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Sustainable innovation practices and their relationship with the performance of industrial companies

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Abstract

Purpose – Conditioning factors of the globalized world have created new requirements and opportunities in developing management models for organizations that englobe sustainability aspects, which presume substantial investments in innovation. Therefore, the purpose of this paper is to analyze the relation between sustainable innovation practices and the performance of industrial companies.
Design/methodology/approach – This was a quantitative study and carried out by applying a research survey in Brazilian industrial companies.
Findings – The results showed that there are significantly positive associations between several variables related to sustainable innovation practices and company performance, being, therefore, possible to confirm the original proposed hypothesis.
Research limitations/implications – The main limiting factors were theoretical choices, comprehension of the phenomenon through the perception of the respondents, and the number of companies in the sample, as little representation was found in the researched population. In this manner, the results cannot be applied to the universe of considered research, being restricted solely to the group of companies in the sample.
Practical implications – From the main contributions, it is possible to highlight, at a theoretical level, the joint approach to issues of sustainable innovation and performance, since there are few studies covering the impact of adopting innovation practices on company performance. At a practical level, understanding of how the behavior of Brazilian industrial companies contributes to the wide distribution of practices that may contribute to better business performance and generate competitive advantages.
Social implications – At a social level, understanding of the benefits in adopting sustainable innovations practices favors the minimization of negative socio-environmental impacts.
Originality/value – By analyzing the themes of sustainable innovation and industrial performance, the present study may contribute to adopting business behavior that strategically and systemically integrates the objectives of sustainable innovation.

Keywords Sustainable innovation, Business performance
Paper type Research paper

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1. Introduction

The patterns of production and consumption have changed substantially in the last decades, leading to transformations in society and in the environment, and creating demands and constraints for companies, so that competitiveness is increasingly related to the adoption of innovation management that includes sustainability.

Hence, companies have realized the importance of adopting sustainable innovation practices in order to minimize negative social and environmental impacts that result from their activities and, consequently, achieve superior corporate performance. Legislation and the society itself are demanding from organizations that innovation in products, services, processes and business models be accompanied by the responsibility for sustainable development.

Dyck and Silvestre (2018) observe that there is an increasing awareness of society to find solutions for dealing with socio-environmental crises through the adoption of more sustainable lifestyles. A key factor for this confrontation is to implement innovations that promote sustainable development.

Sustainable innovation is the creation of something new that improves performance in the three dimensions of sustainable development: social, environmental and economic. Such improvements are not limited to technological changes, and may relate to changes in processes, operational practices, business models, thinking and business systems (Szekely & Strebel, 2013).

According to Adams, Jeanrenaud, Bessant, Denyer and Overy (2016), sustainability-oriented innovation relates to changing philosophy and organizational values, as well as products, processes or practices, in order to attain the specific purpose of creating and realizing social and environmental value, beyond economic returns.

From the above mentioned information, we can see that sustainable innovation refers to a company's strategic and systematic attitude regarding economic, social and environmental aspects, and not only to isolated actions, such as the development of new environmentally responsible processes and products.

The adoption of sustainable innovation practices can affect business performance. Several studies, such as those by Gunday, Ulusoy, Kilic and Alpkan (2011), Lopez-Valeiras, Gomez-CondeC and Naranjo-Gil (2015) and Wagner (2010), have linked the results of investments in sustainable innovation to business performance.

Sustainable innovation contributes to business sustainability, since it has a potential positive effect on a company's financial, social and environmental performance (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013).

For Lopez-Valeiras *et al.* (2015), there is an increasing interest at the academic, business and political level regarding the relationship between sustainable innovation and business performance. These authors highlight the need for studies that provide more evidence on this link. Although literature suggests that the management of sustainable innovation can be an important source of benefits for companies, empirical results are still not conclusive.

Thus, in view of the importance of sustainable innovation for the competitiveness of companies and its potential relationship with business performance, the main question of this research is:

RQ1. How does the adoption of sustainable innovation practices relate to the performance of industrial companies?

By addressing these topics, this study can foster the adoption of a business behavior that integrates the goals of sustainable development in a strategic and systemic way.

In spite of their relevance, studies that seek to verify the relationships that are intrinsic to these subjects, as well as the implications for management with regard to the competitiveness of Brazilian companies, are still incipient. In this sense, the results of this research lead to the identification of important elements for the development of this

knowledge area, with a significant contribution to the country's scientific production, as well as to a reflection on business practices.

This paper is structured in six sections, besides this introduction. Sections 2, 3 and 4 present the theoretical contributions and Section 5 describes the methodological procedures. Subsequently, we present the analysis and discussion of results, followed by the final remarks.

2. Sustainable innovation practices

Sustainable innovation can contribute to organizations' competitive advantage, since sustainability has led companies to a prominent position before stakeholders. For Schaltegger, Lüdeke-Freund and Hansen (2016), business activities are responsible for many environmental and social problems; therefore, concerns toward sustainability are of critical importance.

For Dyck and Silvestre (2018), the world's awareness of social and ecological crises has grown, bringing the need for more sustainable lifestyles. Organizations have a critical role in facing these crises, by implementing innovations that promote sustainable development.

According to Charter and Clark (2007), there is not a single established concept for sustainable innovation, which reflects the difficulty to define sustainability and sustainable development. However, despite this conceptual trouble, there is an emerging recognition that sustainable innovation is related to entrepreneurship and to new concepts, technologies, products and services, as well as to the adoption of new processes and social systems.

The authors emphasize that, although the terms sustainable innovation and eco-innovation are often used as synonyms, eco-innovation only addresses the environmental and economic dimensions, while sustainable innovation also comprises ethical and social aspects. For Boons, Montalvo, Quist and Wagner (2013), sustainable innovation goes beyond eco-innovation by including social objectives, and refers more clearly to the holistic and long-term process of sustainable development.

Siqueira and Pitassi (2016) state that sustainability-oriented innovation is a wider concept than eco-innovation, since it encompasses the social dimension and is a multilevel phenomenon that requires three major forces for its promotion: at the macro level: government policies and actions that overcome the immense risks involved in radical innovations; at the company level: the development of new business models; and at the individual level: changes in people's cognitive mechanisms, attitudes and behaviors.

Szekely and Strebel (2013) define sustainable innovation as the creation of something new that improves performance in the three dimensions of sustainable development: social, environmental and economic. Such improvements are not limited to technological changes, and regard changes in processes, operational practices, business models, thinking and business systems.

Hansen, Grosse-Dunker and Reichwald (2009) observe that sustainability-oriented innovation is a tool that covers both sustainability issues and the inclusion of new customer and market segments, thus adding a positive value to the firm's global capital.

Hence, the great challenge for organizations is to innovate through the perspective of sustainable development, by adding value to products and processes and contributing to minimize socio-environmental impacts that result from industrial activity.

A company can implement incremental or radical sustainable innovations. However, in practice, most firms' sustainable innovations are incremental. This is due to the difficulty of organizations to go beyond incremental levels, because there is not a large market for sustainable products and services yet. Social changes are necessary to value these products and services (Charter & Clark, 2007).

For Boons (2009), sustainable innovations need to go beyond incremental levels, since sustainable development requires the change of production and consumption systems. Thus, sustainable innovation needs to cross the business environment and be valued by society, so that companies can invest in levels of radical innovation, building a new logic toward sustainability.

In order to evaluate and structure the effects of sustainable innovations, Hansen *et al.* (2009) propose a generic model called the Sustainability Innovation Cube (SIC), which includes three dimensions: target, life cycle and types of innovation. The target dimension explores the concept of the Triple Bottom Line, by distinguishing the economic, environmental and social effects of innovations. The life cycle dimension relates to the effects of products and technologies in the different stages of their life cycles. The types of innovation dimension consider technological innovations of products or processes, innovations in business models and product-service systems (PSS). Considering the possible intersections of these dimensions, the model has 27 individual areas that show the moment when the potential effects of sustainability emerge.

Through the three dimensions of the generic model – target, life cycle and types of innovation – Hansen *et al.* (2009) identified practical implications for the management of sustainable innovation, represented by the following categories: integration of the sustainability criterion; integration of stakeholders and users; expansion of the PSS; targeted marketing for sustainable innovation; and sustainability awareness.

Bocken, Short, Rana and Evans (2014) suggest a set of sustainable business model archetypes, in order to develop a common language that can accelerate the development of sustainable business models in research and practice. They identified several examples of mechanisms and solutions that can contribute to the innovation of business models for sustainability, based on a review of literature and business practices. They proposed eight archetypes, grouped in the dimensions of technological, social and organizational innovation, to describe mechanisms and solutions that can contribute to sustainability: to maximize material and energy efficiency; to create value from waste; to substitute by renewable and natural processes; to deliver functionality instead of ownership; to adopt a leadership role; to encourage sufficiency; to adapt businesses to society and environment; and to develop a scale of solutions. Table I presents this proposal.

Innovation	Archetypes	Definition
Technological	To maximize material and energy efficiency	To do more with fewer resources, creating less residues, emissions and pollution
	To create value from waste	The concept of "waste" is removed, by changing existing waste flows into useful and valuable contribution for another production, and making better use of underutilized capacity
	To substitute by renewable and natural processes	To reduce environmental impacts and increase business resistance, by identifying resource limitations associated to non-renewable resources and current production systems
Social	To deliver functionality instead of ownership	To provide services that meet users' needs, without physical products
	To adopt a leadership role	Proactive involvement with interested parties, in order to ensure long-term healthcare and welfare
	To encourage sufficiency	Solutions that actively seek to reduce production and consumption
Organizational	To adapt businesses to society and environment	To prioritize the delivery of social and environmental benefits, instead of maximizing economic profit (i.e. the interested party's value), through a close collaboration between the company and local communities and other interested parties. The traditional business model, where the customer is the main beneficiary, may change
	To develop a scale of solutions	To provide sustainable solutions on a large scale, in order to maximize benefits for society and the environment

Source: Adapted from Bocken *et al.* (2014)

Table I.
Innovation archetypes of the business model for sustainability

Archetypes have the potential to incorporate sustainability into business objectives and processes, increase the adoption of innovations, accelerate their introduction, and reduce implementation risks. The authors also point out that the objective of this categorization is not only to reduce social and environmental negative issues, but also to help reformulate business models to ensure sustainability (Bocken, Short, Rana, & Evans, 2014).

According to the authors, companies can use a combination of archetypes to shape their own change, in order to explore new ways to create and deliver sustainable value. The eight archetypes proposed were used as a basis for the analysis of sustainable innovation practices, because they comprise a wide set of actions.

Some factors are relevant for the adoption of sustainable innovation, such as the size and nature of the activity. Robinson and Stubberud (2013) observe that large companies are more likely to implement green innovation practices, because they generally have more capital to invest. On the other hand, small companies face challenges in competing with larger companies, and can find in environmental innovation an effective and sustainable way to provide consumers with products that they appreciate.

Zee, Fok and Hartman (2011), in a study with small and large companies in Germany, found that large companies are more inclined to produce green products and services. On the other hand, small businesses tend to have higher levels of environmental awareness and a greater belief in the importance of sustainability.

Nidumolu, Prahalad and Rangaswani (2009) by studying sustainable initiatives of large organizations, noticed that success is related to the fact that sustainability is perceived as a new innovation frontier. Successful companies reconcile sustainability with innovation, and thereby achieve competitive advantage, because they redefine products, technologies, processes and business models, and still reduce costs, by using less inputs; and new processes and products also generate additional revenues or allow the creation of new businesses.

Klewitz and Hansen (2014), in turn, deal with sustainability-oriented innovation in small and medium-sized enterprises (SMEs), since such organizations are increasingly recognized as fundamental for sustainable development. From a systematic review of the literature, they identify product, process and organizational innovation practices and develop an integrated framework on sustainability-oriented innovation for SMEs.

In industrial companies, which are the object of this study, research and development (R&D) in manufacturing companies is a key innovation issue. Thus, the importance of environmental issues in R&D, in relation to new technology elements, is growing, as companies seek to promote eco-innovation (Kobayashi, Kato, Maezawa, & Sano, 2011).

The adoption of sustainable innovation practices is increasingly highlighted in the business context, and although several studies have addressed their application, there are still gaps regarding companies' performance, which we discuss in the next section.

3. Business performance

For Kennerley and Neely (2002, p. 222), "performance measurement is still a critical and much debated issue, despite the recognition of its important role in the efficient and effective management of organizations." The authors further observe that "few organizations appear to have systematic processes to manage the evolution of their measurement systems, and few researchers seem to have explored the issue."

Measuring performance is a critical factor for organizations. Most of them recognize its importance, but they lack a systematic process with defined parameters for evaluation and control. Performance is a parameter used to quantify the "efficiency and/or effectiveness of a past action" (Neely, Adams, & Kennerley, 2002, p. xii) and "the organization's ability to achieve its objectives, by using its resources efficiently" (Daft & Marcic, 2004, p. 10).

To evaluate business performance, it is necessary to define the parameters that the company will use. Indicators are instruments that help to measure business performance,

and are composed of one or more variables that, associated, reveal wider meanings of the phenomena to which they refer, allowing the monitoring of the firm's interests and the planning of actions to improve performance (Villas Bôas, 2011; Callado, 2010).

Financial measures were widely used to evaluate the performance of organizations, but since the 1980s, due to the increasing complexity of the markets where organizations compete, there is a growing perception that it is no longer appropriate to use financial measures as the only criterion to evaluate business success (Kennerley & Neely, 2002). Therefore, a series of performance measures is necessary, so that organizations can think about their organizational results and provide parameters for decision-making.

Several studies associate innovation and sustainability with business performance. Regarding the innovative performance, Gunday *et al.* (2011) emphasize that literature has addressed innovation with the objective of analyzing the relationships between the types of innovation and company performance; thus, there are many conceptual studies. However, the authors observe that the analytical and empirical studies related to the subject are still limited, both in quantity and in depth of analysis.

Through the analysis of 184 manufacturing companies in Turkey, they highlighted the positive effects of innovation on the different dimensions of business performance: innovative, production, market and financial performance. Table II describes the four different categories proposed in the study.

Several studies have discussed the influence of corporate sustainability on organizational performance in recent decades, such as Wagner's (2010). This author analyzed the relationship between sustainability management and economic performance; by using separate measures for social and environmental performance, he showed that the latter has a direct effect on economic performance, while the former presents only a moderate effect.

Sustainable innovation incorporates technological improvements that can lead to energy saving, pollution minimization, waste recycling, green product development and corporate environmental management. This type of innovation also contributes to business sustainability, since it has a potential positive effect on a company's financial, social and environmental results (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013).

For companies, sustainable innovations should generate a good diffusion rate in the market and high profits, while improving the natural environment (Hillary, 2000). As a result,

Business performance	
Financial performance	Return on assets (profit/total assets)
	Firm general profitability
	Return on sales (profit/total sales)
	Cash flow (excluding investments)
Innovative performance	Renewal of the administrative system in tune with the firm's environment
	Innovations in work processes and methods
	Quality of new products and services
	Number of new projects for products and services
	Percentage of new products in the portfolio of existing products
	Number of innovations under intellectual property protection
Production performance	Production flexibility (volume)
	Production and speed of delivery
	Production Cost
	Quality and conformity
Market performance	Total sales
	Market share
	Customers' satisfaction

Source: Gunday *et al.* (2011, p. 670)

Table II.
Business performance indicators

companies that are pioneers in green innovation will enhance their corporate image, develop new markets, and achieve competitive advantage (Aragon-Correa & Sharma, 2003).

Cheng, Yang and Sheu (2014) investigated the interrelationships between the types of eco-innovation (process, product and organizational) and their impact on business performance in Taiwanese companies. As a result, business performance, measured by return on investment (ROI), market share, profitability and sales, can be boosted by eco-innovation.

On the other hand, some studies show that eco-innovation is not always related to higher profits (Marcus & Fremeth, 2009). Aguilera-Caracuel and Ortiz-de-Mandojana (2013) found no improvement in the financial performance of green innovative companies when compared to non-green innovative firms. However, although the green innovation potential for improving financial performance is evident, this effect may occur only in the long term, and companies must have the necessary conditions to enhance performance.

In addition, they suggest that the commitment and support from top management are essential for the development and implementation of green innovation; it is imperative that managers glimpse opportunities and integrate environmental initiatives into the company's overall strategy in order to achieve better financial results.

In summary, we highlight the need for researches that provide more evidence on the link between sustainable innovation and organizational performance. Although literature suggests that management of sustainable innovation can be an important source of benefits for companies, empirical results are still not conclusive (Lopez-Valeiras, Gomez-Conde, & Naranjo-Gil, 2015).

Based on these topics, we tried to relate the adoption of sustainable innovation practices to the performance of industrial companies through a conceptual model.

4. Conceptual model of the study

Based on the literature review, we present the conceptual model for analyzing sustainable innovation practices and business performance, which jointly addresses both topics.

We evaluated sustainable innovation practices based on the study by Bocken *et al.* (2014) in order to analyze the following dimensions: business adjustment to society; development of sustainable solutions; maximization of energy and water efficiency, and reduction of emissions; value creation from waste; substitution by renewable and natural processes; delivery of functionality rather than ownership; adoption of a leadership role.

We assessed business performance by considering the dimensions proposed by Gunday *et al.* (2011), through the financial, innovative, production and market aspects.

Therefore, based on the conceptual model, we developed the following hypotheses that guided this research:

H1. There is a positive relationship between the adoption of sustainable innovation practices and business performance.

H2. The adoption of sustainable innovation practices differs according to business performance.

The hypotheses stem from Szekely and Strebel's (2012) conception, and emphasize that sustainable innovation strategy is the creation of something new that leads to the improvement of business performance, and from Aguilera-Caracuel and Ortiz-de-Mandojana (2013), who stress that sustainable innovation contributes to business sustainability, since it has a potential positive effect on a firm's financial, social and environmental results.

5. Method

The study has a quantitative descriptive approach, and we conducted a survey with Brazilian industrial companies that invest in innovation. For data collection, we developed a structured questionnaire based on the conceptual model of Figure 1. It had closed questions and a

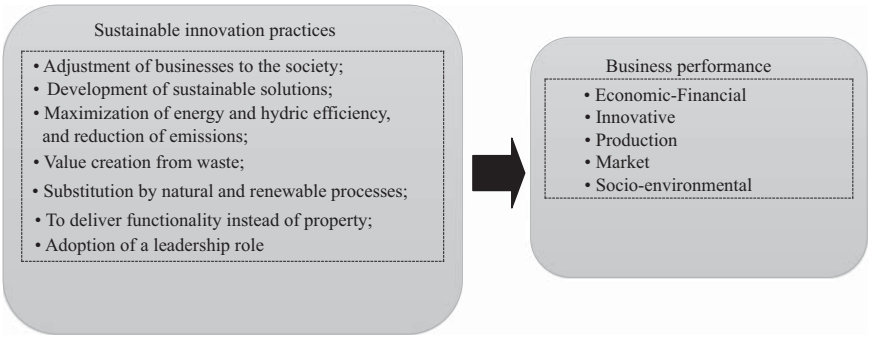

Figure 1.
Conceptual model

Sources: Adapted from Bocken *et al*. (2014), Gunday *et al*. (2011)

five-level item scale was used, where respondents specified their level of agreement or disagreement for a series of statements (from 1 – strongly disagree – to 5 – strongly agree) Experts in the areas of innovation and sustainability validated the data collection instrument.

As experts in the research topics, we selected professors that belong to the National Council for Scientific and Technological Development [CNPq] research groups, from important Brazilian universities, like the Federal University of Santa Maria, Federal University of Rio Grande do Sul, and University of São Paulo; and, in Spain, the University of Vigo. This step sought to check the adequacy of the data collection instrument with regard to clarity, format, content and scales.

Following experts' suggestions, we improved the questionnaire, after which we carried out a pre-test with three companies in order to verify its appropriateness and the difficulties for completing it. After making the necessary adjustments, we sent it to the companies through an online platform, along with a letter of invitation that explained the study objectives. We also conducted telephone and Facebook contacts with the firms in order to clarify the purpose and relevance of the research. We decided to apply the questionnaire through an online platform due to easy access to the target population. For Malhotra (2012), data collection through the internet has been growing fast due to its agility and lower cost.

The research universe comprised Brazilian industrial companies that had investments in innovation. We chose this population as research object because this type of company is more inclined to implement a strategic management of sustainable innovation, and, consequently, make changes in the business model, thus presenting a superior corporate performance.

We selected the research sample from the register of members of the National Association of Research and Development in Innovative Companies (ANPEI), which is the organization that represents the segment of innovative companies and institutions in Brazil. It operates with the government, the production sector and opinion leaders in order to spread the importance of technological innovation for the competitiveness of companies and the country's development (ANPEI, 2014a).

ANPEI has 168 associated companies, which belong to a wide range of industrial sectors, such as technological services, chemical, electronics, auto parts, machinery and equipment, petrochemical, energy, biotechnology, pulp and paper, food, construction, steel, mining and others (ANPEI, 2014b).

The sampling process also considered the Brazilian companies that participated in Mercopar – Latin America's subcontracting and industrial innovation fair – in the year 2015, which added 88 companies. The fair reflects the capacity of the metal-mechanic sector, the advances and quality of industry, and functions as a market thermometer, the perfect

meeting point to spread innovations and raise the level of companies' competitiveness (Mercopar, 2015).

Thus, the study's target population consisted of 256 companies, linked to ANPEI or participants of Mercopar (2015). It was a non-probabilistic sampling, since we contacted all these companies, and the sample comprised those that effectively received, answered and returned the properly completed questionnaires. They were sent through an online platform to all companies of the population, between September 2015 and January 2016. We got back 51 questionnaires, representing 19.92 percent of the population. Although the return rate was not high, the achieved results allow the specific analysis of the characteristics and behaviors of those companies. However, we cannot extrapolate the evidence found to the research universe.

We tabulated and treated the collected data by using software Microsoft Excel and Statistical Package for the Social Sciences, followed by Spearman's ρ correlation and Mann–Whitney's non-parametric test.

6. Analysis and discussion of results

Companies are characterized by their lifetime, industrial sector, number of employees, gross operating revenue in 2014, type of predominant innovation introduced in the previous five years, and main responsibility for the innovation activity. Table III presents a summary of the main attributes of the companies investigated, showing the predominant profile.

The average lifetime of the companies is 28 years, the oldest organization being 116 years old and the youngest, one year old. The considerable variation in lifetime suggests traditional and conservative perceptions from the oldest ones, considering that 25 percent of the companies are above 35 years old, as well as more modern and entrepreneurial conceptions from younger organizations, since 25 percent of the firms are below 8 years old.

Also, companies mostly belong to the sectors of machinery and equipment, technological and chemical. For these sectors, investments in innovation and/or sustainability have a critical importance due to their productive nature. In addition, the sample is composed of less extractive sectors, which, in general, present greater innovation activities.

In terms of size, most of the companies can be classified as micro and small-sized enterprises, considering the number of employees and SEBRAE's (2006) classification criteria; and as micro, small and medium-sized, based on their gross operating revenue for the year 2014 and BNDES' (2010) ranking. These data reveal that there is a predominance of micro and small firms in Brazil. Thus, understanding the business behavior regarding innovation and sustainability in this sample can contribute to the diffusion of practices that provide higher business competitiveness.

Regarding the characteristics related to innovation, the data show that organizations introduced in the market, in the previous five years, product and process innovations, showing that product innovation is linked to process innovation, which can contribute to a higher business competitiveness. Even though a significant number of companies are mainly responsible for the innovation activity, we found that the search for external sources of innovation stands out, such as cooperation with other firms, research institutes and

Lifetime	28 years, on average
Industrial sector	Machinery and equipment, technological and chemical.
Number of employees	From 20 to 99 (small firm)
Gross operating revenue	Less than R$ 2.4m (micro-firm)
Type of innovation	Product and process innovation
Responsibility for innovation activity	Firm is solely responsible for the innovation activity

Table III.
Synthesis of the companies' profile

universities (64 percent). The data confirm Pintec's findings (IBGE, 2013) by pointing out that, in Brazilian industrial companies, investments in external sources of innovation are higher than those spent on internal R&D activities.

6.1 Correlation analysis of sustainable innovation practices and business performance

The association between sustainable innovation practices and business performance was found from the correlation analysis between the indicators of the independent and dependent variables. We used Spearman's correlation coefficient because it is the most appropriate for non-normal distributions, as it is the case of this study.

In order to understand Tables V and VI, we present the indicators that appear in those tables in Table IV.

Table V presents the bivariate correlation coefficients and the observed levels of significance regarding the sustainable innovation practices and financial and innovative performance.

The data in Table V indicate the existence of 16 significant associations (at 0.005* and 0.001**), involving the 18 indicators related to sustainable innovation practices and business performance.

No.	Variables	No.	Variables
P1	Integration with local communities and other stakeholders, to generate social and environmental benefits	D1	Return on assets (profit/total assets)
P2	Mechanisms of interaction with their stakeholders	D2	Firm's overall profitability
P3	Sustainable solutions that bring benefits to the society and the environment	D3	Return on sales (profit/total sales)
P4	Products and/or services aimed at less use of resources, in order to reduce waste, emissions and pollution	D4	Cash flow (excluding investments)
P5	Practices to improve energy efficiency	D5	Renewal of the administrative system in tune with the firm's environment
P6	Practices to improve hydric efficiency	D6	Innovations in work processes and methods
P7	Practices to reduce emissions in the supply chain	D7	Quality of new products and services
P8	Practices that aim to remove the concept of "waste," by changing the wasted inputs into a useful and valuable contribution for other production	D8	Number of new projects for products and services
P9	Economic and environmental costs reduced through material reuse and change of waste into value	D9	Percentage of new products in the existing product portfolio
P10	Innovation in products and manufacturing processes, by using renewable resources and energy, and developing new sustainable solutions	D10	Number of innovations under intellectual property protection
P11	A Product-Service System (PSS) which seeks to create alternatives for substituting products by services, based on the idea that consumers do not buy the product itself, but rather the provided utility	D11	Production flexibility (volume)
P12	Actions that seek the creation and projection of new sustainable needs, that may change the course of current lifestyles of the population	D12	Production and speed of delivery
P13	Sustainable practices to ensure stakeholders' well-being	D13	Production cost
P14	Production systems and selected suppliers, in order to provide environmental and social benefits	D14	Quality and conformity
		D15	Total sales
		D16	Market share
		D17	Customers' satisfaction

Table IV. Legend of Tables V and VI

Sustainable innovation practices		Financial performance					Innovative performance				
		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
P1	Cor. Coef.	0.309*	0.325*	0.403**	0.297*	0.293*	0.246	0.380**	0.432**	0.358**	0.409**
	Sig.	*0.028*	*0.020*	*0.003*	*0.043*	*0.037*	*0.082*	*0.006*	*0.002*	*0.010*	*0.003*
P2	Cor. Coef.	0.259	0.366**	0.351*	0.250	0.214	0.312*	0.369**	0.309*	0.284*	0.329*
	Sig.	*0.066*	*0.008*	*0.12*	*0.076*	*0.131*	*0.026*	*0.008*	*0.028*	*0.044*	*0.018*
P3	Cor. Coef.	0.091	0.182	0.175	0.133	0.299*	0.229	0.352*	0.233	0.234	0.339*
	Sig.	*0.526*	*0.202*	*0.219*	*0.354*	*0.33*	*0.106*	*0.011*	*0.101*	*0.099*	*0.015*
P4	Cor. Coef.	0.117	0.122	0.072	0.071	0.268	0.159	0.233	0.258	0.107	0.206
	Sig.	*0.414*	*0.394*	*0.617*	*0.619*	*0.057*	*0.264*	*0.101*	*0.067*	*0.454*	*0.147*
P5	Cor. Coef.	0.137	0.187	0.209	0.107	0.249	0.206	0.404**	0.226	0.262	0.372**
	Sig.	*0.338*	*0.190*	*0.141*	*0.454*	*0.078*	*0.148*	*0.003*	*0.111*	*0.064*	*0.007*
P6	Cor. Coef.	0.193	0.226	0.135	0.213	0.315*	0.250	0.374**	0.157	0.157	0.256
	Sig.	*0.175*	*0.110*	*0.343*	*0.133*	*0.024*	*0.077*	*0.007*	*0.272*	*0.271*	*0.070*
P7	Cor. Coef.	0.306*	0.240	0.307*	0.185	0.449**	0.153	0.373**	0.147	0.228	0.412**
	Sig.	*0.029*	*0.090*	*0.029*	*0.193*	*0.001*	*0.283*	*0.007*	*0.303*	*0.107*	*0.003*
P8	Cor. Coef.	−0.026	−0.048	−0.073	0.097	0.227	0.088	0.094	−0.096	−0.002	0.070
	Sig.	*0.858*	*0.737*	*0.611*	*0.499*	*0.109*	*0.538*	*0.512*	*0.505*	*0.988*	*0.624*
P9	Cor. Coef.	−0.099	−0.077	0.013	0.013	0.279*	0.149	0.182	0.060	0.130	0.209
	Sig.	*0.489*	*0.593*	*0.927*	*0.929*	*0.047*	*0.297*	*0.201*	*0.677*	*0.364*	*0.141*
P10	Cor. Coef.	0.147	0.048	0.110	0.121	0.247	0.084	0.277*	0.089	0.151	0.315*
	Sig.	*0.303*	*0.738*	*0.442*	*0.397*	*0.081*	*0.556*	*0.049*	*0.536*	*0.291*	*0.024*
P11	Cor. Coef.	0.184	0.151	0.160	0.258	0.173	0.123	0.142	0.032	0.067	0.113
	Sig.	*0.197*	*0.291*	*0.261*	*0.068*	*0.226*	*0.391*	*0.321*	*0.826*	*0.639*	*0.429*
P12	Cor. Coef.	0.117	0.159	0.201	0.163	0.238	0.013	0.192	0.271	0.273	0.468**
	Sig.	*0.413*	*0.264*	*0.158*	*0.254*	*0.093*	*0.930*	*0.178*	*0.054*	*0.052*	*0.001*
P13	Cor. Coef.	0.307*	0.351*	0.387**	0.320*	0.381**	0.197	0.303*	0.321*	0.257	0.358**
	Sig.	*0.028*	*0.011*	*0.005*	*0.022*	*0.006*	*0.166*	*0.031*	*0.021*	*0.069*	*0.010*
P14	Cor. Coef.	0.418**	0.386**	0.400**	0.433**	0.472**	0.078	0.312*	0.402**	0.369**	0.470**
	Sig.	*0.002*	*0.005*	*0.004*	*0.001*	*0.000*	*0.586*	*0.026*	*0.003*	*0.008*	*0.000*

Notes: *,**Significant POSITIVE correlation ($p = 0.05$; 0.01, respectively)

Table V.
Sustainable innovation practices and financial and innovative performance – Spearman correlation

The correlation tests allow stating that there is a positive association between five of the variables that comprise the sustainable innovation practices and four of the variables of financial performance.

From the correlation analysis, we can say that the variables of the sustainable innovation practices that present an association with the indicators of financial performance are:

- integration with local communities and other stakeholders to generate social and environmental benefits, with return on assets, company's overall profitability, return on sales and cash flow;
- mechanisms of interaction with stakeholders, with the firm's overall profitability and return on sales;
- practices for reducing emissions in the supply chain, with return on assets and return on sales;
- sustainable practices to ensure the well-being of stakeholders, with return on assets, firm's overall profitability, return on sales and cash flow; and
- production systems and selected suppliers to generate environmental and social benefits, with return on assets, firm's overall profitability, return on sales and cash flow.

We observed that sustainable innovation practices related to stakeholders, emission reduction and suppliers' selection are associated with the financial performance indicators. This result confirms Hillary's (2000) view that, within business environments, sustainable innovations should generate a high rate of diffusion in the market and

high profits, while propitiate improvements the natural environment. It also confirms the results of Cheng *et al.* (2014), who examined the interrelationships between the types of eco-innovation (process, product and organizational) and their impact on business performance in Taiwanese firms. These authors showed that business performance, measured by ROI, market share, profitability and sales, could be strengthened by eco-innovation.

Data in Table V indicate 33 significant associations (at 0.005* and 0.001**) that involve the 20 indicators that relate to sustainable innovation practices and innovative performance.

The correlation tests allow us to state that there is a positive association between 11 of the variables that compose the sustainable innovation practices, and 6 of the variables on innovative performance.

From the correlation analysis, we can say that the variables of sustainable innovation practices that have an association with the indicators of innovative performance are:

- integration with local communities and other stakeholders for the generation of social and environmental benefits, with the renewal of the administrative system in tune with the company's environment, quality of new products and services, number of new projects for products and services, percentage of new products present in the existing product portfolio, and number of innovations under intellectual property protection;
- mechanisms of interaction with stakeholders, with innovations in work processes and methods, quality of new products and services, number of new projects for products and services, percentage of new products present in the existing product portfolio, and number of innovations under intellectual property protection;
- sustainable solutions that bring benefits to society and the environment, with the renewal of the administrative system in tune with company's environment, quality of new products and services and number of innovations under intellectual property protection;
- practices to improve energy efficiency, with quality of new products and services, and number of innovations under intellectual property protection;
- practices to improve hydric efficiency, with the renewal of the administrative system in tune with the company's environment, and quality of new products and services;
- practices to reduce emissions in the supply chain, with renewal of the administrative system in tune with company's environment, quality of new products and services, and number of innovations under protection of intellectual property;
- reduced economic and environmental costs through the reuse of material and change of waste into value, with renovation of the administrative system in tune with the company's environment;
- innovation in products and production processes by using renewable resources and energy and designing new sustainable solutions, with quality of new products and services, and number of innovations under protection of intellectual property;
- actions that seek the creation and projection of new sustainable needs that can change the course of the population's current lifestyles, with number of innovations under protection of intellectual property;
- sustainable practices to ensure the well-being of stakeholders, with the renewal of the administrative system in tune with company's environment, quality of new products and services, number of new projects for products and services, and number of innovations under protection of intellectual property; and

- production systems and suppliers selected to provide environmental and social benefits, with the renewal of the administrative system in tune with the company's environment, quality of new products and services, number of new projects for products and services, percentage of new products present in the portfolio of existing products, and number of innovations under protection of intellectual property.

We could observe that the practices of sustainable innovation have many associations with the indicators of innovative performance, showing that innovation focused on sustainability contributes to an innovative performance, which confirms the findings of Nidumolu *et al.* (2009). These authors studied sustainable initiatives of large organizations, and noticed that success was related to the fact that sustainability was seen as a new frontier of innovation. Successful companies balance sustainability with innovation and achieve competitive advantage, because they redefine products, technologies, processes, and business models, and still reduce costs by using less inputs; in addition, new processes and products generate additional revenues or allow the creation of new businesses.

Table VI shows the bivariate correlation coefficients and the significance levels observed regarding the sustainable innovation practices and production and market performance.

The data in Table VI indicate ten significant associations (at 0.005* and 0.001**), involving the 18 indicators related to sustainable innovation practices and production performance. Correlation tests allow us to state that there is a positive association between

Sustainable innovation practices		Production performance				Market performance		
		D11	D12	D13	D14	D15	D16	D17
P1	Cor. Coef.	0.142	0.210	0.008	0.171	0.234	0.291*	0.006
	Sig.	*0.320*	*0.139*	*0.956*	*0.230*	*0.098*	*0.038*	*0.964*
P2	Cor. Coef.	0.233	0.258	0.054	0.135	0.305*	0.320*	0.061
	Sig.	*0.099*	*0.068*	*0.708*	*0.345*	*0.029*	*0.022*	*0.672*
P3	Cor. Coef.	−0.092	0.078	−0.111	−0.077	0.211	0.061	0.154
	Sig.	*0.521*	*0.585*	*0.439*	*0.590*	*0.137*	*0.668*	*0.279*
P4	Cor. Coef.	−0.055	0.148	0.013	0.072	−0.022	0.086	0.111
	Sig.	*0.703*	*0.301*	*0.926*	*0.615*	*0.876*	*0.551*	*0.437*
P5	Cor. Coef.	−0.098	0.076	-0.016	0.199	0.101	0.107	0.144
	Sig.	*0.494*	*0.594*	*0.911*	*0.161*	*0.483*	*0.456*	*0.312*
P6	Cor. Coef.	0.059	0.073	0.144	0.347*	0.162	0.181	0.274
	Sig.	*0.682*	*0.612*	*0.314*	*0.013*	*0.256*	*0.205*	*0.052*
P7	Cor. Coef.	0.032	0.250	0.283*	0.300*	0.238	0.124	0.302*
	Sig.	*0.821*	*0.077*	*0.044*	*0.032*	*0.093*	*0.386*	*0.031*
P8	Cor. Coef.	0.018	0.055	0.125	0.285*	0.007	−0.037	0.097
	Sig.	*0.900*	*0.702*	*0.382*	*0.043*	*0.963*	*0.796*	*0.497*
P9	Cor. Coef.	0.099	0.115	0.127	0.201	0.004	−0.008	−0.049
	Sig.	*0.491*	*0.423*	*0.375*	*0.158*	*0.978*	*0.956*	*0.731*
P10	Cor. Coef.	−0.002	0.138	0.211	0.184	0.057	0.050	0.126
	Sig.	*0.989*	*0.334*	*0.136*	*0.197*	*0.689*	*0.727*	*0.379*
P11	Cor. Coef.	−0.042	0.145	0.083	−0.046	0.091	0.050	0.085
	Sig.	*0.772*	*0.311*	*0.563*	*0.749*	*0.523*	*0.729*	*0.553*
P12	Cor. Coef.	0.006	0.182	0.074	0.169	0.187	0.178	0.071
	Sig.	*0.965*	*0.202*	*0.606*	*0.237*	*0.188*	*0.211*	*0.618*
P13	Cor. Coef.	0.292*	0.430**	0.088	0.375**	0.399**	0.304*	0.256
	Sig.	*0.038*	*0.002*	*0.541*	*0.007*	*0.004*	*0.030*	*0.070*
P14	Cor. Coef.	0.310*	0.385**	0.285*	0.255	0.376**	0.190	0.343*
	Sig.	*0.027*	*0.005*	*0.043*	*0.071*	*0.007*	*0.182*	*0.014*

Table VI.
Sustainable innovation practices and production and market performance – Spearman correlation

Notes: *,**Significant POSITIVE correlation ($p = 0.05$; 0.01, respectively)

five of the variables that compose the sustainable innovation practices and four of the production performance variables.

From the correlation analysis, we can say that these are the variables of sustainable innovation practices associated with the indicators of production performance:

- practices to improve hydric efficiency, with quality and conformity;
- practices to reduce emissions in the supply chain, with production cost and quality and conformity;
- practices that aim to remove the "waste" concept, by changing wasted inputs into a useful and valuable contribution for other production, with quality and conformity;
- sustainable practices to ensure the well-being of stakeholders, with production flexibility (volume), production and speed of delivery, and quality and conformity; and
- production systems and selected suppliers, in order to provide environmental and social benefits, with production flexibility (volume), production and speed of delivery, and production cost.

Results showed that sustainable innovation practices related to resource saving contribute to production performance, which confirms Aguilera-Caracuel and Ortiz-de-Mandojana's (2013) view that sustainable innovation incorporates technological improvements that can lead to energy saving, pollution minimization, waste recycling, green product development and corporate environmental management.

The data in Table VI indicate eight significant associations (at 0.005* and 0.001**) involving the 17 indicators related to sustainable innovation practices and market performance. Correlation tests allow us to state that there is a positive association between five of the variables that compose the sustainable innovation practices and three of the variables regarding production performance.

Based on the correlation analysis conducted herein, the variables of sustainable innovation practices that showed association with the indicators of market performance are:

- integration with local communities and other stakeholders, to generate social and environmental benefits, with market share;
- mechanisms of interaction with their stakeholders, with total sales and market share;
- practices to reduce emissions in the supply chain, with customers' satisfaction;
- sustainable practices to ensure stakeholders' well-being, with total sales and market share; and
- production systems and selected suppliers, in order to provide environmental and social benefits, with total sales and customers' satisfaction.

Based on the data presented herein, we can affirm that the adoption of sustainable innovation practices is associated with business performance, since we found significant positive relationships of these practices with the variables of financial, innovative, production and market performance. Hence, our results confirm the findings of Aguilera-Caracuel and Ortiz-de-Mandojana (2013), Hillary (2000), Aragon-Correa and Sharma (2003) and Cheng *et al.* (2014).

6.2 Analysis of the difference of means between practices of sustainable innovation and business performance

To analyze the differences regarding the adoption of sustainable innovation practices and business performance, we ranked companies in two groups: higher and lower performance.

Then, we analyzed the variables in each of the groups in order to observe the differences and similarities of between types of companies.

The criterion used for creating the groups was based on the general average of the "business performance" construct. From the average, we established a ranking, and divided companies in two groups, as shown in Table VII.

Considering the two groups, Table VIII presents the results of the Mann–Whitney test, which checked if the adoption of sustainable innovation practices distinguished business performance between the groups.

By comparing the adoption of sustainable innovation practices according to business performance, the Mann–Whitney test proved that 6 of the 14 variables were significant. Thus, we can conclude that companies with higher performance have a higher level of adoption regarding the following aspects: integration with local communities and other stakeholders to generate social and environmental benefits; mechanisms to interact with their stakeholders; practices to reduce emissions in the supply chain; PSS that seeks to create alternatives for product substitution by services; sustainable practices to ensure stakeholders' well-being; and production systems and selected suppliers to provide environmental and social benefits.

Table VII. Classification of business performance

Performance	Frequency	%
Lower performance	25	49.0
Higher performance	26	51.0
Total	51	100

Table VIII. Differences between sustainable innovation practices and business performance

Sustainable innovation practices	Business performance: Lower Mean rank	Business performance: Higher Mean rank	Mann–Whitney Test Sig.
Integration with local communities and other stakeholders, to generate social and environmental benefits	21.64	30.19	0.035*
Mechanisms of interaction with their stakeholders	21.40	30.42	0.027*
Sustainable solutions that bring benefits to the society and the environment	24.54	27.40	0.473
Products and/or services aimed at less use of resources, in order to reduce waste, emissions and pollution	24.46	27.48	0.441
Practices to improve energy efficiency	23.48	28.42	0.214
Practices to improve hydric efficiency	23.64	28.27	0.237
Practices to reduce emissions in the supply chain	20.48	31.31	0.007**
Practices that aim to remove the concept of "waste," by changing the wasted inputs into a useful and valuable contribution for other production	25.78	26.21	0.914
Economic and environmental costs reduced through material reuse and change of waste into value	25.90	26.10	0.961
Innovation in products and manufacturing processes, by using renewable resources and energy, and developing new sustainable solutions	23.00	28.88	0.147
A Product-Service System (PSS) which seeks to create alternatives for substituting products by services, based on the idea that consumers do not buy the product itself, but rather the provided utility	21.54	30.29	0.032*
Actions that seek the creation and projection of new sustainable needs, that may change the course of current lifestyles of the population	22.62	29.25	0.103
Sustainable practices to ensure stakeholders' well-being	21.04	30.77	0.015*
Production systems and selected suppliers, in order to provide environmental and social benefits	19.96	31.81	0.003**

Notes: Significance level between means: *$p < 0.05$; **$p < 0.01$

These results, once more, confirm the findings of Aguilera-Caracuel and Ortiz-de-Mandojana (2013) that sustainable innovation contributes to business sustainability, since it has a potential positive effect on the financial, social and environmental results of a company. Firms with higher performance have more intensity sustainable innovation practices related to interaction with stakeholders, reduction of emissions in the supply chain, substitution of products by services and practices for suppliers' selection.

According to the results, the first hypothesis of the study was confirmed (*H1*), since we found positive associations between the dependent and independent variables. The second hypothesis was also confirmed (*H2*), since we found several practices that differ significantly regarding business performance.

The results, which imply that investments to adopt sustainable innovation practices can contribute to a superior corporate performance, confirm the arguments of Lopez-Valeiras *et al.* (2015), who highlighted the need for studies that provide more evidence on the link between sustainable innovation and organizational performance. Although literature suggests that the management of sustainable innovation can be an important source of benefits for companies, the empirical results are still not conclusive.

7. Final remarks

The main objective of this study was to analyze the relationship between the adoption of sustainable innovation practices and the performance of industrial companies.

In general, the results showed that the adoption of sustainable innovation practices is related to business performance, since we found positive associations between dependent and independent variables. We also observed significant differences between the adoption of sustainable innovation practices and business performance, confirming the study's hypotheses.

Based on business performance, we found significant differences of means for the following variables: integration with local communities and other stakeholders to generate social and environmental benefits; mechanisms of interaction with stakeholders; practices to reduce emissions in the supply chain; PSS that seeks to create alternatives for product replacement by services; sustainable practices to ensure stakeholders' well-being; and production systems and selected suppliers to provide environmental and social benefits.

From the aforementioned statements, we can conclude that the adoption of sustainable innovation practices contributes to superior corporate performance.

As a main contribution of the research to theory, we highlight the joint approach of the topics of sustainable innovation and performance, considering that, in the literature, studies that address the impact of the adoption of innovation practices on business performance are still incipient.

At the practical level, understanding the behavior of industrial companies contributes to the diffusion of practices that can result in a better business performance and create competitive advantage. And, at the social level, understanding the benefits of adopting sustainable innovation practices favors the minimization of negative socio-environmental impacts.

As main limitations, we mention the theoretical choices, the study of the phenomenon through the perception of respondents, and the number of companies surveyed, since we got a low return, which is not representative considering the population researched herein. Therefore, we cannot generalize the results for the research universe, keeping them valid just for the companies that composed our sample.

We suggest that future studies try to expand the sample in order to deepen our results and establish new analyses in order to find new variables that explain this phenomenon.

Despite the limitations of the study, we presented evidence of the behavior of companies regarding the adoption of sustainable innovation practices and business performance by identifying important elements for the development of this knowledge area.

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