al.,2021;
	Lack of technical knowledge or qualification	Alayón et al.,2022; Caldera et al.,2019; Jaramillo et al.,2018; Mahmood et al.,2019; Neri et al.,2021; Oliveira Junior et al.,2021;
Human dimensions		
	Laws and regulations	Bakos et al.,2019; Caldera et al.,2019; Steur et al.,2019; Neri et al.,2021;
Cultural dimensions	Resistance to change	Oliveira Junior et al.,2021;
Structural difficulties	Difficulty in measuring the return	Bakos et al.,2019;
	Uncertainties about the future and/or economy	Cabral, 2015; Cordeiro & Vieira, 2012;

Source: Prepared by the author (2024).

Questions were elaborated using the Likert agreement scale, a unified scale, making it possible to identify meaning and intensity in each item (Lucian & Dornelas, 2015). The answers were ranged as: I totally disagree with value 1, I disagree with value 2, I am indifferent with value 3, I agree with value 4, and I totally agree with value 5.

To verify the effectiveness of the questionnaire, a previous test was conducted in the first two companies interviewed, and the professionals presented positive feedback regarding

the clarity of the questions, the construction of the questionnaire and the speed of conclusion.

#### *Data collection procedures and analysis*

Data collection occurred between October and November 2024, using Google Forms and a messaging tool to improve the response rate. The resulting sample produced a margin of error of 19.5%, slightly higher than the ideal estimate. However, the sample size was considered representative for the study, and as all questionnaires were answered in their entirety, there was no need for exclusion.

As a way of comparing with the research carried out and presented in the theoretical framework, descriptive statistics were used for data analysis. In this case, Barbetta (2010) was the main reference in the development of calculations of proportions, percentages, standard deviation, average, mode and other methods of exploratory data analysis.

After the average of the answers for each item, the barriers were ordered through the grading scale, with values close to 5 indicating a greater tendency towards a given barrier, values close to 1 indicating less relevance. After identifying the means for each item, the barriers were ordered from highest to lowest, as a form of subsequent comparison and verification of correlation between them.

To verify whether there is a relationship between the barriers to innovation and the barriers to sustainability, a correlation analysis was performed using a correlation matrix. The main measure used to quantify this relationship is Pearson's correlation coefficient ( $r$ ), which ranges from -1 to 1. An  $r$ -value close to 1 indicates a strong positive correlation, close to -1 a strong negative correlation, and close to 0 means that there is no significant linear correlation between the variables. The associated  $p$ -value ( $p$ -value) tests the statistical significance of the correlation. A  $p$ -value below 0.05 is considered indicative of a statistically significant correlation. These indicators are fundamental to understanding whether the variables are associated in a relevant way (Field, 2013).

## **4 Results and analysis**

The results of descriptive statistics for the barriers to innovation are presented in Table 4.

**Table 4** Results of barriers to innovation

<i>Barriers to Innovation</i>	<i>Average</i>	<i>Standard deviation</i>	<i>Variance</i>
Lack of financial resources (FRF)	3,64	1,11	1,22
Lack of technical knowledge (FCT)	3,24	1,08	1,2
Lack of time (FT)	2,64	1,1	1,13
Laws and regulations (DLR)	3,32	1,27	1,43
High Initial Cost (ACI)	3,88	0,86	0,72
Political and/or economic uncertainties (IPE)	3,96	0,93	0,84
Resistance to change (RM)	2,92	1,3	1,71
Difficulty measuring return (DMR)	3,36	1,17	1,4

Source: Survey data.

The barrier that presented the highest average on the scale, according to the industries collected, is related to Political and/or economic uncertainties with 3.96. Among other things, the main impediment that promotes greater influence on the entrepreneur's decision when it comes to investments in innovation occurs due to the difficulty of understanding and clarity of the conduct of the rulers and the economic future of the country and the planet. The political and/or economic uncertainty is also present in small and medium-sized enterprises in Portugal (Cordeiro & Vieira, 2012) and in the state of Ceará in the Brazilian scenario (Cabral, 2015).

Regarding the financial condition, it is noted that the next two barriers enter this context, with the high initial cost and the lack of financial resources completing the three main barriers identified with 3.88 and 3.64 average, respectively. It is also noted that the high initial cost was the barrier that presented the lowest standard deviation and variability of the data. The high initial cost for innovation and the lack of financial resources are also highlighted in studies involving companies in other countries such as Portugal (Cordeiro & Vieira, 2012), France (Antonioli et al., 2017) and Poland (Beyer, 2012).

It is important to highlight that the lack of time is a condition that is not relevant for small and medium-sized manufacturing industries in the Western region of Paraná. With an average of 2.64, this barrier was the least important in the study, adding up to almost 60% of the total number of respondents who disagree and totally disagree that this is an important impediment to investments in innovation in their businesses. This result corroborates the studies found in the theoretical framework for innovation, where it is pointed out only in the study in a financial institution in Jordan (Alshwayat et al., 2022).

**Table 5** Top barriers to innovation by sector

<i>Sector</i>	<i>Main barrier</i>	<i>Average</i>
Metallurgy	Lack of financial resources	4,29
Foods	Political and/or economic uncertainty	3,8
Chemists	High initial cost	3,75
Furniture	Political and/or economic uncertainty	4,75

Source: Survey data.

It is observed that the small and medium-sized manufacturing industries of the Food and Furniture sectors, as well as the global result, presented political and/or economic uncertainties as the main barrier to investment in innovation. The metallurgy sector, which represents 28% and the largest share of the sample, pointed to the lack of financial resources as the main impediment to investments in innovation, with an average of 4.29. The chemical sector also presented a financial context in its results and had as its main barrier the high cost of innovation. The other sectors had a smaller number of respondents, which could affect the robustness of the analysis, so they were not considered.

The difference in barriers observed between sectors can be explained by the nature of the industries and the type of innovation that each one requires. The metallurgical sector involves greater dependence on more expensive machinery, equipment and production technologies, which may explain the lack of financial resources as a major barrier (Dangelico & Pujari, 2017). The food and furniture sector may be more impacted by external factors, such as political and economic instability, since these industries are strongly influenced by consumption policies, government regulations, and fluctuations in

the population's purchasing power (Rodrigues & Silva, 2020). The chemical sector deals with the need for high investments in research and development to innovate, which justifies the high initial cost as a barrier (Silva & Oliveira, 2018).

**Table 6** Main barriers to innovation by size

<i>Size</i>	<i>Main barrier</i>	<i>Average</i>
Micro	Political and/or economic uncertainty	4,15
Small	High initial cost	4,17
Medium	Lack of financial resources	4,00

Source: Survey data.

Political and/or economic uncertainties are the main impediment to investments in innovation in micro companies in the Western region of Paraná. Financial conditions appear in small and medium-sized companies, where the high initial cost for innovation and the lack of financial resources, respectively, were more relevant.

Microenterprises are more impacted by political and economic uncertainties due to their vulnerability and lack of adaptability (Figueiredo & Silva, 2020). Small companies face barriers related to the high initial cost for innovation, as they have financial difficulties to invest in new processes or technologies (Carvalho & Pinto, 2019). Medium-sized companies, on the other hand, mainly deal with a lack of financial resources, because, although they have more structure than small companies, they still do not have the same access to capital as large companies, which limits their ability to innovate (Lopes & Santos, 2021). These barriers vary according to the size of the company due to its differences in financial capacity, access to resources, and sensitivity to external factors (Foss & Knudsen, 2019).

Therefore, the main barriers that prevent investments in innovation involving micro, small and medium-sized manufacturing industries in the Western region of Paraná are: political and/or economic uncertainties, high initial cost for innovation and lack of financial resources. These results can be explained by a combination of economic, structural, and institutional factors.

The descriptive statistics were also used to evaluate the responses obtained from the barriers to sustainability.

**Table 7** Sustainability Barriers Results

<i>Barriers to Sustainability</i>	<i>Average</i>	<i>Standard deviation</i>	<i>Variance</i>
Lack of financial resources (FRF)	3,36	1,31	1,71
Lack of technical knowledge (FCT)	3,00	1,23	1,39
Lack of time (FT)	2,92	1,26	1,49
Laws and regulations (DLR)	3,64	0,95	0,81
High Initial Cost (ACI)	3,64	1,04	1,13
Political and/or economic uncertainties (IPE)	3,08	0,85	0,72
Resistance to change (RM)	3,04	0,97	0,93
Difficulty measuring return (DMR)	3,72	1,01	0,97

Source: Survey data.

Different from what was identified in the results of the barriers to innovation, there is a different scenario for sustainability, and the main difficulty encountered by small and medium-sized industries in the region to invest in sustainability is caused by the difficulty of measuring the return for this type of investment, with an average of 3.72. It is also noticed that this barrier presented one of the lowest variances when compared to the eight studied, with 0.97, which leads us to conclude the low variability among the respondents and greater consensus among them.

The main barrier found for investments in sustainability in small and medium-sized manufacturing industries in the Western region of Paraná is not restricted to this location alone. The difficulty of measuring return on investments is widely discussed in the scientific community (Friede et al., 2023).

It is noted that, compared to the results obtained for innovation, the barriers to sustainability were closer to the main ones identified, including the difficulties with laws and regulations having the same relevance as the high initial cost for investments in sustainability, both with 3.64 and very close to the 3.72 difficulty in measuring the financial return.

Similarly to what was observed in the barriers to innovation, the lack of time was shown to be the barrier that has the least relevance for the respondents in the Western region of Paraná, presenting an average of 2.92, a factor different from that previously found in which several verified articles point to this barrier as important in companies.

**Table 8** Sustainability barriers results by sector

<i>Sector</i>	<i>Main barrier</i>	<i>Average</i>
Metallurgy	Difficulty in measuring the return	3,57
Foods	Difficulty in measuring the return	4,17
Chemists	Difficulties with laws and regulations	4,00
Furniture	High initial cost	4,00

Source: Survey data.

The sector with the highest percentage among the respondents, the metallurgical sector, presented as the main barrier the difficulty in measuring the financial return on investments in this direction, as well as the second largest respondent sector, the food sector. For the chemical sector, the main barrier is the difficulties with laws and regulations involving sustainability, and the furniture sector presented the high initial cost as the main impediment to investments in this area.

As discussed in the barriers to innovation, the differences in barriers to sustainability between sectors can be explained by the specific characteristics of each one. In the metallurgical and food sector, the difficulty in measuring the financial return of sustainable initiatives is related to the complexity and long-term nature of the impacts, such as the reduction of waste or energy consumption, which are not always immediately reflected in finances (Oliveira & Almeida, 2018).

As for the chemical sector, companies face barriers due to the high complexity of environmental regulations, which require compliance with strict standards and are expensive to implement, representing a greater challenge for small and medium-sized companies (Pereira & Costa, 2020). In the furniture sector, the high initial cost to adopt

sustainable practices, such as investing in eco-friendly materials and efficient production technologies, represents a significant obstacle, especially when there are no immediate guarantees of financial return (Silva & Martins, 2019).

**Table 9** Main barriers to sustainability by size

<i>Size</i>	<i>Main barrier</i>	<i>Average</i>
Micro	High initial cost	3,92
Small	Difficulty in measuring the return	4,17
Medium	Difficulties with laws and regulations	3,17

Source: Survey data.

The results of the size profile for each company showed a distinction between them. Respondents from micro companies pointed out that the high initial cost is a significant barrier to this size of business. In the case of small companies, the main barrier is the difficulty in measuring the financial return obtained from investments in this area, while difficulties with laws and regulations were the main impediment reported by respondents from medium-sized companies.

What may explain these results in terms of size is that microenterprises generally face more severe financial barriers, which makes them more sensitive to the initial costs of sustainable practices, such as cleaner technologies or environmental certifications (Duarte & Oliveira, 2017). Small companies, on the other hand, despite having greater operating capacity, deal with the difficulty of measuring the financial return on investments in sustainability, especially due to the lack of clear metrics and the long-term benefits (Silva & Lopes, 2019). Medium-sized companies, in turn, face greater challenges with environmental regulations due to the complexity of the legislation and the need to adapt their processes to comply with environmental standards, often without having the financial flexibility that large companies have (Pereira & Costa, 2020).

#### *Relationship between barriers to innovation and sustainability*

Considering that the main barriers to innovation and sustainability have been previously identified and analysed, it is possible to achieve the last objective established in this research, which seeks to verify the existence of a relationship between the two types of barriers obtained in data collection.

Thus, it was decided to use a simple linear regression statistical method as a way to determine the correlation coefficient, but also to conduct a comparative analysis between the results found. Thus, the following table presents a column in which the barriers are ordered according to the level of agreement indicated by the respondents.

**Table 10** Comparison Table Between Barriers to Innovation and Sustainability

<i>Innovation</i>	<i>Average</i>	<i>Sustainability</i>	<i>Average</i>
Political and/or economic uncertainties	3,96	Difficulty measuring return	3,72
High initial cost	3,88	Difficulties with laws and regulations	3,64
Lack of financial resources	3,64	High initial cost	3,64
Difficulty measuring return	3,36	Lack of financial resources	3,36

Difficulties with laws and regulations	3,32	Political and/or economic uncertainties	3,08
Lack of technical knowledge	3,24	Resistance to change	3,04
Resistance to change	2,92	Lack of technical knowledge	3,00
Lack of time	2,64	Lack of time	2,92

Source: Survey data.

In comparison, there is a low relationship between the main barriers to innovation and sustainability, while there is a divergence in the type and level of agreement between each of them. With political and/or economic uncertainties being the main innovation barrier, it reached only 5th place in the average score in barriers to sustainability. Similarly, the difficulty of measuring financial return, which obtained the highest average level of agreement in the answers for sustainability, presented only the 4th highest value among the barriers to innovation.

However, it should be noted that, considering the four main barriers identified for innovation and sustainability, three are present in the top positions of both: high initial cost (2nd position in innovation and 3rd position in sustainability), lack of financial resources (3rd position in innovation and 4th position in sustainability) and the difficulty of measuring the return (4th position in innovation and 1st position in sustainability). In addition, the last position, that is, those that respondents understand to be less relevant, is the same for both innovation and sustainability, which is the lack of time. Therefore, it is necessary to consider, at least in a comparative way, a possible relationship between them.

**Table 11** Summary diagram with the main correlations

Barriers to Innovation	Barriers to Sustainability	p value	r Pearson
Lack of time	Lack of time	< 0.001	0,657
Resistance to change	Resistance to change	< 0.001	0,631
High initial cost	Lack of financial resources	< 0.001	0,631
High initial cost	High initial cost	< 0.001	0,623
Resistance to change	Political and/or economic uncertainties	< 0.01	0,606
Lack of technical knowledge	Political and/or economic uncertainties	< 0.01	0,599
Lack of financial resources	Lack of financial resources	< 0.01	0,588
Difficulty measuring return	Difficulty measuring return	< 0.01	0,586
Lack of time	Lack of financial resources	< 0.01	0,579
Lack of technical knowledge	Resistance to change	< 0.01	0,576
Difficulty with laws and regulations	Difficulty with laws and regulations	< 0.01	0,566
Lack of technical knowledge	Lack of technical knowledge	< 0.01	0,561
Difficulty measuring return	Lack of time	< 0.01	0,540

Source: Survey data.

Table 11 shows a filter with the main correlations between barriers to innovation and sustainability, with Pearson's r values higher than 0.500. It is noted that there is coherence

in the application of the test, observing the barriers that presented the greatest strength of correlation between them, with lack of time, resistance to change and high initial cost being present and correlated between innovation and sustainability, which may suggest conviction on the part of the respondents to follow a certain uniformity of the level of similar agreement between them.

There is also a correlation between the high initial cost barrier to innovation and the lack of financial resources for sustainability, suggesting that financial conditions may present a similar level of agreement to the respondents regarding the evaluation of the accounting situation of companies regarding investments in innovation and sustainability. In total, considering all combinations in which the p-value was less than 0.05, there were a total of 26 correlations between the barriers to innovation and sustainability.

Therefore, considering the results obtained in the identification of the main barriers to innovation and sustainability, as well as the elaboration of the correlation matrix between all variables, the study can verify, highlighting all the limitations and considerations made, that there may be a correlation between the barriers to innovation and sustainability in small and medium-sized manufacturing industries in the Western region of Paraná.

## **5 Final considerations**

The goal of the research was to analyse the barriers to innovation and sustainability in small and medium-sized manufacturing industries in Western Paraná/Brazil, from a survey of the main barriers with a sample of 25 SMEs from different sectors and cities in the region.

The results revealed that the three primary barriers to innovation in small and medium-sized manufacturing industries in Western Paraná are: political and/or economic uncertainties, high initial costs for innovation, and the lack of financial resources. For sustainability, the three primary barriers identified were: difficulty in measuring financial return, challenges with laws and regulations, and high initial costs.

The results also demonstrated that there are variations in the main barriers encountered by companies based on their industrial sector and size. Chemical industries identified high initial costs as a barrier to innovation, while the food sector highlighted political and/or economic uncertainties as the most significant challenge. For sustainability, the chemical sector pointed out difficulties with laws and regulations as the main barrier, whereas the food sector emphasised the challenge of measuring returns as the principal impediment to sustainable practices.

Differences were also observed depending on the size of the companies. Small manufacturing industries understand that the high initial cost is the main barrier to innovation, and the medium ones point to the lack of financial resources as the main impediment. In sustainability, small companies have the difficulty of measuring return as the main barrier, while difficulties with laws and regulations are verified in medium-sized manufacturing industries in the region.

Finally, performing a comparative analysis between the main barriers identified for innovation and sustainability, it was concluded that there may be a correlation between

some barriers, considering that the analysis pointed out 26 significant combinations based on Pearson's p-value and r results. Issues such as a lack of time, resistance to change, and high initial costs are present and correlated in innovation and sustainability, suggesting that respondents perceive these issues in a similar manner across both categories. Additionally, there is a correlation between the high initial cost for innovation and the lack of financial resources for sustainability, indicating that the financial condition of respondents is a key factor in both innovation and sustainability decisions

This research contributes to the advancement of knowledge by identifying and comparing local barriers with evidence from international studies, broadening the understanding of the particularities faced by these industries in specific regional contexts. In addition, by presenting a correlation between barriers to innovation and sustainability, this study contributes to a more holistic and interdependent analysis of the challenges that small and medium-sized industries face.

The research offers a practical approach, enabling the findings to be transformed into actions to mitigate barriers in the industries and sectors analysed, and provides guidelines that can be applied in other regions with similar characteristics in industrial development, innovation, and sustainability. Furthermore, the study enables the creation of more targeted public policies and private initiatives, with a focus on overcoming the specific challenges that industries face. The discussions presented could support the managers of local companies, helping them to adopt more efficient strategies adapted to the regional reality and improve their competitiveness and long-term sustainability, strengthening the regional industrial ecosystem and promoting a more favourable environment for sustainable growth and innovation.

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