https://bar.anpad.org.br

BAR – Brazilian Administration Review
Vol. 18, No. 3, Art. 4, e200126, 2021
https://doi.org/10.1590/1807-7692bar2021200126

Research Article

Does Ecological Sustainability Really Matter? Evaluation of Its Mediating Role in the Relationship between Innovation and Competitiveness

Rafael Ricardo Jacomossi[1]
Paulo Roberto Feldmann[2]
Alcides Barrichello[3]
Rogério Scabim Morano[4]

[1] Centro Universitário FEI, São Paulo, SP, Brazil
[2] Universidade de São Paulo, São Paulo, SP, Brazil
[3] Universidade Presbiteriana Mackenzie, São Paulo, SP, Brazil
[4] Universidade Federal de São Paulo, Diadema, SP, Brazil

Received 24 November 2020. This paper was with the authors for one revision. Accepted 03 August 2021. First published online 17 August 2021.
Editors-in-Chief: Carlo Gabriel Porto Bellini (Universidade Federal da Paraíba, Brazil)
Ivan Lapuente Garrido (Universidade do Vale do Rio dos Sinos, Brazil)
Associate Editor: Mônica Cavalcanti Sá de Abreu (Universidade Federal do Ceará, Fortaleza, CE, Brazil)
Reviewers: two anonymous reviewers
Editorial assistants: Kler Godoy and Simone Rafael (ANPAD, Maringá, PR, Brazil)

ABSTRACT

Organizational studies highlight the role of innovation for competitiveness, but few of them address ecological sustainability as one of the variables in this relationship. The traditional model only considers economic growth to be anchored in the dimension of innovation, disregarding the environment. Thus, the purpose of this study was to analyze the influence of ecological sustainability on the relationship between innovation and global competitiveness. To reach the goal of the manuscript, a database was used that included indicators from 119 countries present in the Global Competitiveness Report of WEF and the Global Innovation Index. The data were treated using regression analysis with mediation techniques. The results suggest significant mediation of ecological sustainability in the relationship between innovation and global competitiveness. This work shows the importance of ecological sustainability to increase country's innovative activity and consequently its competitiveness. Additionally, it draws attention to the gap in studies that present these relationships at the country level. In terms of practical contributions, the findings support the recommendation for companies to focus on actions to environmental and innovation management improving sustainability and increasing organizational performance and long-term survival. Finally, this research also draws attention to the lack of an important indicator of ecological sustainability in a report addressing countries' competitiveness.

Keywords: World Economic Forum; competitiveness of nations; ecological sustainability; innovation; mediation

JEL Code: nonadherent

INTRODUCTION

Organizational studies on the theme of competitiveness show the role of technological innovation as an instrument to promote productivity gains, improving the firms' competitive conditions (Gordon, 2016; Ichijo & Nonaka, 2007; Kalmakova, Bilan, Zhidebekkyzy, & Sagiyeva, 2021; Nelson & Winter, 1982). The traditional model, however, has been criticized for disregarding the environment while anchoring economic growth in the dimension of innovation. This model has shown to be incomplete, neglecting other factors (Barrichello, Morano, Feldmann, & Jacomossi, 2020; Feldmann, Jacomossi, Barrichello, & Morano, 2019) such as the ecological sustainability that, according to Beck (1992), Giddens (1991), Jacomossi and Demajorovic (2017), and Kalmakova, Bilan, Zhidebekkyzy, and Sagiyeva (2021), has proven to be legitimate in modern society.

For Castells (2016), productivity gains through efficiency do not compensate the carbon emissions resulting from increased consumption. Giddens (1991) states that modernity has a dark side that gradually becomes apparent. For the author, placing science and technology at the service of the industrialization process in search of ever-greater profits has caused an unprecedented modification of nature, degrading the resources and threatening the survival of present and future generations. Demajorovic (2003) corroborates these views, adding that infinite human potential to build knowledge brings uncertainty about the future, creating challenges for society to adjust its capacities to the increasingly rapid changes.

Organizations can respond to these challenges by guiding their decisions by using a process of rationality that emphasizes both economic and environmental gains (Faustenhammer & Gössler, 2011). Jacomossi and Demajorovic (2017) demonstrate that it is possible to develop a learning model for innovation in organizations that contemplates the environmental dimension.

The evolution of this debate led to a new element of analysis, eco-innovation, also known as environmental innovation. This element is used to verify the firms' conditions to innovate, considering the concerns with the environment (Angelo, Jabbour, & Galina, 2012; Hermundsdottir & Aspelund, 2021; Jacomossi & Demajorovic, 2017). Kammerer (2009) and Beise and Rennings (2005) define this type of innovation as one that arises at the organizational level and benefits the environment. It encompasses all organizational changes and novelties that seek to mitigate or eliminate its environmental impacts. Along with the environmental benefit comes an economic gain. By adapting their processes and adopting such practices, companies can increase their productivity and improve competitiveness, making rational use of resources (Horbach, Rammer, & Rennings, 2012).

In the debate on countries' competitiveness, Porter (1990) argues that this type of competitiveness has to do with the enterprises operating in the nations' territories, which means that countries, industries, and companies are elements of analysis that cannot be dissociated. Reports on nations' competitiveness, such as the studies of the World Economic Forum (WEF) (Schwab, 2019; Schwab, Sala-i-Martín, & Samans, 2017; Schwab, Sala-i-Martín, Samans, & Blanke, 2015; 2016), highlight the relationship between innovation and competitiveness. However, they do not

address the issue of ecological sustainability as one of the potential drivers for improving productivity. The literature presents studies that indicate the role of innovation as a competitiveness driver, as well as research highlighting the importance of sustainability in this process. It is clear, therefore, the need to investigate these variables together. In this context, the research question built in this study is: Does ecological sustainability influence the relationship between innovation and the competitiveness of nations?

Thus, this study analyzes, at a macroeconomic level, the influence of ecological sustainability on the relationship between innovation and global competitiveness. Thus, it is expected that the present work can contribute to a better understanding of the importance of considering ecological sustainability in micro and macroeconomic strategies. Although several studies portray such influence at the level of firms, there is a need for research that presents these relations at the country level.

This work is composed, in addition to this introduction, by literature review sections involving the relationships between the variables studied (innovation, global competitiveness, and ecological sustainability), hypothesis and theoretical model construction, methodology used, as well as analysis and discussion of results, and conclusions.

LITERATURE REVIEW

Enterprises seek several goals, including high profit, competitiveness, and long-term survival. Besides, ecological sustainability has become a fundamental issue by business and non-business organizations since it leads to superior performance. Sustainability requires sufficient resources and capacities to be implemented (Zhang, Khan, Lee, & Salik, 2019).

The relationship between the variables innovation, global competitiveness, and ecological sustainability, seen in pairs, is the object of research, as shown in the following subsections. However, there is little research that relates the three variables concomitantly. Thus, the literature presented here follows this dynamic, which will support the proposed theoretical model, while simultaneously evaluating all relationships.

Innovation and global competitiveness

The classic explanation regarding the process of nations' growth and development is based on a combination of the following factors of production: cheap labor, an abundance of raw materials, and the availability of capital. The factor innovation is added to this discussion, based on Schumpeter (1934). From the author's studies, the economic competitiveness paradigm has been based on the capacity of companies and countries to innovate. Studies focusing on the performance of firms and nations point to the role of technological innovation as a crucial inducing factor to explain economic growth and wealth generation (Ichijo & Nonaka, 2007; Mytelka, 2000; Nelson & Winter, 1982; Pavitt, 1984; Schumpeter, 1934).

The scope of studies that highlight innovation as one of the main driving forces for economic development and business competitiveness — both in the academic and organizational fields — has grown significantly (Barrichello, Santos, & Morano, 2020; Sukumar, Jafari-Sadeghi, Garcia-Perez, & Dutta, 2020; Torres, Pagnussatt, & Severo, 2017). The research by Torre, Pagnussatt, and Severo (2017) highlighted the main concepts of innovation as a source of competitive advantage, showing that it should be one of the organizations' strategies to differentiate from competitors and to contribute to their sustainability over time.

Microeconomic studies, on the other hand, have been dedicated to examining the function of innovation in increasing the performance of organizations. Porter (1990) analyzes competition in various sectors of the economy in several countries, showing that the most successful companies are those that better use technological knowledge, dealing effectively with innovation. The author concludes that the progress and development of countries are related to how developed their business environments are, enabling them to innovate faster than their foreign rivals.

Additionally, many studies (Barrichello, Morano, et al., 2020; Denkowska, Fijorek, & Yna Wegrz, 2020; Dima, Begu, Vasilescu, & Maassen, 2018; Quan, Xiao, Ji, & Zhang, 2021) point out the importance of education on competitiveness of countries. The findings of these studies highlight the importance of innovation and education as influencers of countries' competitiveness. Policy development concerning the workforce's lifelong learning possibilities and the focus on R&D activities can contribute to the competitiveness of countries.

As can be seen, the studies show that the relationship between innovation and competitiveness is relevant, as well as it is important to understand the role of ecological sustainability as a way to reinforce the innovative practices of companies and countries.

The relationship between innovation and ecological sustainability

Human life depends on the environment, but the high-speed exploitation of natural resources has increased degradation and jeopardized nature's capacity for regeneration (Hardin, 1968; Li et al., 2021; Morano, Moraes, & Jacomossi, 2018). In this context, the companies have contributed to the worsening of this situation (Melville, 2010). Moyano-Fuentes, Maqueira-Marín, and Bruque-Cámara (2018) examined the relationship between technological innovation and engagement in environmental sustainability, considering the firms' institutional and competitive environment. The most innovative companies are also the ones more engaged in environmental sustainability, looking for satisfying economic restrictions established by the competitive environment and the institutional pressures from all the stakeholders.

Sustainability in the context of innovation can be seen in the development of innovative green products (Wu et al., 2021). Green product innovation is a fundamental factor for achieving environmental sustainability, growth, and better quality of life (Angelo et al., 2012; Zhan, Tan, Ji, & Tseng, 2018). A priority for academia and organizations nowadays is to develop the understanding that environmental innovation is a result of the combination of innovation and sustainability (Cheng, Yang, & Sheu, 2014). Companies must incorporate environmental

sustainability into product development, observing the different dimensions and types of ecological products. In turn, public policies must act as an active function in stimulating demand for green products by subsidies and discounts for green markets in emerging stages (Dangelico & Pujari, 2010).

Dutra, Silva, and Cubas (2019) recognize the possibility that socio-environmental actions taken by companies can generate results in terms of economic performance. Such actions are in line with global challenges and are among the several sustainable development goals listed in Agenda 2030, established by the United Nations (UN). For the authors, in general, companies have a significant concern to produce with social, environmental, and economic sustainability, in line with the ninth Sustainability Development Objective (SDG), which prioritizes the construction of incentive to innovation, inclusive and sustainable industrialization, and resilient infrastructure.

Environmental sustainability can be hard to implement, mainly for small and medium-sized enterprises (SMEs) (Kernecker, Seufert, & Chapman, 2021). For Kanda, Hjelm, Clausen, and Bienkowska (2018), SMEs can look for external support to manage some of their issues in innovation. In this sense, some organizations support such companies in the innovation process.

These organizations offer economic innovations such as prototyping, collection, and dissemination of information and brand. These innovations seek to validate the environmental benefits of ecological innovations. Beise and Rennings (2005) state that there is little support for activities that require changes in public policies toward eco-innovation. Thus, public policies must encourage and promote the creation of different types of organizations that support eco-innovation, creating the opportunity to facilitate the implementation of all needed activities (Ford, Steen, & Verreynne, 2014).

Silva et al. (2019) measured the environmental performance of publicly traded companies that integrate the Brazilian corporate sustainability (ISE) and carbon-efficient (ICO2) indices of the Brazilian stock exchange (BMF & Bovespa) using the IPAT indicator (Impact, Population, Affluence — represented by the level of resource consumption by the population — and Technology). The indicator showed effectiveness in assessing the technological efficiency of production, revealing that there is no direct relationship between variation in the quantity produced and the size of the impact since the variable 'technology' is the element that influences the generation of impact. The authors conclude that the environmental impact depends on the degree of technology the firms adopt. Also, the public administration can use the IPAT to develop environmental policies associated with the companies' performance, and the indicator may be used to assess the effectiveness of the state's environmental investments (Köhler et al., 2013).

Innovation is highly necessary to achieve competitiveness and sustainability in value chains, reinforcing the importance of public-private partnerships (innovation platforms) that are necessary conditions to achieve the excellent capacity for innovation in these spaces (Degato & Carlos, 2017). Klewitz, Zeyen, and Hansen (2012) mention the possibility of organizational

environmental innovation, a broader process with effects across the company. In this case, environmental innovation would be associated with reshaping all strategic thinking.

The relevance of environmental, social, and other effects following the progress took the sustainability challenges beyond the traditional front of governments and civil society, gaining the corporate agenda (Mathur & Berwa, 2017). In this context, Marikina (2018) found a strong correlation between ecological sustainability and global competitiveness. According to the author, ecological regulation plays a prominent role both in achieving sustainability and in the positive development of countries' competitiveness.

As seen, the discussion on global competitiveness also goes through the intricacies of innovation and ecological sustainability, so it is important to investigate the direct relationship between ecological sustainability and global competitiveness.

The relationship between ecological sustainability and global competitiveness

Countries' economic and environmental performance are inter-connected (Crowder & Reganold, 2015; Gilli, Mazzanti, & Nicolli, 2013; Salvati & Carlucci, 2011). In this sense, Borland, Ambrosini, Lindgreen, & Vanhamme (2016) propose that competitiveness should consider not only the business environment but also global natural environments. It is essential to treat the analysis of competitiveness systemically, demonstrating the influence of economic, social, and environmental variables on competitiveness (Soares & Hansen, 2014). Innovative agricultural systems, for example, allow sustainably achieving production goals, with organic agriculture being the most innovative of these systems (Crowder & Reganold, 2015). However, there are still important divergences in the debates about the relationships among the countries' environmental, economic, and innovation performances (Gilli et al., 2013; Salvati & Carlucci, 2011).

In modern societies, economic activities are nearly related to environmental challenges. The connection between environmental regulation and industrial competitiveness has received more attention due to pressures on environmental protection and economic development (Stavropoulos, Wall, & Xu, 2018). In this context, sustainable development has entered a new era in the development of metric-driven environmental policies. Countries are required to integrate environmental performance metrics into policies related to pollution control and management of natural resources (Lang & Marsden, 2018; Wendling, Emerson, Esty, Levy, & Sherbinin, 2018).

This theme brings up the need for corporations to adapt their processes while maintaining competitiveness. Innovation proves to be an essential factor, as it allows the restructuring of organizational processes, in addition to the development of new products, technology, and processes. However, the academic understanding of competitiveness, sustainability, and innovation have been fragmented (Desore & Narula, 2018). It is possible to observe that, in the short term, there is a movement of investment in sustainable innovation to obtain competitiveness, profiting from the benefits of eco-efficiency or the value-added. In the long term,

sustainability problems require substantial investments in innovation, which brings the managerial challenge of investing without affecting competitiveness (Spezamiglio, Galina, & Calia, 2016). For Soares and Hansen (2014), the organizations' plans to increase competitiveness have to include the factors related to sustainability.

High competitiveness requires constant attention to the conditions under which companies can gain or lose value. A company's competitiveness determines its long-term performance. Sustainable companies perform better in the long term in the face of restrictions imposed by the economic, social, and environmental systems. The firms develop their strategies and sustainably create value in the future. Sustainable practices are fundamental in business models, ensuring the survival of companies since strategies in these directions are long-lasting and offer competitive advantages (Lloret, 2016). Using resources in a balanced way helps the organization's sustainable development, providing an adequate way for the company to remain competitive and sustainable (Ambruş, Izvercian, Ivascu, & Artene, 2017).

Tan, Ochoa, Langston, and Shen (2015) associate the need to use resources efficiently to adapt to climate change. For the authors, entrepreneurs should seek to incorporate sustainable practices, although this action may burden the contracts with additional costs that may reduce economic performance. However, at the international level, companies with high sustainability performance can await greater revenue growth, and sustainability performance has the chance to become a competitive advantage.

The strictness of environmental regulations initially harms the industry, considering their implementation cost. However, the introduction of innovations brings a subsequent positive impact. Thus, traditional negative expectation about the effects of implementing environmental regulations applies only to the first part of the process. After, the investment is compensated, when the companies understand the market opportunities created by the regulation (Stavropoulos et al., 2018).

Finally, according to Porter and Linde (1995), Marikina (2018), and Zhan, Tan, Ji, and Tseng (2018), soft environmental regulations fail to push firms to achieve an innovation edge. On the other hand, rigorous regulations lead to producing innovation that becomes a differential, with positive impacts.

Development of the hypothesis and theoretical model

The literature shows the concern about — and the inseparable role of — the relationship between innovation, environmental sustainability, and competitiveness of nations (Beise & Rennings, 2005; Horbach et al., 2012; Kammerer, 2009; Porter & Linde, 1995).

In its Global Competitiveness Report (GCR) 2013/2014, the World Economic Forum expanded its understanding of competitiveness to involve sustainability. The report states three important concepts. First, 'sustainable competitiveness' is "the set of institutions, policies, and factors that make a nation remain productive over the long term while ensuring social and environmental

sustainability" (Schwab, Sala-i-Martín, & Brende, 2013, p. 55). The second concept, 'social sustainability,' is "institutions, policies, and factors that enable all members of society to experience the best possible health, participation, and security; and that maximize their potential to contribute to and benefit from the economic prosperity of the country in which they live" (Schwab et al., 2013, p. 59). Finally, 'environmentally sustainable competitiveness' is "the institutions, policies, and factors that ensure efficient management of resources to enable prosperity for present and future generations" (Schwab et al., 2013, p. 58). This last concept takes into account the relationship between several elements of competitiveness and environmental sustainability. In its reports, WEF highlighted that only competitiveness does not necessarily drive sustainable levels of prosperity (Schwab et al., 2013; Schwab, Sala-i-Martín, Eide, & Blanke 2014).

In the GCR 2013/2014, the item 'environmental sustainability' in the Global Competitiveness Index (GCI) structure was composed of three groups of indicators covering (1) environmental policy, (2) use of renewable resources, and (3) degradation of the environment. Another three groups of indicators that made up the item 'social sustainability' were (1) access to basic needs, (2) vulnerability to shocks (economic exclusion), and (3) social cohesion. Together with the traditional GCI, the GCR presented the Sustainability-adjusted Global Competitiveness Index (SGCI), which easily mediates sustainable competitiveness among countries. The SGCI was obtained by averaging the scores for social and environmental sustainability (Schwab et al., 2013).

According to the GCR 2014/2015, the results of the analysis comparing SGCI and GCI did not indicate a clear association between being competitive and being sustainable (Schwab et al., 2014).

Thus, from the GCR 2015/2016 on, the definition of competitiveness returned to be the one adopted previously, "the set of institutions, policies, and factors that determine the level of productivity of an economy" (Schwab et al., 2015, p. 4). According to the GCR 2015/2016, the focus remained on productivity since growth models indicate that, in the long term, productivity is the key factor that explains a country's level of prosperity and, therefore, the prosperity of its citizens.

Notwithstanding, some authors used the SGCI to demonstrate the importance of the relationship between innovation, sustainability, and competitiveness, elaborating studies that correlate the SGCI and the Global Innovation Index (GII), the latter published by the University of Cornell, IMD, WIPO, and IMD World Competitiveness Yearbook (Fonseca & Lima, 2015).

The research developed by Doyle and Perez-Alaniz (2017) addresses the lack of sustainability indicators in the GCR, offering a broad review of sustainable competitiveness as an aggregating concept that unites the comprehensions around sustainable development and covers the aspects of social, economic, and environmental sustainability. For the authors, by comprehensively measuring sustainable competitiveness, the SGCI is a plausible synthetic metric to assess different aspects of sustainable development in different countries.

Although environmental vulnerability and its socioeconomic effects were explicitly discussed in the GCRs 2013/2014 and 2014/2015 (Schwab et al., 2013; 2014), these issues were absent in the following reports (Schwab et al., 2017; 2015; 2016). Despotovic, Cvetanovic, Nedic, and Despotovic (2019) used data from the GCR to correlate social sustainability indexes and their impact on the economic dimension of sustainability, but they did not obtain conclusive findings. Based on these results, the authors confirmed the complexity of studying this topic, considering its economic, competitive, social, and environmental developments.

Zhang, Khan, Lee, and Salik (2019) examined the influence of innovation management and technological innovation on the organizations' performance, considering the potential mediating role of sustainability in this relationship. The study indicated that innovation management and technological innovation contribute significantly and positively to the organizations' sustainability and performance. Additionally, the authors indicated that sustainability mediates innovation management and organizational performance and partially mediates technological innovation and organizational performance.

The works by Doyle and Perez-Alaniz (2017) and Zhang et al. (2019) inspire further examination on the theme of environmental sustainability within the scope of the GCR, despite the previous studies that showed no relationship between competitiveness and sustainability (Schwab et al., 2014).

Additionally, the research by Marikina (2018) describes the impact that environmental and management regulations have on competitiveness in Balkan countries. This research demonstrated that regulation affects both achieving ecological sustainability and the development of competitiveness in the countries. Despite the results, the research lacks support concerning the cause and effect relationship between ecological sustainability and the countries' competitiveness due to the statistical tools used and the lack of reports regarding the significance of the verified relationships. The understanding of how much ecological sustainability affects competitiveness may be an exciting piece of information to assess the real importance of sustainability as a component of competitiveness.

Considering the literature review, this study examines the following hypothesis:

> *H1*: The relationship between innovation and global competitiveness is mediated by ecological sustainability.

The theoretical model presented in Figure 1 was designed to test H1.

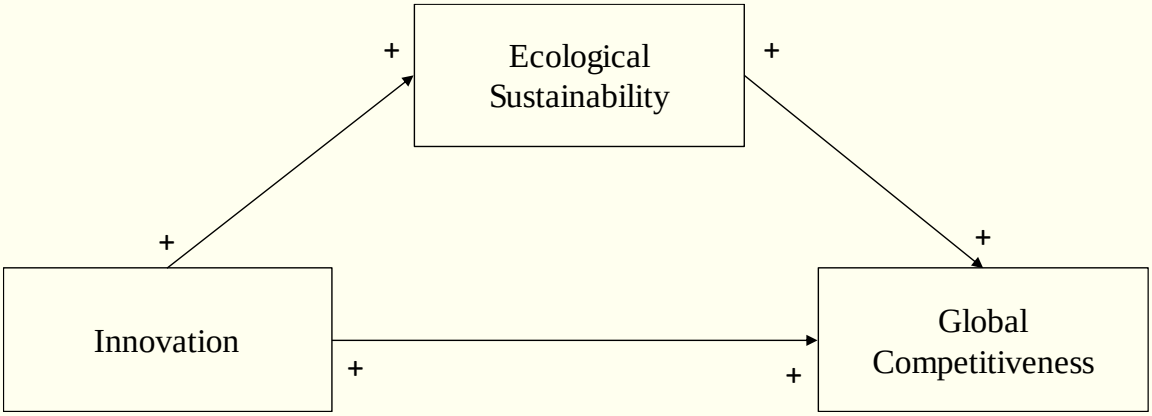

Figure 1. Theoretical model developed
Note. Elaborated by the authors.

This model seeks to understand whether ecological sustainability acts as a variable that mediates the relationship between innovation and competitiveness, interfering in how the first affects the second. Mediation analysis is a statistical method used to assess evidence of how a causal antecedent 'X' transmits its effect to a consequent variable 'Y' (Hayes, 2018). The S-O-R (stimuli-organism-response) model of behavioral psychology – which shows that an active organism interferes between stimulus and response, for instance – represents the most general formulation of a mediation hypothesis. The main idea in this model depicts the effects of stimuli on the behavior being mediated by several processes of transformation internal to the organism, making the stimulus-response relationship sometimes observable only indirectly (Baron & Kenny, 1986; Woodworth, 1926).

METHODOLOGY

The research used secondary data obtained from the combination of indicators from 119 countries present in the Global Competitiveness Report (GCR) 2017-2018 (Schwab et al., 2017) and Global Innovation Index 2018 (GII) (Dutta, Lanvin, & Wunsch-Vincent, 2018). This research was anchored in these two reports since the GCR contemplates aspects of innovation and global competitiveness, variables that are the focus of the study but not present information on ecological sustainability in the countries. Thus, such a variable was researched in another report that dealt with the topic and was close to the initial variables. This report was the GII, taking care to keep the same countries from both sources of information and the same period of publication, avoiding discrepancies between the data analyzed.

The indicators related to innovation and global competitiveness were retrieved from the GCR. Innovation involves data in the so-called pillar 12 of the report and is related to the presence of high-quality scientific research institutions, investment in research and development (R&D), the protection of intellectual property, and collaboration in research and technological developments between industries and universities. Global competitiveness is obtained by the use of GCI itself,

assessing the factors and institutions identified as determinants in productivity and long-term economic growth and prosperity of the nations. Both indicators are derived from the World Economic Forum (WEF) survey and other indexes prepared by the WEF, such as the Human Capital Index, the Networked Readiness Index, the Gender Gap Index, the Enabling Trade Index, and the Travel & Tourism Competitiveness Index. The survey also considered data from other WEF reports, such as The Inclusive Economic Growth and Development Report, and other studies on regional competitiveness. The WEF survey got the opinions of around 14,000 business executives in different economies between February and June 2017. The 2017 edition of the survey was available in 39 languages, 21 of which were available online (Schwab et al., 2017).

The indicator related to ecological sustainability, on the other hand, was taken from the Global Innovation Index (GII), a developing project that constructs on its previous editions while incorporating newly available data. The index is based on the latest research on the measurement of innovation. The GII model describes 90.8% of the world's population and 96.3% of the world's GDP (Dutta et al., 2018). Ecological sustainability is one of three sub-pillars existing in pillar 3, infrastructure, in GII. As mentioned before, the decision to use the GII was because there is no indicator in the GCR related to ecological sustainability. Appendix A shows the countries that are in the two reports. Countries appearing in only one of them were excluded from the analysis.

Table 1 presents the definitions of the variables used in the theoretical model developed. The ecological sustainability variable was extracted from the GII (Dutta et al., 2018), and the others – global competitiveness and innovation – obtained from the GCR (Schwab et al., 2017).

Table 1

Conceptual definitions of variables used

Variable	Definition
Ecological sustainability	Composed by the number of ISO 14001 certificates of conformity issued on environmental management systems, the Environmental Performance Index of Columbia and Yale Universities, and GDP per unit of energy use (efficiency in the use of energy).
Global competitiveness	Given by factors that establish the level of a country's productivity, which defines the level of development that it can achieve.
Innovation	Enough investment in research and development (R&D), especially by the private sector; the presence of high-quality scientific research institutions that can generate the basic knowledge needed to build the new technologies; extensive collaboration in research and technological developments between universities and industry; and the protection of intellectual property.

Note. Based on Schwab, K., Sala-i-Martín, X., & Samans, R. (2017). *The Global Competitiveness Report 2017-2018*. Geneva, CH: World Economic Forum and Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (2018). *Global Innovation Index 2018*. Ithaca, NY; Fontainebleau, FR; Geneva, CH: Cornell University, INSEAD, and WIPO.

The ecological sustainability variable is formed with three items: GDP per unit of energy use, environmental performance, and ISO 14001 environmental certificates (Dutta et al., 2018).

The GDP per unit of energy use is adopted to monitor the impacts of energy policies, forecast energy demand, study the evolution of the domestic energy market, and evaluate possible areas for action (Dutta et al., 2018).

Environmental performance is based on 24 indicators that assess the environmental health and vitality of the ecosystem in countries. They are part of the Environmental Performance Index (EPI), a report developed by the Yale Center for Environmental Law & Policy, which measures how close countries are to the settled environmental policy goals designed in the Paris Climate Agreement and the United Nations Sustainable Development Goals (SDGs) 2015 (Dutta et al., 2018).

ISO 14001 certificates determine the requirements for an environmental management system that a company must use to improve its environmental achievement. ISO 14001 is planned for organizations that look to manage their environmental responsibilities regularly, contributing to environmental sustainability (Dutta et al., 2018).

The quantitative method adopted involved regression analysis with model 4 of PROCESS (Hayes, 2018), macro of the software IBM SPSS Statistics® 20.0. Considering the theoretical model proposed, with an independent variable influencing a dependent variable, and a third variable presenting a possible indirect route of influence, regressions analysis seems to be the best choice to evaluate the relationship among the elements considered.

ANALYSIS AND DISCUSSION OF RESULTS

The hypothesis was tested with the simple mediation model using the bootstrapping resampling method, as suggested by Hayes (2018). The author considers bootstrapping resampling as the most appropriate method for assessing indirect effects since it does not require any assumption about the format of these effects' distribution. In addition, non-standardized coefficients are the preferred metric to report causal modeling results. Thus, the study tested the hypothesis using the PROCESS (model 4), SPSS macro developed by Hayes (2018), with 5,000 bootstrapping resamples, to obtain the total effects, direct and indirect, of the theoretical model proposed, and also adopting non-standard path coefficients.

The innovation variable increased ecological sustainability (B = 4.9395; SE = 1.1101; t = 4.4406, $p < 0.0001$, $R^2 = 0.1442$), which had a positive effect on global competitiveness (B = 0.0141, SE = 0.0035, t = 4.0592, $p < 0.001$, $R^2 = 0.6592$) when controlling innovation. In addition, the indirect effect of innovation on global competitiveness mediated by ecological sustainability was positive (0.0694). The confidence interval of the effect, based on the bootstrapping method [0.0315 : 0.1270; 5,000 resamples], does not contain zero, which supports the hypothesis of mediation.

The results suggest significant mediation of ecological sustainability in the relationship between innovation and global competitiveness. Despite the results indicating partial mediation (Baron

& Kenny, 1986), it was decided not to use this designation, as recommended by Preacher and Kelley (2011) and Rucker, Preacher, Tormala, and Petty (2011), adopting the proposal of relative magnitude between the indirect effect (mediation indicator) and the total effect (direct effect + indirect effect) between innovation and global competitiveness considered by the authors. Following the recommendations of Pieters (2017), Table 2 shows the totality of relationships with the use of the mediating variable.

Table 2

Total, direct, and indirect effects of innovation for global competitiveness

			Confidence interval*	
Description	Value	Standard error	LL	UL
Total effect (TE)	0.6005	0.0443	0.5128	0.6883
Direct effect (DE)	0.5311	0.0450	0.4420	0.6203
Indirect effect (IE)	0.0694	0.0242	0.0309	0.1258
IE/TE	0.1156	0.0388	0.0533	0.2130
IE/DE	0.1307	0.0513	0.0563	0.2706

Note. * Interval calculated with 95% confidence. Source: Elaborated by the authors.

In the relationship between indirect and total effect, it appears that 11.56% of the effect of innovation on global competitiveness is due to ecological sustainability. This finding shows the relative importance of this variable in the influence of innovation on global competitiveness. Another method was also used to check the size of the indirect effect, the kappa-squared, advised by Preacher and Kelley (2011), which indicates the intensity of the indirect effect found concerning the maximum possible indirect effect. According to the authors, in general, an effect that may seem minor in absolute size may be relatively large when considering the range of potential values that the effect could have assumed, considering the characteristics of the model or the distribution of variables. Even under ideal distribution conditions and linear relationships, there are limits to the values that the regression coefficients (and, therefore, the indirect effects) can assume, given certain characteristics of the data. In this study, the Preacher and Kelley's kappa-squared showed a value of 0.1438 (SE = 0.0377 [0.0732 : 0.2210]).

Therefore, items linked to innovation, such as investment in R&D, the presence of high-quality scientific research institutions, and extensive collaboration in R&D between universities and private companies, continue to be important to determine the level of productivity of an economy, increasing a country's potential prosperity. On the other hand, rational use of energy, environmental protection, and state regulatory policies (Marikina, 2018; Zhan et al., 2018) work as an incentive for companies to align themselves with standards established by norms such as ISO 14001. Combined, the importance of these variables lies in the country's maximum potential prosperity. It is still unclear whether ecological sustainability should be viewed as a fundamental and unique element for a country's prosperity, since the indirect path between innovation and global competitiveness, although relevant, does not prove to be the most valuable.

Theoretical models are an attempt to simulate reality, enabling the study of relationships between variables to better understand the behavior of nature (Chwif & Medina, 2014; Ford, 2010). The simple mediation model is the most fundamental mediation model that can be estimated and oversimplifies the complex dynamics by which 'X' (innovation) influences 'Y' (global competitiveness) in real processes scientifically explored (Hayes, 2018). However, the findings of this research stimulate the debate about the real importance of ecological sustainability — and how this element can be measured — in the relationship between innovation and global competitiveness, without encouraging those who neglect the necessary care for the environment (Fiala, 2008; Isaac, 2019; Sekerka & Stimel, 2011).

Countries known as large polluting economies, such as China, have been implementing initiatives that have the potential to minimize environmental impacts. In this sense, the country develops several projects in the areas of road transport, agriculture, clean energy, and manufacturing in general (Woetzel & Joerss, 2009). Hermawan and Astuti (2021) analyze in their research the various policies implemented by the countries of the Association of Southeast Asian Nations (ASEAN), to reduce marine plastic waste. Several indicators are used in the study, concluding that the process used in the handling of marine plastic waste needs to be resolved collaboratively and comprehensively. The authors add that although each country already has programmatic indexes and regulatory actions, there are still indicators that need to be improved, such as government spending, inspection programs, and pollution reduction costs. The study by Avilés-Sacoto, Avilés-Sacoto, Güemes-Castorena, and Cook (2021) assesses different states in Mexico in terms of their environmental performance and offers a perspective on how environmental initiatives can contribute to protecting and preserving the environment. From an environmental point of view, the assessment helps understand how different initiatives contribute to the conservation of natural resources and sustainable development.

Companies, in turn, are moving in the same direction, taking ecological sustainability to the center of their corporate strategy. Siemens, for example, has built an environmental portfolio centered on carbon-efficient products. Saint-Gobain, the construction and packaging enterprise, developed sustainable housing technologies in the center of its strategy for product development (Engel, Enkvist, & Henderson, 2015).

Unilever is another company that engages in these issues. One example is the continuous improvement process to mitigate the impact of its packaging on the environment (Boz, Korhonen, & Sand, 2020). Another case concerning Unilever occurs with the acquisition of Ben and Jerry's, an ice cream manufacturer and recognized as one of the most social and environmentally responsible brands in the United States. In this agreement, it was established in the contractual clauses that Unilever would maintain the practices that enshrined Ben and Jerry's about society and the environment (Craven-Matthews, Nordlund, & Fouzbi, 2021).

Overall, several companies, including McDonald's, Nestlé, Kraft-Heinz, PepsiCo, and Coca-Cola have set goals in their strategic plans to improve the sustainability of their packaging by 2025 and beyond, which includes greater recycling and recycled material, reducing virgin material in its composition, sustainable supply, weight reduction, and packaging design for improved recovery

(Boz et al., 2020). In another direction, companies like Nestlé, Cargill, Unilever, and Mondelez International have made efforts to reduce deforestation in their supply chain (Veggeberg, Delabre, & Jespersen, 2021).

Another important point in the discussion about innovation, global competitiveness, and ecological sustainability is related to circular economy practices. The traditional consumption model is based on the uncontrolled extraction of natural resources to supply productive activity and, at the end of the cycle, not taking advantage of what will be discarded (Melo, 2020). In contrast to the current model, the circular economy aims to generate less waste during the production process. Thus, materials and resources already included in these processes, which would have been discarded before, are reused, minimizing environmental impacts (Santomauro, 2020).

An example of this is plastic culture that uses polymers such as PE, PP, and PVC in greenhouse and mulching (soil cover) films, irrigation systems, harvesting systems, bag silos (large flexible silos), and other applications whose plastic used must have the correct destination so as not to harm rural production, thus bringing environmental and economic benefits (Santomauro, 2020). These plastic films are chemically additive to provide resistance to field conditions, where anti-UV, used to protect against ultraviolet rays, and anti-drip, used to break the surface tension of water, stand out (Chavarria & Santos, 2013).

The findings of this research show that ecological sustainability influences the relationship between innovation and global competitiveness, which indicates that the GCR should contemplate this dimension when building the Global Competitiveness Index. This possibility has already been suggested in previous GCRs (Schwab et al., 2013), but the effort was discontinued (Schwab et al., 2014). The economic development process should consider variables related to the environment, responding to the current global scenario that demands such a debate.

CONCLUSION

This paper analyzed, at a macroeconomic level, the influence of ecological sustainability on the relationship between innovation and global competitiveness. There are several studies (Ambruş et al., 2017; Dutra, Silva, & Cubas, 2019; Moyano-Fuentes et al., 2018) that portray such influence at the level of firms. However, further research on these relationships is needed to observe the countries, which is the contribution of this research. Notwithstanding, this study avoids using any political or ideological narrative.

The research used indicators of global competitiveness and innovation, found in the Global Competitiveness Report (GCR) of the World Economic Forum, and indicators of ecological sustainability found in the Global Innovation Index (GII), prepared by Cornell University, Institut Européen d'Administration des Affaires, and the World Intellectual Property Organization.

It is noteworthy that the competitiveness indicators are based, in general, on economic, infrastructure, institutional/political, health, and education factors. However, they do not consider indicators referring to ecological sustainability. The 2013 and 2014 GCR editions evaluated the possibility of considering ecological sustainability in the construction of the Global Competitiveness Index (Schwab et al., 2013; 2014). This initiative was unsuccessful, considering that the subsequent editions stopped discussing the topic (Schwab, 2019; Schwab et al., 2017; 2015; 2016).

This study, however, proved the importance of the topic by using multivariate data analysis to demonstrate the mediating role of ecological sustainability in the relationship between innovation and global competitiveness. As a result, it is possible to argue that the GCR should reconsider the use of ecological sustainability as an element in the construction of the GCI since it contributes to the prosperity of companies and countries. Such inclusion was also advocated by Doyle and Perez-Alaniz (2017). They affirm that ecological sustainability indicators should be incorporated into the WEF report to form a new index of sustainable competitiveness. This index could be an important and credible metric to analyze sustainable development in several countries. Such a perspective would enhance a more assertive adoption of managerial policies related to the search for convergence between environmental and economic interests.

Nevertheless, the mediation found does not support the notion that ecological sustainability is solely responsible for countries' competitiveness, which can reinforce a duality, sometimes perceived as antagonistic, between economy and environment. On the other hand, the existence of the mediation suggests to political and economic agents that such antagonism is naive when observing that ecological sustainability is one way to achieve competitiveness. Thus, a higher rate of competitiveness in countries is connected to innovation activities, and part of this relationship occurs through ecological sustainability. This study shows that the complementarity of these dimensions cannot be overestimated nor overlooked. Common sense and balance are necessary for the treatment of the three variables presented in the model discussed in this research (innovation, ecological sustainability, and global competitiveness), which shows that the joint and rational approach to these elements is crucial for the countries' prosperity.

In terms of practical contributions, it is clear that the rational use of resources, the development of green innovations, and the implementation of environmental certifications must be part of firms' strategies. The findings support the recommendation for companies to pay attention to environmental and innovation management to improve sustainability and to increase organizational performance and long-term survival. On the other hand, the public administration has to adopt laws and policies for the protection and management of natural reserves and the environment as a whole (Marikina, 2018; Zhan et al., 2018).

As for the limitations of the research, it is essential to mention the use of two different reports, with different methodologies and approaches, to compose the theoretical model presented. This procedure may be justified by the existing adherence between the GCR and the GII, mainly regarding the similar scope of countries in the two reports. Future studies would benefit from using other sources to explore the topics addressed here.

The ecological sustainability theme is controversial and arouses passions, both on the side of the uncompromising defense of the environment, even to the detriment of a minimum of prosperity for human beings, and on the side of the clash between the possibility of generating wealth and the protection of the environment.

The present paper proposed to locate sources related to innovation and competitiveness, but that could not be linked to the aforementioned extremes. It was to seek ecological sustainability data in a separate source from the GCR, ensuring that the research was no longer starting from a premise about the importance of ecological sustainability in the relationship between innovation and competitiveness.

REFERENCES

Ambruş, R., Izvercian, M., Ivascu, L., & Artene, A. (2017, June). The link between competitiveness and sustainability of enterprises. *BE-ci International Conference on Business and Economics*. Birmingham, UK, 4.

Angelo, F. D., Jabbour, C. J. C., & Galina, S. V. (2012). Environmental innovation: In search of a meaning. *World Journal of Entrepreneurship, Management and Sustainable Development*, *8*(2/3), 113–121. https://doi.org/10.1108/20425961211247734

Avilés-Sacoto, E. C., Avilés-Sacoto, S. V., Güemes-Castorena, D., & Cook, W. D. (2021). Environmental performance evaluation: A state-level DEA analysis. *Socio-Economic Planning Sciences*. https://doi.org/10.1016/j.seps.2021.101082

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037//0022-3514.51.6.1173

Barrichello, A., Morano, R. S., Feldmann, P. R., & Jacomossi, R. R. (2020). The importance of education in the context of innovation and competitiveness of nations. *International Journal of Education Economics and Development*, *11*(2), 204–224. https://doi.org/10.1504/IJEED.2020.106587

Barrichello, A., Santos, E. G. dos, & Morano, R. S. (2020). Determinant and priority factors of innovation for the development of nations. *Innovation & Management Review*, *17*(3), 307-302. https://doi.org/10.1108/INMR-04-2019-0040

Beck, U. (1992). *Risk Society: Towards a New Modernity*. London: SAGE Publications.

Beise, M., & Rennings, K. (2005). Lead markets and regulation: A framework for analyzing the international diffusion of environmental innovations. *Ecological Economics*, *52*(1), 5–17. https://doi.org/10.1016/j.ecolecon.2004.06.007

Borland, H., Ambrosini, V., Lindgreen, A., & Vanhamme, J. (2016). Building theory at the intersection of ecological sustainability and strategic management. *Journal of Business Ethics*, *135*(2), 293–307. https://doi.org/10.1007/s10551-014-2471-6

Boz, Z., Korhonen, V., & Sand, C. K. (2020). Consumer considerations for the implementation of sustainable packaging: A review. *Sustainability (Switzerland)*, *12*(6), 1–34. https://doi.org/10.3390/su12062192

Castells, M. (2016). *A sociedade em rede* (17th ed.). São Paulo, SP: Paz e Terra.

Chavarria, G., & Santos, H. P. dos. (2013). Cultivo protegido de videira: Manejo fitossanitário, qualidade enológica e impacto ambiental. *Revista Brasileira de Fruticultura*, *35*(3), 910–918. https://doi.org/10.1590/S0100-29452013000300031

Cheng, C. C. J., Yang, C. L., & Sheu, C. (2014). The link between eco-innovation and business performance: A Taiwanese industry context. *Journal of Cleaner Production*, *64*, 81–90. https://doi.org/10.1016/j.jclepro.2013.09.050

Chwif, L., & Medina, A. (2014). *Modelagem e simulação de eventos discretos: teoria e aplicações* (4th ed.). São Paulo, SP: Elsevier Brasil.

Craven-Matthews, E. L., Nordlund, A., & Fouzbi, Z. (2021). When big fish eats small fish: The acquisition of Ben & Jerry's by Unilever. Retrieved from https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=9042493&fileOId=9042494

Crowder, D. W., & Reganold, J. P. (2015). Financial competitiveness of organic agriculture on a global scale. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(24), 7611–7616. https://doi.org/10.1073/pnas.1423674112

Dangelico, R. M., & Pujari, D. (2010). Mainstreaming green product innovation: Why and how companies integrate environmental sustainability. *Journal of Business Ethics*, *95*(3), 471–486. https://doi.org/10.1007/s10551-010-0434-0

Degato, D. D., & Carlos, B. V. (2017). Innovation capacity evaluation framework for sustainable value chains. *Journal on Innovation and Sustainability*, *8*(3), 16–50. https://doi.org/10.24212/2179-3565.2017v8i3p16-50

Demajorovic, J. (2003). *Sociedade de risco e responsabilidade socioambiental: Perspectivas para a educação corporativa*. São Paulo, SP: Senac.

Denkowska, S., Fijorek, K., & Yna Wegrz, G. (2020). Formal and non-formal education and training as an instrument fostering innovation and competitiveness in EU member countries. *Journal of Competitiveness*, *12*(3), 82–98. https://doi.org/10.7441/joc.2020.03.05

Desore, A., & Narula, S. A. (2018). An overview on corporate response towards sustainability issues in textile industry. *Environment, Development and Sustainability*, *20*(4), 1439–1459. https://doi.org/10.1007/s10668-017-9949-1

Despotovic, D., Cvetanovic, S., Nedic, V., & Despotovic, M. (2019). Social Aspects of Sustainable Competitiveness in the Selected European Countries in the Period 2012–2015. *Social Indicators Research*, *141*(2), 841–860. https://doi.org/10.1007/s11205-018-1840-4

Dima, A. M., Begu, L., Vasilescu, M. D., & Maassen, M. A. (2018). The relationship between the knowledge economy and global competitiveness in the European Union. *Sustainability (Switzerland)*, *10*(6), 1706. https://doi.org/10.3390/su10061706

Doyle, E., & Perez-Alaniz, M. (2017). From the concept to the measurement of sustainable competitiveness: Social and environmental aspects. *Entrepreneurial Business and Economics Review*, *5*(4), 35–59. https://doi.org/10.15678/EBER.2017.050402

Dutra, A. R. A., Silva, E. S., & Cubas, A. L. V. (2019). Innovation ecosystems and measures aimed at environmental sustainability: Cidade Pedra Branca case study. *Interações*, *20*(1), 155–170. https://doi.org/10.20435/inter.v20i1.1878

Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (2018). *Global Innovation Index 2018*. Ithaca, NY; Fontainebleau, FR; Geneva, CH: Cornell University, INSEAD, and WIPO.

Engel, H., Enkvist, P.-A., & Henderson, K. (2015). *How companies can adapt to climate change*. *McKinsey Quarterly - Insights & Publications*. Retrieved from https://www.mckinsey.com/business-functions/sustainability/our-insights/how-companies-can-adapt-to-climate-change

Faustenhammer, A., & Gössler, M. (2011). Preparing for the next crisis: What can organizations do to prepare managers for an uncertain future? *Business Strategy Series*, *12*(2), 51–55. https://doi.org/10.1108/17515631111114840

Feldmann, P. R., Jacomossi, R. R., Barrichello, A., & Morano, R. S. (2019). The relationship between innovation and global competitiveness: The mediating role of management practices evaluated by structural equation modeling. *Revista Brasileira de Gestão de Negócios*, *21*(2), 195–212. Retrieved from https://rbgn.fecap.br/RBGN/article/view/3970/pdf

Fiala, N. (2008). Measuring sustainability: Why the ecological footprint is bad economics and bad environmental science. *Ecological Economics*, *67*(4), 519-525. https://doi.org/10.1016/j.ecolecon.2008.07.023

Fonseca, L. M., & Lima, V. M. (2015). Countries three wise men: Sustainability innovation, and competitiveness. *Journal of Industrial Engineering and Management*, *8*(4), 1288–1302. https://doi.org/10.3926/jiem.1525

Ford, A. (2010). *Modelling the environment* (2nd ed.). Washington, DC: Island Press.

Ford, J. A., Steen, J., & Verreynne, M. L. (2014). How environmental regulations affect innovation in the Australian oil and gas industry: going beyond the Porter hypothesis. *Journal of Cleaner Production*, *84*, 204–213. https://doi.org/10.1016/j.jclepro.2013.12.062

Giddens, A. (1991). *As conseqüências da modernidade*. São Paulo, SP: UNESP.

Gilli, M., Mazzanti, M., & Nicolli, F. (2013). Sustainability and competitiveness in evolutionary perspectives: Environmental innovations, structural change and economic dynamics in the EU. *Journal of Socio-Economics*, *45*, 204–215. https://doi.org/10.1016/j.socec.2013.05.008

Gordon, R. J. (2016). *The rise and fall of American growth : the U.S. standard of living since the Civil War*. Oxford, UK: Princeton University Press.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859),1243-1248. https://doi.org/10.1126/science.162.3859.1243

Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. (T. D. Little, Ed.) (2nd ed.). New York, NY: The Guilford Press.

Hermawan, S., & Astuti, W. (2021). Analysing several ASEAN countries' policy for combating marine plastic litter. *Environmental Law Review*, *23*(1), 9–22. https://doi.org/10.1177%2F1461452921991731

Hermundsdottir, F., & Aspelund, A. (2021). Sustainability innovations and firm competitiveness: A review. *Journal of Cleaner Production*, *280*(Part 1), 124715. https://doi.org/10.1016/j.jclepro.2020.124715

Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact - The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, *78*, 112–122. https://doi.org/10.1016/j.ecolecon.2012.04.005

Ichijo, K., & Nonaka, I. (2007). *Knowledge creation and management: New challenges for managers*. New York: Oxford University Press.

Isaac, J. C. (2019). Beyond Trump? A critique of Nancy Fraser's call for a new left hegemony. *Philosophy and Social Criticism*, *45*(9–10), 1157–1169. https://doi.org/10.1177/0191453719872293

Jacomossi, R. R., & Demajorovic, J. (2017). Determinant factors of organizational learning for environmental innovation: A multicase study. *Revista de Administração Contemporânea*, *21*(5), 685–709. https://doi.org/10.1590/1982-7849rac2017160281

Kalmakova, D., Bilan, Y., Zhidebekkyzy, A., & Sagiyeva, R. (2021). Commercialization of conventional and sustainability-oriented innovations: A comparative systematic literature review. *Problems and Perspectives in Management*, *19*(1), 340–353. https://doi.org/10.21511/ppm.19(1).2021.29

Kammerer, D. (2009). The effects of customer benefit and regulation on environmental product innovation. Empirical evidence from appliance manufacturers in Germany. *Ecological Economics*, *68*(8–9), 2285–2295. https://doi.org/10.1016/j.ecolecon.2009.02.016

Kanda, W., Hjelm, O., Clausen, J., & Bienkowska, D. (2018). Roles of intermediaries in supporting eco-innovation. *Journal of Cleaner Production*, *205*, 1006–1016. https://doi.org/10.1016/j.jclepro.2018.09.132

Kernecker, M., Seufert, V., & Chapman, M. (2021). Farmer-centered ecological intensification: Using innovation characteristics to identify barriers and opportunities for a transition of agroecosystems towards sustainability. *Agricultural Systems*, *191*(April), 103142. https://doi.org/10.1016/j.agsy.2021.103142

Klewitz, J., Zeyen, A., & Hansen, E. G. (2012). Intermediaries driving eco-innovation in SMEs: A qualitative investigation. *European Journal of Innovation Management*, *15*(4), 442–467. https://doi.org/10.1108/14601061211272376

Köhler, J., Schade, W., Leduc, G., Wiesenthal, T., Schade, B., & Espinoza, L. T. (2013). Leaving fossil fuels behind? An innovation system analysis of low carbon cars. *Journal of Cleaner Production*, *48*, 176–186. https://doi.org/10.1016/j.jclepro.2012.09.042

Lang, M., & Marsden, T. (2018). Rethinking growth: Towards the well-being economy. *Local Economy*, *33*(5), 496–514. https://doi.org/10.1177/0269094218792474

Li, A., Gao, L., Chen, S., Zhao, J., Ujiyad, S., Huang, J., ... Bryan, B. A. (2021). Financial inclusion may limit sustainable development under economic globalization and climate change. *Environmental Research Letters*, *16*(5), 054049. https://doi.org/10.1088/1748-9326/abf465

Lloret, A. (2016). Modeling corporate sustainability strategy. *Journal of Business Research*, *69*(2), 418–425. https://doi.org/10.1016/j.jbusres.2015.06.047

Marikina, M. (2018). The impact of ecological regulations and management on national competitiveness in the balkan states. *Journal of Competitiveness*, *10*(4), 120–135. https://doi.org/10.7441/joc.2018.04.08

Mathur, K., & Berwa, A. (2017). Sustainable competitiveness: Redefining the future with technology and innovation. *Journal of Sustainable Finance and Investment*, *7*(3), 290–306. https://doi.org/10.1080/20430795.2017.1300855

Melo, L. C. (2020). Economia circular é urgente. Retrieved from https://sagresonline.com.br/artigo-economia-circular-e-urgente/

Melville, N. P. (2010). Information systems innovation for environmental sustainability. *MIS Quarterly*, *34*(1), 1–21. Retrieved from https://www.misq.org/downloadable/download/linkSample/link_id/838/

Morano, R. S., Moraes, E. A. de, & Jacomossi, R. R. (2018). Can small groups avoid the tragedy of the commons? *AI and Society*, *33*(1), 71–80. https://doi.org/10.1007/s00146-017-0720-9

Moyano-Fuentes, J., Maqueira-Marín, J. M., & Bruque-Cámara, S. (2018). Process innovation and environmental sustainability engagement: An application on technological firms. *Journal of Cleaner Production*, *171*, 844–856. https://doi.org/10.1016/j.jclepro.2017.10.067

Mytelka, L. K. (2000). Local systems of innovation in a globalized world economy. *Industry and Innovation*, *7*(1), 15–32. https://doi.org/10.1080/713670244

Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, UK: The Belknap Press of Harvard University Press.

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, *13*(6), 343–373. https://doi.org/10.1016/0048-7333(84)90018-0

Pieters, R. (2017). Meaningful mediation analysis: Plausible causal inference and informative communication. *Journal of Consumer Research*, *44*(3), 692–716. https://doi.org/10.1093/jcr/ucx081

Porter, M. (1990). *The Competitive Advantage of Nations*. New York, NY: Free Press.

Porter, M., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectiv*, *9*(4), 97–118. Retrieved from https://www.jstor.org/stable/2138392

Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, *16*(2), 93–115. https://doi.org/10.1037/a0022658

Quan, X., Xiao, H., Ji, Q., & Zhang, J. (2021). Can innovative knowledge management platforms lead to corporate innovation? Evidence from academician workstations in China. *Journal of Knowledge Management*, *25*(1), 117–135. https://doi.org/10.1108/JKM-12-2019-0684

Rucker, D. D., Preacher, K. J., Tormala, Z. L., & Petty, R. E. (2011). Mediation analysis in Social Psychology: Current practices and new recommendations. *Social and Personality Psychology Compass*, *5*(6), 359–371. https://doi.org/10.1111/j.1751-9004.2011.00355.x

Salvati, L., & Carlucci, M. (2011). The economic and environmental performances of rural districts in Italy: Are competitiveness and sustainability compatible targets? *Ecological Economics*, *70*, 2446–2453. https://doi.org/10.1016/j.ecolecon.2011.07.030

Santomauro, A. C. (2020). Economia circular: Conceito protege ambiente e ajuda a reduzir custos. *Plástico Moderno*, *47*(540), 16–22.

Schumpeter, J. A. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*. Cambridge, UK: Harvard University Press.

Schwab, K. (2019). *The Global Competitiveness Report 2019*. *World Economic Forum*. Geneva, CH: World Economic Forum. https://doi.org/ISBN-13:978-92-95044-73-9

Schwab, K., Sala-i-Martín, X., & Brende, B. (2013). *The Global Competitiveness Report, 2013-2014*. Geneva, CH: World Economic Forum. https://doi.org/10.5860/choice.44-5759

Schwab, K., Sala-i-Martín, X., Eide, E. B., & Blanke, J. (2014). *The Global Competitiveness Report, 2014-2015*. Geneva, CH: World Economic Forum. https://doi.org/10.5860/choice.44-5759

Schwab, K., Sala-i-Martín, X., & Samans, R. (2017). *The Global Competitiveness Report 2017 - 2018*. Geneva, CH: World Economic Forum.

Schwab, K., Sala-i-Martín, X., Samans, R., & Blanke, J. (2015). *The Global Competitiveness Report, 2015-2016*. Geneva, CH: World Economic Forum. https://doi.org/10.5860/choice.44-5759

Schwab, K., Sala-i-Martín, X., Samans, R., & Blanke, J. (2016). *The Global Competitiveness Report 2016 - 2017*. Geneva, CH: World Economic Forum. https://doi.org/92-95044-35-5

Sekerka, L. E., & Stimel, D. (2011). How durable is sustainable enterprise? Ecological sustainability meets the reality of tough economic times. *Business Horizons*, *54*(2), 115–124. https://doi.org/10.1016/j.bushor.2010.09.006

Silva, B. A. da, Constantino, M., Oliveira, O. S. de, Santos, S. A. L. dos, Tabak, B. M., & Costa, R. B. da. (2019). New indicator for measuring the environmental sustainability of publicly traded companies: An innovation for the IPAT approach. *Journal of Cleaner Production*, *215*, 354–363. https://doi.org/10.1016/j.jclepro.2019.01.039

Soares, E. C., & Hansen, P. B. (2014). The overlap, gaps and relations between the competitiveness of elements and cities of sustainability. *Revista de Administração de Roraima-RARR*, *4*(2), 74–96.

Spezamiglio, B. dos S., Galina, S. V. R., & Calia, R. C. (2016). Competitiveness, innovation and sustainability: an interrelation through literature sistematization. *REAd. Revista Eletrônica de Administração*, *22*(2), 363–393. https://doi.org/10.1590/1413-2311.009162016.62887

Stavropoulos, S., Wall, R., & Xu, Y. (2018). Environmental regulations and industrial competitiveness: Evidence from China. *Applied Economics*, *50*(12), 1378–1394. https://doi.org/10.1080/00036846.2017.1363858

Sukumar, A., Jafari-Sadeghi, V., Garcia-Perez, A., & Dutta, D. K. (2020). The potential link between corporate innovations and corporate competitiveness: evidence from IT firms in the UK. *Journal of Knowledge Management*, *24*(5), 965–983. https://doi.org/10.1108/JKM-10-2019-0590

Tan, Y., Ochoa, J. J., Langston, C., & Shen, L. (2015). An empirical study on the relationship between sustainability performance and business competitiveness of international construction contractors. *Journal of Cleaner Production*, *93*, 273–278. https://doi.org/10.1016/j.jclepro.2015.01.034

Torres, L. B., Pagnussatt, T. B., & Severo, E. A. (2017). A inovação como fonte para vantagem competitiva nas organizações: uma revisão sistemática da literatura. *Revista Gestão Inovação e Tecnologias*, *7*(4), 4028–4043. https://doi.org/10.7198/geintec.v7.i4.1022

Veggeberg, B. E., Delabre I., & Jespersen, K. (2021). *Businesses are finally committing to protecting forests: But how are local livelihoods affected?* (Centre for Business and Development Studies). Copenhagen. Retrieved from https://research.cbs.dk/en/publications/businesses-are-finally-committing-to-protecting-forests-but-how-a

Wendling, Z. A., Emerson, J. W., Esty, D. C., Levy, M. A., & Sherbinin, A. d. (2018). *2018 Environmental Performance Index*. New Haven, CT: Yale Center for Environmental Law & Policy. Retrieved from https://epi.yale.edu/downloads/epi2018policymakerssummaryv01.pdf

Woetzel, J. R., & Joerss, M. (2009). *China' s green revolution*. *McKinsey Quarterly*. Retrieved from https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/Sustainability/cost%20curve%20PDFs/china_green_revolution.ashx

Woodworth, R. S. (1926). Dynamic Psychology. *The Pedagogical Seminary and Journal of Genetic Psychology*, *33*(1), 103–118. https://doi.org/10.1080/08856559.1926.10532344

Wu, C.-H., Tsai, S.-B., Liu, W., Shao, X.-F., Sun, R., & Wacławek, M. (2021). Eco-technology and eco-innovation for green sustainable growth. *Ecological Chemistry and Engineering S.*, *28*(1), 7–10. https://doi.org/10.2478/eces-2021-0001

Zhan, Y., Tan, K. H., Ji, G., & Tseng, M.-L. (2018). Sustainable Chinese manufacturing competitiveness in the 21st century: Green and lean practices, pressure and performance. *International Journal of Computer Integrated Manufacturing*, *31*(6), 523–536. https://doi.org/10.1080/0951192X.2016.1268721

Zhang, Y., Khan, U., Lee, S., & Salik, M. (2019). The influence of management innovation and technological innovation on organization performance. A mediating role of sustainability. *Sustainability*, *11*(2), 495. https://doi.org/10.3390/su11020495

Authors' contributions

1st author: conceptualization (equal), data curation (equal), funding acquisition (equal), methodology (equal), project administration (equal) resources (equal), supervision (lead), visualization (equal), writing – original draft (equal), writing – review & editing (equal).

2nd author: conceptualization (equal), funding acquisition (equal), project administration (equal), resources (equal), visualization (equal), writing – original draft (equal), writing – review & editing (equal).

3rd author: conceptualization (equal), data curation (equal), formal analysis (equal), funding acquisition (equal), investigation (equal), methodology (lead), resources (equal), software (supporting), validation (equal), visualization (equal), writing – review & editing (equal).

4th author: Conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), resources (equal), software (supporting), validation (equal), visualization (equal), writing – review & editing (equal).

Authors

Rafael Ricardo Jacomossi
Centro Universitário FEI, Departamento de Administração
Rua Tamandaré, 688, Liberdade, 01525-001, São Paulo, SP, Brazil
rjacomossi@fei.edu.br
https://orcid.org/0000-0001-5584-142X

Paulo Roberto Feldmann
Universidade de São Paulo, Faculdade de Economia, Administração e Contabilidade
Av. Prof. Luciano Gualberto, 908, Butantã, 5508-010, São Paulo, SP, Brazil
feldmann@usp.br
https://orcid.org/0000-0001-5662-8735

Alcides Barrichello*
Universidade Presbiteriana Mackenzie, Centro de Ciências Sociais e Aplicadas
Rua da Consolação, 930, Consolação, 01302-000, São Paulo, SP, Brazil
alcidesbarrichel@uol.com.br
https://orcid.org/0000-0003-1531-3651

Rogério Scabim Morano
Universidade Federal de São Paulo, Instituto de Ciência e Tecnologia, Instituto de Ciências Ambientais, Químicas e Farmacêuticas
Rua São Nicolau, 210 – Sala 41 (4º andar), 09913-030, Diadema, SP, Brazil
r.morano@unifesp.br
https://orcid.org/0000-0002-3233-0843

* Corresponding author

Peer review is responsible for acknowledging an article's potential contribution to the frontiers of scholarly knowledge on business or public administration. The authors are the ultimate responsible for the consistency of the theoretical references, the accurate report of empirical data, the personal perspectives, and the use of copyrighted material.
This content was evaluated using the double-blind peer review process. The disclosure of the reviewers' information on the first page is made only after concluding the evaluation process, and with the voluntary consent of the respective reviewers.

APPENDIX A

Table A1

Countries/regions from GCR/GII database

Region	Country
East Asia and the Pacific (15)	Australia
	Brunei Darussalam
	Cambodia
	China
	Hong Kong SAR
	Indonesia
	Japan
	Korea, Rep.
	Malaysia
	Mongolia
	New Zealand
	Philippines
	Singapore
	Thailand
	Vietnam
Eurasia (9)	Armenia
	Azerbaijan
	Georgia
	Kazakhstan
	Kyrgyz Republic
	Moldova
	Russian Federation
	Tajikistan
	Ukraine
Latin America and the Caribbean (17)	Argentina
	Brazil
	Chile
	Colombia
	Costa Rica
	Dominican Republic
	Ecuador
	El Salvador
	Guatemala
	Honduras

Continues

Table A1 (continued)

Region	Country
Latin America and the Caribbean (17)	Jamaica
	Mexico
	Panama
	Paraguay
	Peru
	Trinidad and Tobago
	Uruguay
Europe (36)	Albania
	Austria
	Belgium
	Bosnia
	Bulgaria
	Croatia
	Cyprus
	Czech Republic
	Denmark
	Estonia
	Finland
	France
	Germany
	Greece
	Hungary
	Iceland
	Ireland
	Italy
	Latvia
	Lithuania
	Luxembourg
	Malta
	Montenegro
	Netherlands
	Norway
	Poland
	Portugal
	Romania
	Serbia
	Slovak Republic
	Slovenia

Continues

Table A1 (continued)

Region	Country
Europe (36)	Spain
	Sweden
	Switzerland
	Turkey
	United Kingdom
Middle East and North Africa (15)	Algeria
	Bahrain
	Egypt
	Iran, Islamic Rep.
	Israel
	Jordan
	Kuwait
	Lebanon
	Morocco
	Oman
	Qatar
	Saudi Arabia
	Tunisia
	United Arab Emirates
	Yemen
Sub-Saharan Africa (20)	Benin
	Botswana
	Cameroon
	Ghana
	Guinea
	Kenya
	Madagascar
	Malawi
	Mali
	Mauritius
	Mozambique
	Namibia
	Nigeria
	Rwanda
	Senegal
	South Africa
	Tanzania
	Uganda

Continues

Table A1 (continued)

Region	Country
Sub-Saharan Africa (20)	Zambia
	Zimbabwe
North America (2)	Canada
	United States
South Asia (5)	Bangladesh
	India
	Nepal
	Pakistan
	Sri Lanka

Note. Based on Schwab, K., Sala-i-Martín, X., & Samans, R. (2017). The Global Competitiveness Report 2017-2018. Geneva, CH: World Economic Forum and Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (2018). Global Innovation Index 2018. Ithaca, NY; Fontainebleau, FR; Geneva, CH: Cornell University, INSEAD, and WIPO.