RELISE

SUSTAINABILITY AND INNOVATION: TRENDS AND REFLECTIONS[1]

SUSTENTABILIDADE E INOVAÇÃO: TENDÊNCIAS E REFLEXÕES

Sérgio Luis Dias Doliveira[2]

Adriana Queiroz Silva[3]

Flavia Massuga[4]

ABSTRACT

This study seeks to contribute to the understanding of sustainability and innovation and its consequences, based on a survey of works and research developed in this area of knowledge. For this purpose, a systematic literature review was conducted, applying the Methodi Ordinatio to the research databases Science Direct, Scopus and Scientific Electronic Library Online (Scielo). In total, 105 studies were assessed quantitatively and qualitatively, revealing trends and directions. The results show that the relevance and interest in the theme have increased and confirm the relationship between sustainability and innovation. Thematic clusters evidenced in the studies are also described, which mediate the discussions on innovation and sustainability, mainly encompassing business models, paths and predictors of sustainable innovation, open innovation and partnerships with stakeholders, supply chain management, economic performance, systems perspective, dynamic capabilities, and theoretical concepts and models with emphasis on frugal innovation.

Keywords: innovation, sustainability, sustainable innovations, management, organizations.

RESUMO

Este estudo busca contribuir na compreensão da sustentabilidade e inovação e seus desdobramentos, a partir de um levantamento de trabalhos e pesquisas desenvolvidas nesta área de conhecimento. Para esse propósito, foi conduzida uma revisão sistemática de literatura, a partir do *Methodi Ordinatio* nas bases

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[2] Universidade Estadual do Centro-Oeste. sldd@uol.com.br
[3] Universidade Estadual do Centro-Oeste. aqueirozsilva@uol.com.br
[4] Universidade Estadual do Centro-Oeste. flavia.massuga@gmail.com

de pesquisa *Science Direct, Scopus* e *Scientific Electronic Library Online (Scielo).* Ao total, 105 estudos foram avaliados, quantitativamente e qualitativamente, possibilitando a evidenciação de tendências e direcionamentos. Os resultados apontam para um crescimento da relevância e preocupações com a temática e confirmam a relação entre sustentabilidade e inovação. Ainda, são descritos clusters temáticos evidenciados nos estudos e que realizam a mediação das discussões sobre inovação e sustentabilidade abrangendo principalmente: modelos de negócios, caminhos e preditores da inovação sustentável, inovação aberta e parcerias com stakeholders, gestão da cadeia de suprimento, desempenho econômico, perspectiva de sistemas, capacidades dinâmicas e conceitos e modelos teóricos com destaque à inovação frugal.

Palavras-chaves: inovação, sustentabilidade, inovações sustentáveis, gestão, organizações.

INTRODUCTION

The context of increasing concern with sustainability has been not only measured and perceived over the last 30 or 40 years; it is also changing. Contemporaneity has not solved social inequality or hunger for significant parts of the population (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS [FAO], 2022). Thus, these hardships have not diminished, but they perhaps have aided in mitigating, discreetly, the possibility of an environmental catastrophe (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION [NASA], 2023). It is noticeable that these obstacles and situations of civilization remain (THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], 2022). They are examined from several perspectives, especially because they permeate a socio-technical transformation (MARKARD, 2020). Therefore, sustainability has become an area that integrates and proposes relevant solutions that should be investigated.

Organizations, inserted into a broader social system and curtailed by institutional pressures, must reassess their priorities and goals, aiming to meet

not only corporate needs but also the current social and environmental demands (BARBIERI *et al.,* 2010; ALMEIDA; MELO, 2016; DU; BSTIELER; YALCINKAYA, 2022). This sustainability is better attained through innovations, which is corroborated by investigations in the field of study (KUZMA *et al*., 2020). For instance, Mousavi and Bossink (2017) state that innovation is one of the paths through which companies can contribute to sustainable development. Dyck and Silvestre (2018) similarly comment on how essential organizational innovation is for facing society's socio-ecological crises.

Given the already confirmed relationship between innovation and sustainability, it is possible to observe and indicate some trends over the last years based on the literature produced, considering the correlation between innovation and the Triple Bottom Line (TBL) of sustainability, especially because innovation goes hand in hand with social, environmental, and economic solutions (ELKINGTON, 1999; DOLIVEIRA *et al.,* 2018). Thus, we aim to review the leading publications in the period and assess the current trends and directions of the discussion. We also seek to understand how the main proposals and directions for solving the current social and environmental problems are establishing themselves, as well as identifying the ones that require better structures.

To achieve our goal, we conducted a systematic literature review employing the Methodi Ordinatio, which rates scientific papers according to their relevance in the field of study. The selected papers were assessed through two processes: 1) a quantitative analysis of the relevant studies selected; 2) a qualitative analysis of the themes and directions identified, focusing on the ten papers regarded as the most relevant by the methodology. The following sections present the theoretical framework and methodology, followed by the research findings.

THEORETICAL FRAMEWORK

Transformations of sustainability and sustainable development

The concern with sustainability has consolidated itself over the years as increasingly more necessary and relevant (BARBIERI *et al.*, 2010; CLARO; CLARO; AMANCIO, 2008; KLARIN, 2018). It comprises human civilization problems that require reflection and investigation so as to understand them from a more dynamic and systemic perspective. Thus, sustainability has become a field of knowledge that contributes to understanding phenomena such as poverty, environmental destruction, and social inequality. It also seeks solutions to mitigate those problems, especially through innovative processes. Most of these obstacles have reached greater intensity since the Industrial Revolution in the 18th century (DOLIVEIRA *et al.*, 2018; LYNCH, 2019).

The beginning of the 1970s, due to several discussions regarding population growth and environmental chaos related to the difficulty of reconstituting and recovering natural resources (SACHS, 1986), saw the birth of the proposal for sustainable development. The observations at the time indicated that the style of social development of the period would not be able to contemplate everyone due to the limitations of natural resources. This perspective triggered a different, necessary understanding that things could be conducted less aggressively towards the environment and individuals (BLACKBURN, 2007).

This manner of reflecting, investigating, and proposing alternatives has consolidated itself in the context of the observed transformations that may affect human survival in our ecosystem. Life can develop with the proper quality within what is possible to change in a consumption-based society (NADAL *et al.,* 2020). However, it is crucial to reassess the priorities and methods to obtain such quality of life. The notion of preserving current resources so that future

generations have the same conditions to survive is the mantra of sustainable development, proposed by the World Commission on Environment and Development (WCED, 1991). This proposal has been consolidated, but it also has worn itself out over time, assuming different meanings from the one originally defined (FRANCO *et al.*, 2020).

In this process of construction and reconstruction of sustainability, some transformations are reflected in the experiments developed and in the search for models or methods to find possible solutions and technologies (PLANKO *et al.*, 2016). In this context, organizations also seek to commit themselves to this perspective, aware of the relations and impacts caused by their activities and consequently seeking solutions and changes according to the new principles of sustainability and sustainable development (BERNAL; EDGAR; BURNES, 2018). Corporate strategies must be adapted, especially in research and development, taking into account the interests of the involved parties, the preservation of environmental resources, and the conditions of living in society necessary for the future (ALMEIDA; MELO, 2016). This remodeling also generates opportunities for organizations, which can replace polluting and costly technologies, creating simultaneous economic gains (DANGELICO; DEYASHISH; PONTRANDOLFO, 2016; LE; IKRAM, 2022). Seeking products, processes, and experiences that change the understanding about the desired solutions to attain more balance within the three pillars of sustainability is the great challenge laid before them (SPEZAMIGLIO; GALINA; CALIA, 2016).

Innovation: axis of transformation

Innovation has offered a fundamental contribution to this discussion, simultaneously playing the role of savior and destroyer. Innovation proposes solutions that have provided better living conditions for humans today, such as longer life expectancy, but it also greatly consumes natural resources, pollutes

several ecosystems, causes large-scale unemployment, and creates the need for social reorganization. For a long time, technological development meant economic growth at any cost, with no concerns with depleting the planet's resources and its capability to recover from the inappropriate use of the environment (MICHELINO *et al.*, 2019). Nowadays, however, innovation has become an engine for possibilities and improvements in several different areas, aiding the adaptation process for resource use and improving life conditions in society (HANSEN; BULLINGER; REICHWALD, 2011). These contributions linked to innovation, allied with the balance linked to sustainability, create several improvements or reliefs in social, environmental, and economic aspects (KUASOSKI *et al.*, 2020).

The strength of the link between innovation and sustainability is increasingly more evident (MICHELINO *et al.*, 2019). Studies indicate that the relationship between innovation and sustainability is clear, with innovation being crucial to enhancing sustainability performance (LUQMANI *et al.*, 2017; MOUSAVI, BOSSINK, 2017; DYCK; SILVESTRE, 2018; KUZMA *et al.*, 2020; DU; BSTIELER; YALCINKAYA, 2022). Investments in Sustainability-Oriented Innovation (SOI) have become a natural consequence in the proposal of new products and processes in the literature, which reflects a new way of thinking about the solutions demanded by society (KENNEDY; WHITEMAN; ENDE, 2017).

Innovation occurs largely through product development. However, other types exist, such as organizational, business, social, and process innovation, constituting classifications still little understood in their complexity (PEDRO FILHO *et al*., 2017). It is worth noting that innovation does not occur exclusively through technological changes, even though they are an important tool to achieve sustainability (ADAMS *et al.,* 2016). Changes take place in procedures, practices, and even in business models, transforming regulatory standards and

thus the behavior of individuals and their way of viewing the world and reacting to new configurations (SZEBELY; STREBEL, 2013).

These reformulations take place in a context in which innovation occurs and gains strength as one of the catalysts of industrial growth and originators of countless socio-environmental issues (HALL; VREDENBURG, 2003). The visible consequence, indicated on several occasions, is the incentive to excessive consumption. Another possible effect, to a certain extent, is the climate problems faced more intensely in the last few decades, considering the observations from numerous climate studies from different research centers (SACHS, 1986; NASA, 2020).

It is also worth pointing that innovation usually occurs in two basic ways. The first is incremental innovation, which originates in improvements or small enhancements to a product, production process, structure, equipment, or production resources (MOUSAVI; BOSSINK, 2017). The second is radical innovation, also known as disruptive, which presents itself as a completely new product or process. This model comprises a profound transformation of the entire system, creating unprecedented products that require new, different supply chains. These solutions for problems or necessities are different from the ones employed as the solution to a problem that was previously solved in a less elaborate way (CHRISTENSEN; RAYNOR; McDONALD, 2015). An example of a disruptive solution was the creation of medicines for treating infections, like penicillin and other types of antibiotics that did not exist until decades ago. These new types of medication broke the system that previously existed, forming a novel one with a new supply chain, production processes, and jobs.

In general, social and environmental matters, still emergent in the current context, demand sustainability-oriented practices and remodeling from organizations. Meanwhile, innovation can be regarded as a key to promoting solutions economically, socially, and environmentally viable in this context.

METHODOLOGY

To assess the trends and discussions concerning the themes of innovation and sustainability, we employed the Methodi Ordinatio methodology, which uses the Ordinatio Index equation to rank papers according to their relevance, considering the journal's impact factor, the number of citations, and the year of publication (PAGANI; KOVALESKI; RESENDE, 2015; 2017).

In this systematic literature review, we searched for scientific papers published between the yeard 2016 to 2020 in the electronic research databases Science Direct, Scopus, and Scientific Electronic Library Online (Scielo).

The descriptors employed in the search were "*sustentabilidade*" OR "*desenvolvimento sustentável*" OR *sustentáv** in the AND combination with "*inovação*". Furthermore, we discarded "*Eco-innovation*" from the results for it does not fully encompass the concept of sustainability, seeing that it consists of new technologies that improve economic and environmental performance, overlooking the social pillar (CARRILLO-HERMOSILLA; GONZALES; KONNOLA, 2009). The descriptors above were also employed in their translation into English. The filters for titles and only papers were applied. The search returned 1046 studies, following the distribution presented in Chart 1.

Chart 01 – Search results according to the descriptors in each database.

DESCRIPTORS	DATABASES			
	Science Direct	Scopus	Scielo	Total
(sustentabilidade OR "desenvolvimento sustentável" OR sustantáv*) AND inovação AND NOT ecoinovação	0	7	11	18
(sustainability OR "sustainable development" OR sustainable) AND innovation AND NOT eco-innovation	253	683	92	1028
Total	253	690	103	**1046**

Source: Research data.

The analysis adopted the following criteria:

- Inclusion: 1) papers published in Portuguese, English, and Spanish; and 2) papers with qualitative or quantitative methodology, whose content

integrates the themes of innovation and sustainability in secondary sector organizations.

- **Exclusion**: 1) duplicate papers; 2) papers published in conferences or other works that were not research papers; 3) papers whose title, abstract, or keywords were not related to the theme in question; 4) papers essentially focusing on bibliometrics and review that did not present concepts or conceptual models; 5) papers that approached innovation from a non-sustainable perspective; 6) papers that approach sustainability or innovation as secondary themes; 7) papers that approach the themes of innovation and sustainability in an unrelated manner; 8) papers that did not fully encompass the concept of sustainability; 9) papers that restrict innovation to terms like “social innovation” or “green innovation”; 10) papers centered around eco-innovation; 11) papers that focus on measuring the level of sustainable innovation; 12) papers that view sustainability in the sense of sustainable competitiveness.

Results of the selection of papers

Employing the Zotero software, we removed 146 duplicate papers, leaving 900 studies to be assessed in terms of title, abstract, and keywords, following the criteria established. After reading these elements, we selected 176 papers to undergo the InOrdinatio scientific relevance analysis (PAGANI; KOVALESKI; RESENDE, 2015; 2017), according to the following equation.

$$InOrdinatio = (Fi/1000) + a^* [10 – (AnoPesq – AnoPub)] + (\Sigma Ci)$$

In the equation, “Fi” corresponds to the journal’s impact factor; “a*” is a coefficient that corresponds to the relevance of the year of publication, ranging from 1 to 10 and assigned by the researcher; “AnoPesq” refers to the year in which the review is conducted, whereas “AnoPub” refers to the year of publication of each paper; and “Ci” corresponds to the number of citations of each paper. In this review, we attributed a weighting factor of 5 to a*, seeing that

the relevance of the year of publication was already considered during the search. The impact factor of publications was determined through the Journal Citation Reports (JCR) ranking and the number of citations was obtained on the Google Scholar platform. These data were organized into a Microsoft Excel spreadsheet to apply the equation. After the calculations, we selected the works that presented scores higher than 50 (InOrdinatio > 50), which returned a total of 105 papers to be analyzed. For a better understanding, the methodological path of the Methodi Ordinatio, adopted by this study, is represented in Figure 1.

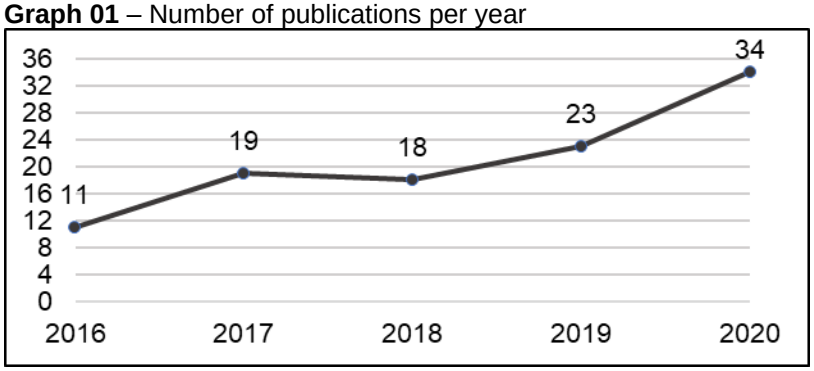
The following section presents the results in two stages. The first, quantitative, aims to present an overview of years of publication, recurring journals, the number of citations per journal, authors, institutions, countries, methodologies, and activity sectors approached. The second, qualitative, seeks to illustrate the directions of the papers through the formation of theme clusters, focusing on the ten most relevant papers, according to the method employed.

RESULTS AND DISCUSSIONS

Quantitative analysis

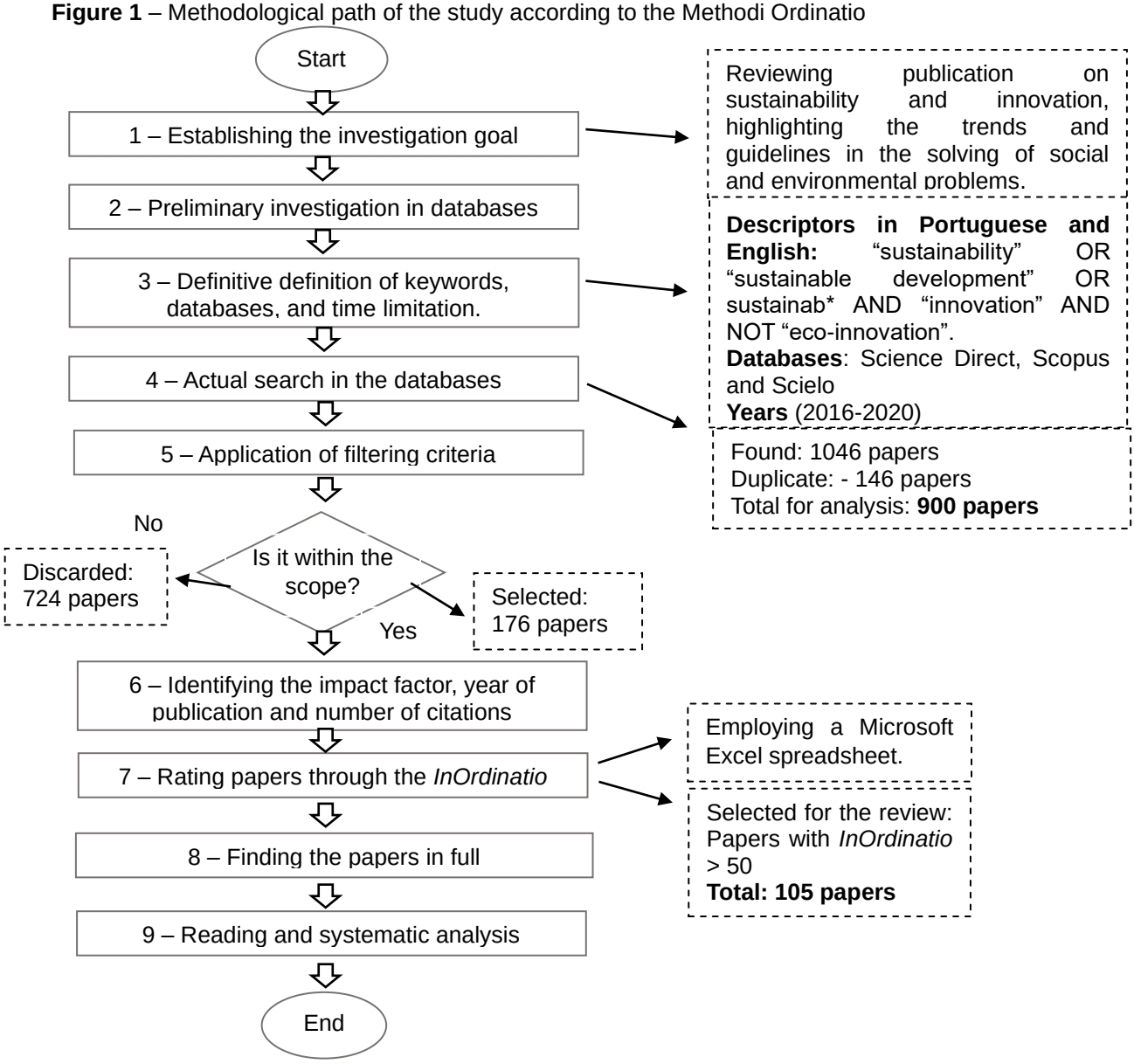
The review selected 105 papers, which revealed some significant information to be considered. Observing the years of publication, we find a tendency of growth over the period investigated, as shown in Graph 1.

Graph 01 – Number of publications per year



Source: Research data.

Figure 1 – Methodological path of the study according to the Methodi Ordinatio



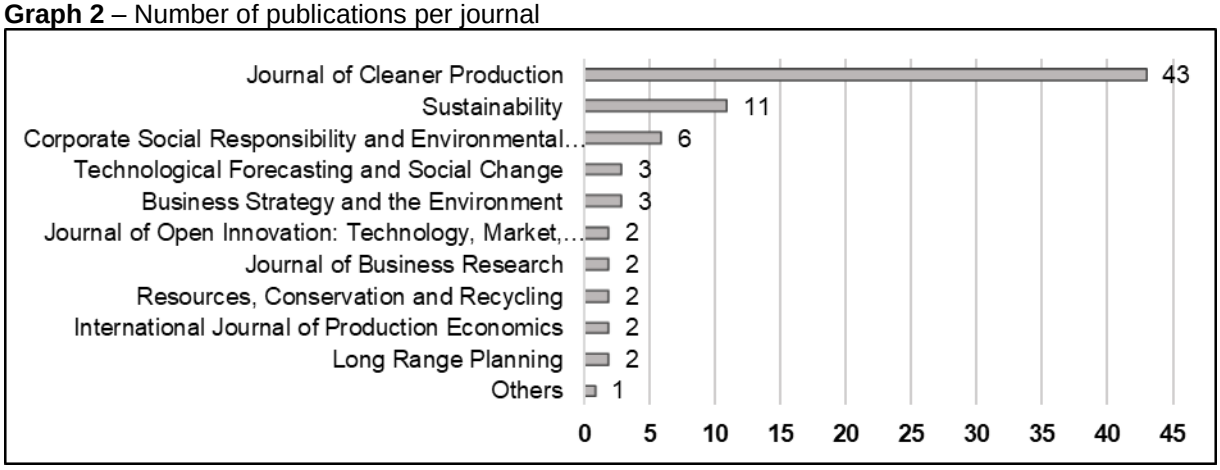
Source: Adapted from Pagani, Kovaleski and Resende (2015).

The line displays the number of papers over the years, revealing that more studies were conducted in the last two years of the period examined. This information shows that the experiments and observations have been increasing,

which indicates that the concerns discussed and addressed by sustainability and innovation are growing in relevance.

Regarding the journals with the highest concentration of publications about the theme, we observe that the Journal of Cleaner Production leads with 41% of the papers selected by the review. It is followed by the journals Sustainability and Corporate Social Responsibility and Environmental Management, with 10.5% and 5.7% of the papers, respectively. The other journals identified are homogeneous in this criterion, presenting three publications at most, which reveals a concentration of publications that requires more development from the other journals of this field. Graph 2 presents a better look at these data.

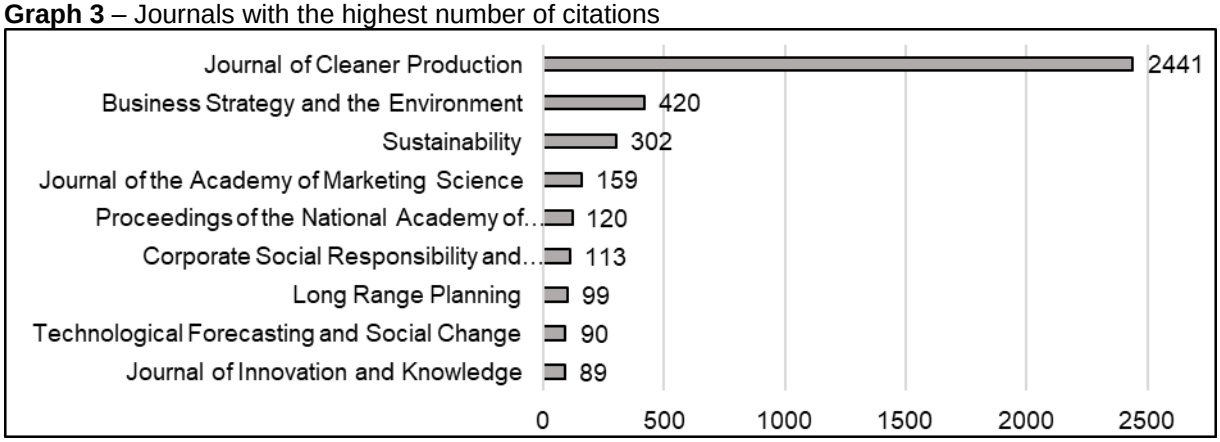
Graph 2 – Number of publications per journal



Source: Research data.

We identify something similar when observing the number of citations per journal. The Journal of Cleaner Production stands out again, with 2,441 citations, almost five times more than the journal Business Strategy and the Environment, which is the second highest-ranked with 420 citations, as shown in Graph 3. These data illustrate the dominance of a journal that has consolidated itself with a high impact in the sustainability area (KUZMA *et al.*, 2020). Undoubtedly, the other journals should present more consistency to reflect the importance of this field of study.

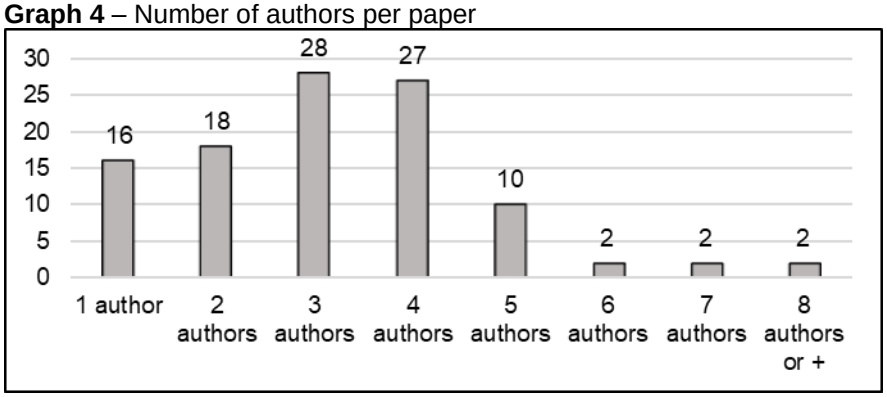
Graph 3 – Journals with the highest number of citations



Source: Research data.

Regarding authorship, Graph 4 shows that, in general, authors form partnerships to conduct the studies and write the papers, predominantly in groups of three or four authors working together (26.7% and 25.7%, respectively).

Graph 4 – Number of authors per paper



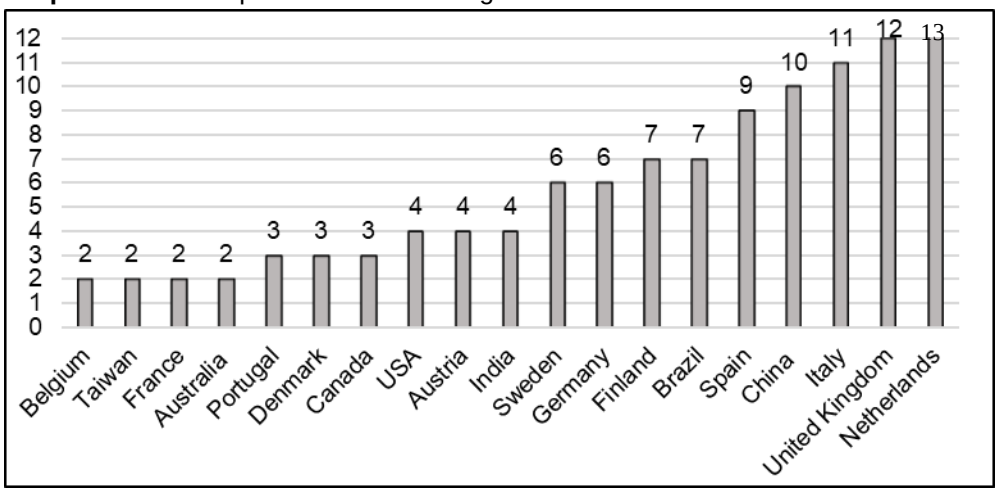
Source: Research data.

The findings also reveal that there is not a concentration of few researchers in the publications. Among the 291 authors identified, only 1.4% participate in three different studies (Bocken, Iñigo, Albareda, and Gupta), while 6.2% take part in two papers (Evans, Vladimirova, Yang, Silvestre, Rauter, Globocnik, Baumgartner, Pansera, Sarkar, Cagliano, De, Chowdhury, Hekkert, Bogers, Sarpong, Dey, Bossink, Kusi-Sarpong). The same occurs with the

universities to which the authors belong, with only the Sapienza University of Rome standing out with three publications.

In terms of geographic distribution, five countries stand out: the United Kingdom (12 publications), Italy (11 publications), China and the Netherlands (10 publications each), and Spain (9 publications). They are followed by Brazil and Finland, with seven papers each, and Germany and Sweden, with six, as shown in Graph 5.

Graph 5 – Most frequent countries of origin of the authors



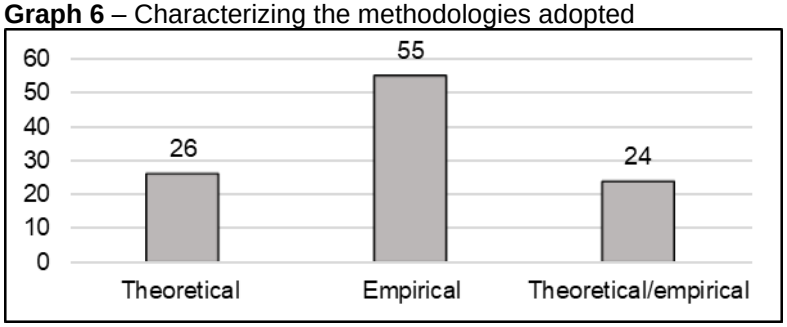
Source: Research data.

The results point to a prevalence of studies in developed and emerging countries, revealing that large economies are more concerned with the subject. Indeed, their greater technological development allows for more advances related to sustainable innovations (KILKIS, 2016; GUPTA; KUSI-SARPONG; REZAEI, 2020; OMRI, 2020). However, further investigations are required to confirm this observation.

Concerning their methodologies, 52.4% of the selected studies developed empirical studies, analyzing a specific object of study through case studies, field studies, or surveys, for instance. On the other hand, 24.8% of the works focus on bibliographic research and the construction of concepts and

models. Finally, 22.8% mixed both approaches, constructing theoretical models and validating them through case studies.

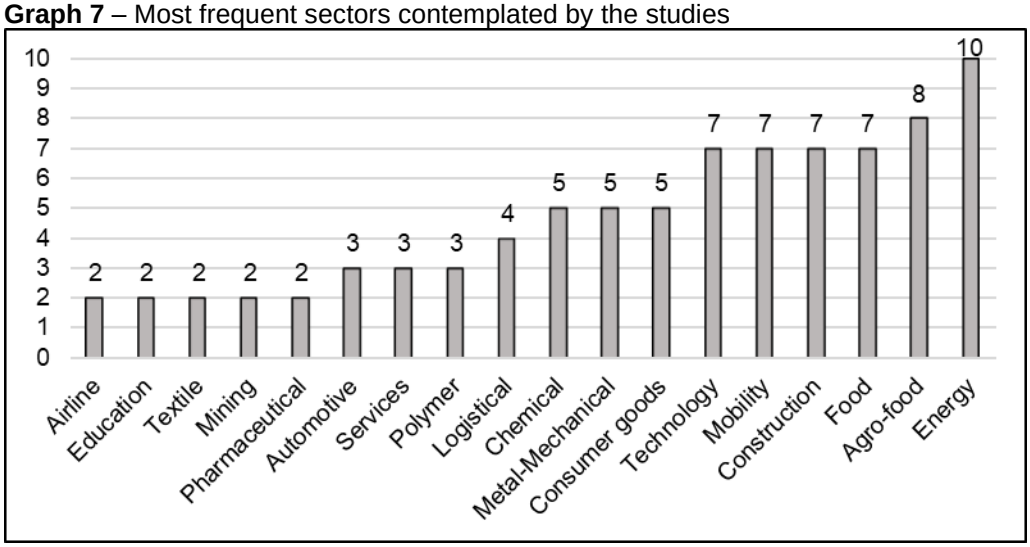
Graph 6 – Characterizing the methodologies adopted



Source: Research data.

In the theoretical-empirical and empirical studies that specified their case studies, we observe the diversity of sectors/segments encompassed. Graph 7 presents the most frequent sectors contemplated by the papers. It is worth mentioning that a few studies examine more than one economic sector.

Graph 7 – Most frequent sectors contemplated by the studies



Source: Research data.

These findings reveal more intense concerns with sustainable innovations in the energy, agro-food, food, construction, mobility, and technology sectors, which are crucial for meeting the demands of the 21st

century. Graph 7 did not display the sectors mentioned only once, including sanitation, recycling, capital goods, and healthcare.

Qualitative analysis

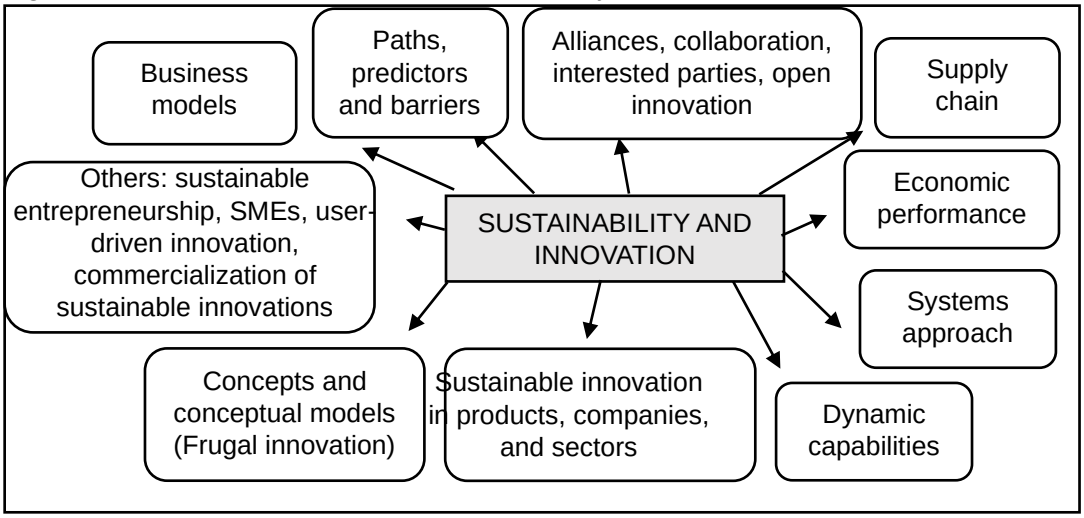
To understand the trends and adopted approaches in the selected studies about innovation and sustainability, Table 1 details the goals, employed methodology, and developed proposals of the ten most relevant papers, according to the InOrdinatio ranking. The themes identified were separated into clusters, as shown in Figure 3, through the extraction of information from the papers aided by the word cloud formed employing the titles, goals, and main findings of the selected studies, as shown in Figure 2.

Figure 2 – Word cloud formed by the studies selected

Source: the authors[5].

5 Elaborated employing the applications infogram (https://infogram.com/) and Word Cloud Generator (https://www.jasondavies.com/wordcloud/)

Figure 03 – Theme clusters related to sustainability and innovation



Source: the authors.

Table 1 – Detailing the ten most relevant articles on the theme according to the InOrdinatio

(Continues)

	InOrdinatio	**Authors/Year**	**Title**
1	455.483	Evans *et al*., (2017)	Business model innovation for sustainability: towards a unified perspective for creation of sustainable business models
Goals		**Methodology**	**Main Results**
Developing a unified theoretical perspective to understand business model innovations that lead to better sustainability performance.		Bibliographic research	It presents five propositions that support the creation of Sustainable Business Models and implications for companies that seek innovation in terms of sustainable business models, suggesting simulation as an experimentation method and highlighting the need for considering multiple metrics: financial, environmental, and social, as well as including the stakeholders' interests to assess the impact of innovation on the business model.
	InOrdinatio	**Authors/Year**	**Title**
2	424.133	Ceschin and Gaziulusoy (2016)	Evolution of design for sustainability: From product design to design for system innovations and transitions
Goals		**Methodology**	**Main Results**
Proposing an overview of the evolution structure and mapping the approaches of Design for Sustainability (DfS).		Bibliographic research and multilevel analysis	It illustrates a transformation of the concern with sustainability, from a perspective geared toward product/service to a socio-technical change. This view is expanding and configuring itself as a systemic process of behavioral change and the search for innovation and solutions for problems like poverty, social inequality, and other difficulties of today's society.

Table 1 – Detailing the ten most relevant articles on the theme according to the InOrdinatio

(Continues)

3	256.651	Yang *et al*., (2017)	Value uncaptured perspective for sustainable business model innovation
Goals		**Methodology**	**Main Results**
Proposing an overview of the evolution structure and mapping the approaches of Design for Sustainability (DfS).		Bibliographic research and multilevel analysis	It illustrates a transformation of the concern with sustainability, from a perspective geared toward product/service to a socio-technical change. This view is expanding and configuring itself as a systemic process of behavioral change and the search for innovation and solutions for problems like poverty, social inequality, and other difficulties of today's society.
	InOrdinatio	**Authors/Year**	**Title**
4	243.651	Baldassarre *et al*. (2017)	Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design
Goals		**Methodology**	**Main Results**
Combining the principles of sustainable business model and user-driven innovation.		Action research / design methodology	It provides a structure that combines sustainable business model innovation with user-driven innovation to face sustainable development challenges through value proposals that blend social, economic, and environmental goals.
	InOrdinatio	**Authors/Year**	**Title**
5	239.651	França *et al*., (2017)	An approach to business model innovation and design for strategic sustainable development
Goals		**Methodology**	**Main Results**
Understanding how the Structure for Strategic Sustainable Development may support business model innovation and design.		Bibliographic research, case study (conceptual modeling and prototyping)	The combination between the Structure for Strategic Sustainable Development and the Business Model Canvas revealed itself efficient to support business model innovation and design for strategic sustainable development.
	InOrdinatio	**Authors/Year**	**Title**
6	217.651	Rosca, Arnold and Bendul (2017)	Business models for sustainable innovation – an empirical analysis of frugal products and services
Goals		**Methodology**	**Main Results**
Describing the relationship between frugal innovation, reverse innovation, sustainability, and business models in this context.		Multiple-case study	Organizations that offer frugal and reverse products and services are able to combine business model elements discerningly and create economic, social, and environmental value.
	InOrdinatio	**Authors/Year**	**Title**

Table 1 – Detailing the ten most relevant articles on the theme according to the InOrdinatio

(Conclusion)

7	196.959	Varadarajan (2017)	Innovating for sustainability: a framework for sustainable innovations and a model of sustainable innovations orientation
Goals		**Methodology**	**Main Results**
Describing the potential paths for sustainable innovation and the factors related to the companies oriented to sustainable innovations.		Bibliographic research	Coercive, mimetic, and normative pressures lead companies to adopt similar strategies, structures, and processes. Larger organizations, more global, with good or bad reputation, that compete in industries that cause greater impacts on the environment, whose suppliers are more involved with sustainability, within a market with a larger customer base, are more oriented toward sustainable innovations.
	InOrdinatio	**Authors/Year**	**Title**
8	164.651	Silvestre and Ţîrcă (2019)	Innovations for sustainable development: Moving toward a sustainable future
Goals		**Methodology**	**Main Results**
Reviewing the literature and proposing a classification for sustainable development innovation.		Bibliographic research	It presents a classification with four different types of innovation: traditional, green, social, and sustainable, with the latter being ideal as it integrates environmental, social, and economic aspects.
	InOrdinatio	**Authors/Year**	**Title**
9	161.651	Lopes *et al*., (2017)	An analysis of the interplay between organizational sustainability, knowledge management, and open innovation
Goals		**Methodology**	**Main Results**
Examining the interplay processes between organizational sustainability, knowledge management, and open innovation.		Case study	The model, tested in a Brazilian company in the rubber product industry, points that the organization with open innovation, through knowledge management and absorption capability, may discover sustainable innovations that entail competitive advantages, such as flexibility, performance, technology, and process and product innovation.
	InOrdinatio	**Authors/Year**	**Title**
10	154.412	Anadon *et al*., (2016)	Making technological innovation work for sustainable development
Goals		**Methodology**	**Main Results**
Presenting ideas and action proposals to better use technological innovation for sustainable development.		Bibliographic research	Dealing with power unbalance is necessary, transforming deep-rooted institutions, standardizing the learning about technological innovation, and ensuring that every innovation stage and scale is considered, systematically taking into account the interests of needy populations to expand the potential of innovation systems to achieve sustainable development.

Source: Research data (2021).

The ten papers ranked as the most relevant by the applied method are largely oriented to innovation and changing business models, recognizing their essential nature for enabling the development of sustainable actions and innovations (BALDASSARRE *et al.*, 2017; EVANS *et al.*, 2017; FRANÇA *et al.,* 2017; ROSCA; ARNOLD; BENDUL, 2017; YANG *et al.*, 2017). The same realization is found, partly, in the other papers selected by this review. A business model consists of the logic adopted by the organization to create and deliver value through its products and services (YANG *et al.*, 2017). The approaches to this theme are related to understanding the relationship between business model innovations and sustainability performance, the proposal of new perspectives for business models like the value uncaptured model proposed by Yang *et al.* (2017) to aid in the identification of opportunities for reaching sustainable business model innovations, and the combination of principles of sustainable business model innovation and user-driven innovation (BALDASSARRE *et al.*, 2017) reinforcing the importance of involving the stakeholders in a more significant value generation. Another approach identified was the combination of two models, the Structure for Strategic Sustainable Development and the Business Model Canvas (BMC), to support sustainable business model innovation and design (FRANÇA *et al.*, 2017).

Other studies focused on proposing new models and a sustainable business model structure that allows the creation of simultaneous value for several interested parties, in the understanding the business model as a mediator between innovation and sustainability, in the necessity for engaging and aligning with the goals of the interested parties, in the motivators for sustainable business model innovation, in the role of the company’s size in the business model developed for sustainable innovation, and in the alliances between small and large companies for a joint business model.

Thus, it is possible to identify that changes and innovations in the business model are seen as crucial for achieving sustainability; a promising approach that goes beyond product and service innovation. It is also worth highlighting the need for involving the stakeholders to amplify the value creation associated with the business example so that the results satisfy all of the actors (OSKAM; BOSSINK; MAN, 2020).

Another relevant study linked to the business model perception approached the theme of design for sustainability, highlighting the shift from understanding sustainability in the perspective of product/service innovation to a macro socio-technical understanding that requires innovations in this context (CESCHIN; GAZIULUSOY, 2016).

Paths, facilitators, and predictors for sustainable innovation were also addressed by the studies. Varadarajan (2017), for instance, not only describes potential paths for innovation, like reducing resource use and new products, processes, and practices, but also points to institutional theory as an explanation for strategic patterns. According to the author, size, globalization, good or bad reputation, competition in sectors that cause greater environmental impacts, and suppliers more involved with sustainability are aspects that influence a more intense orientation toward sustainable innovations.

Other studies pointed that the principles of Design Thinking and Mindfulness are suitable to meet the challenges of sustainability-oriented innovation (BUHL *et al.*, 2019; SIQUEIRA; PITASSI, 2016) and that cleaner production and environmental management have a positive impact on sustainable product innovation (SEVERO; GUIMARÃES; DORION, 2017). Complementing this perspective, strategic orientation, resource orientation, management structure, rewards philosophy, growth orientation, and entrepreneurial culture all significantly and positively influence the success of sustainable innovation in a company (FELLNHOFER, 2017). The association

between companies that operate in a strongly environment-minded sector, with higher profit margins and introduction of sustainable innovations, was also identified in the studies (PRZYCHODZEN; PRZYCHODZEN, 2018). For SMEs, government initiatives, financial resources, technological resources, training, collaboration capability, and construction of open innovation are factors regarded as key to sustainability-oriented innovation (KHURANA; HALEEM; MANNAN, 2019). Furthermore, there are positive relationships between maturity models in corporate social responsibility, integration of the management system, organizational culture, practices of lean management and sustainability innovations. The role of the manager as a sustainability translator is also indispensable for the development of sustainable innovation.

In addition to the predictors, barriers to the adoption of sustainable innovation were also listed, such as the skepticism among managers regarding the economic benefits of sustainability-related innovation (GLOBOCNIK; RAUTER; BAUMGARTNER, 2020). The lack of technical knowledge and research and development resources, the popularity of traditional technology, the high investment and extra workload method, and the loss of flexibility are identified as obstacles to the adoption of sustainable innovation in the supply chain (GUPTA; KUSI-SARPONG; REZAEI, 2020). Furthermore, the need for a complex regulatory approval of sustainable innovations might be a development barrier, especially in smaller or publicly financed institutions (HALL *et al.*, 2018).

Alliances, collaboration, involvement of the interested parties, and open innovation are other perspectives widely addressed in the studies on innovation and sustainability. Among the ten most relevant papers, Lopes *et al.* (2017) state that the knowledge obtained from open innovation, its management, and absorption capability can produce sustainable innovations that entail competitive advantage. Knowledge shared among universities, customers, NGOs, and other interested parties is seen as beneficial for the company, in the

sense that it increases sustainable development innovation. Moreover, the collaboration between the interested parties allows for more accurate predictions of events. Thus, innovative thinking facilitates the response to disruptive changes toward sustainability-oriented innovation. The adoption of networks, alliances, online co-creation with external knowledge sources, environmental collaboration, collaborative innovation, and intrapreneurship are also regarded as catalysts for adopting sustainable innovation, even in supply chains.

Another aspect widely featured in the discussions is the management of the supply chain and supply network. The study of Bag and Gupta (2017), for instance, indicates that normative and mimetic pressures may influence the choice of a more sustainable supplier. Moreover, Ahmadi *et al.* (2020) propose a structure to assess suppliers based on sustainability innovation. Overall, there is a consensus among the studies selected that supply chains must develop responsibility and innovation directed at the solution of environmental, economic, and social problems. That requires technological solutions, efforts, and collaboration between multiple interested parties, lean innovation, responsibility-sharing, development of ethical business models, and long-term strengthening of relationships (GUZAWSKA, 2019; SHETE; ANSARI; KANT, 2020; DE *et al.*, 2020).

A link between sustainable innovations and economic performance was also found in the studies. Usually, financial development appears as a result of sustainability-oriented innovation, making this link a competitive advantage (GHASSIM; BOGERS, 2019; RAUTER *et al.*, 2019; XING *et al.*, 2020).

As previously highlighted in the sustainable business model cluster, changes in the sustainability field require organizations to perceive it from a socio-technical systems perspective. The systems perspective is an approach also found in the studies. For instance, Iñigo and Albareda (2016) state that

sustainable innovation must be understood as an adaptive, complex system constructed under the phenomena of non-linearity, self-organization, and emergency. Liu and Stephens (2019) reinforce this perspective, suggesting that the interaction between innovation and sustainability as a dynamic process of different interested parties forms a sustainable innovation ecosystem.

Another point that stood out in the themes addressed is the identification and management of dynamic capabilities to promote innovation and sustainability. Studies show that the capabilities of the interested parties influence the company's orientation toward sustainable innovation and related capabilities (VERONICA *et al.*, 2020) and that reconciling the capabilities is required for all the key partners in the development of sustainable products and services (BEHNAM; CAGLIANO; GRIJALVO, 2018). Dynamic capabilities related to sustainable innovation also include the ability to assess environmental impacts and conduct the anticipation process, creation of strategies, resilience, response capability, resource reconfiguration, new business practices and methods, adaptation, expansion, transformation, among others (MOUSAVI; BOSSINK, 2017; BERKOWITZ, 2018).

In a more specific manner, a few studies focused on sustainable innovations in determined products, companies, and sectors. They included the mobility sector and sustainable disruptive innovations based on smart sharing systems (MA *et al.*, 2018), the construction sector and the need for continuous innovation for sustainability (CZARNECKI; VAN GEMERT, 2017), the production of green plastic reinforcing the importance of the collaboration between supply chain agents for product development (MORES *et al.*, 2018), the innovation in the mining sector and its contributions to sustainability (ENDL *et al.*, 2019), the agro-food sector and innovations to promote sustainable agro-food systems (LARA *et al.*, 2019), and the food sector and the innovative approaches to innovation sustainable development directed at the future and

retro-innovation (LEÓN-BRAVO *et al.*, 2019). Studies also focus on understanding the sustainable innovation process for a specific product, of biological basis, and a sustainable package for beer, identifying the importance of corporate strategy and open innovation for this process. Other segments addressed include the production of eggs, glass, and plastic, aiming to identify existing sustainable innovations.

More generically, some studies focused on creating concepts and conceptual models that confirm or adjust the relationship between innovation and sustainability (for instance, RANTALA *et al.*, 2018; KUZMA *et al.*, 2020; OMRI, 2020). These analyses prove that innovation has a positive impact on sustainability performance. In this context, one of the ten most relevant studies defended that technological innovation can advance sustainable development goals by overcoming the power unbalance in deep-rooted institutions that usually do not take the interests of needy populations into account (ANADON *et al.*, 2016). Models were also developed to assess innovation strategies adopted (XU, 2018) and sustainability-oriented innovation systems (KILKIS, 2016). Furthermore, other concepts are discussed, such as traditional innovation (based on economic performance), green innovation, social innovation, sustainable innovation, environmental innovation, and eco-innovation, aiming to establish connections (SILVESTRE; ŢÎRCĂ, 2019).

Among the different types of innovation, one that stands out and is seen as a fundamental factor to achieve sustainability by the studies selected is frugal innovation. Frugal innovation maximizes value for the stakeholders while reducing resource use and total costs, making it accessible for customers at the bottom of the pyramid (ROSCA; ARNOLD; BENDUL, 2017). This approach enables sustainability improvements in cost reduction, making products accessible for low-income users while minimizing energy consumption and pollutant emissions (CAPPA *et al.*, 2016). This context also includes

entrepreneurs who create economic value by combining environmental and social objectives with an impact that transcends meeting consumer needs, towards long-term impacts like poverty reduction, promotion of inclusion, and sustainability (PANSERA; SARKAR, 2016; SARKAR; PANSERA, 2017).

Besides frugal innovation, other terms are also associated with sustainability, such as service innovation, with services also having to present innovative aspects and high quality similarly to sustainable products (TSENG *et al.*, 2019), digital innovation as support for innovative approaches to face sustainability challenges (GEORGE; SCHILLEBEECKX, 2020), collaborative innovation as a basic demand for sustainability (ZHANG *et al.*, 2020), and disruptive innovation as necessary for the transition to more sustainable production and consumption (KUOKKANEM; UUSITALO; KOISTINEN, 2019).

Finally, other aspects that were approached, here identified as others, are related to sustainable entrepreneurship as an opportunity for considering ecological and social questions from an innovation perspective (URBANIEC, 2018; KESKIN; WEVERS; BREZET, 2020), guidelines for SMEs concerning the development of sustainable innovations given their resource limitation, development of an infrastructure for user-driven innovation to face sustainability challenges (TRISCHLER; JOHNSON; KRISTENSSON, 2020), and creation of support environments for the commercialization of sustainable innovations, reinforcing the importance of the user's collaboration and involvement (PLANKO *et al.*, 2016; VAN DEN HEILIGENBERG *et al.*, 2016).

FINAL CONSIDERATIONS

This study sought to understand the trends and directions of the discussions on innovation and sustainability. To achieve that, we conducted a systematic literature review employing the Methodi Ordinatio in the research

databases Science Direct, Scopus, and Scientific Electronic Library Online (Scielo). In total, we assessed 105 papers quantitatively and qualitatively.

The results point to a growth in relevance and interest in the theme, considering the higher number of publications in the last two years. The Journal of Cleaner Production stands out with the most publications and citations, which illustrates its relevance in the approaches to the theme. We identified partnerships in the authorship of the studies, but there is not a concentration of studies by a few authors or universities. Developed and emerging countries dominate this research field, demonstrating their bigger concern with the subject. The papers include both theoretical and empirical studies, with the latter being developed in several sectors and segments, especially in the energy, agro-food, construction, mobility, and technology sectors.

The qualitative analysis confirmed that sustainability and innovation walk hand in hand in the different proposals for transformation developed by different types of organizations. We found and indicated clusters of trends and approaches in the field of study. Innovation and business model changes are acknowledged as essential for sustainability and the development of sustainable innovations, transcending the notion of product or service innovation. The studies also indicate paths and predictors that facilitate sustainable innovations and the existing obstacles to be overcome. Opening doors to external stakeholders, collaboration, and partnerships mediated by open innovation are viewed as promising paths toward sustainable innovation, besides the management of the supply chain and supply networks. It is also worth bringing attention to the relationship between innovation, sustainability and economic performance, besides the need for understanding sustainable innovations from a systems perspective. Finally, we observed studies directed at understanding dynamic capabilities that promote innovation and sustainability, exemplifying and describing sustainable innovation processes in

specific products, companies, and sectors, and creating theoretical models and concepts that explain the relationship between innovation and sustainability. The concept of frugal innovation, which aims to develop products more accessible to low-income individuals using fewer resources, stands out as able to have an impact in the three sustainability dimensions.

These descriptions or studies reveal the need for developing this area of knowledge and show how transformations are occurring in organizations of the most different natures. These experiments and observations help the segment to mature, seeing that they provide a better understanding of the area in its different required practices.

There is still a path to be constructed toward the perception of sustainability and transformations of current phenomena that seek to improve social living and create harmony with the environment. The balance to be achieved goes through an economic solution in the relationship between the several types of social organizations. This perception includes the change of individual behaviors and choices that are often not the easiest. This period of socio-technical transition is currently underway, and these occurrences are often not easily identified.

Based on our findings, it was possible to outline a few perspectives of the studies and investigations developed about sustainability and innovation. This study also presents how the discussions have transformed over the last few years, and the directions followed to find more solutions. Other phenomena were not explored and may be objects of study for future research, such as how the market and entrepreneurship are influenced by the concerns with sustainability and innovation, besides their consequences as a contemporaneous social phenomenon. Thus, there is still much knowledge to be constructed and a long path to walk.

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