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Eco-innovation determinants in manufacturing SMEs from emerging markets: Systematic literature review and challenges

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ABSTRACT

The debate on eco-innovation is a recent and emergent topic between practitioners and in the academy. Especially in developing economies, such as in Brazil, this topic is very incipient mainly in Small and Medium-Sized Enterprises (SMEs) context. Hence, the purpose of this study is to identify what are the determinant factors for the successful adoption of eco-innovation in Brazilian SMEs. The findings reveal several similarities/differences and intersections/overlaps resulting in a list of sixteen primary determinants. Results also demonstrated that eco-innovations in SMEs may be enabled by breaking away from the immediatist culture, by the participation of SMEs in cooperation networks, by considering the regulations affecting the sector where the SME operates and the applicable legislation, by investing in R&D of innovative technologies in conjunction with external agents, by qualified professionals planning for and implementing eco-innovation and by reinforcing the financial condition of the SMEs. The practical contribution of this study is a consolidated comprehensive framework of eco-innovation to Brazilian SMEs providing important insights and challenges to academics, policy makers, and practitioners, improving the diffusion of eco-innovative practices. Furthermore, others emerging economies will benefit from the findings of our research.

1. Introduction

Currently, sustainable development and technological innovation are recurring themes in society, academic and business environments. The first studies of innovation date back to the propositions to categorize the concept of innovation made by Schumpeter (1911) in his book "The Theory of Economic Development" published in Austria. Blackburn (2007, 2008) claims that a definition of environmental sustainability is not yet fully clear in business circles. Additionally, Blackburn (2007) and Carrilo-Hermosilla et al. (2009) discuss some aspects related to the history of sustainability, and refer to the 1972 United Nations Conference on Human Development in Stockholm as the time when the term sustainability first surfaced, a fact that Mendonça et al. (2012) corroborate. Regarding the discussion about integrating innovation and sustainability domains, the first studies published in the literature

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according to Maçaneiro and Cunha (2012), were carried out by Fussler and James (1996), James (1997) and Rennings (2000). Fussler and James (1996) are credited with having coined the term "eco-innovation" in a book titled "Driving Eco-Innovation: A Breakthrough Discipline for Innovation and Sustainability".

If on the one hand, the theme of innovation has been strictly connected with economic concerns, such as competitiveness, demand and investment, on the other hand, the environmental area has been hard put to incorporate the technological innovation processes. Compared with publications on classical innovation, there are currently only a few studies about the management of technological eco-innovation and its processes (Ozaki et al., 2013; Klewitz and Hansen, 2014). The management of technological eco-innovation and its processes have been widely discussed in the context of large companies, and mainly in industrial and technological sectors. However, the discussion about the impacts in Small and Medium-Sized Enterprises (SMEs) is still very incipient and inconclusive.

Moreover, in the field of environmental sustainability, there are limited researches about the integration and comprehension of these two themes specific to SMEs context (Klewitz and Hansen, 2014; Sabadie, 2014; Borghesi et al., 2015). Nevertheless, the debate of innovation in SMEs is generally focused on other topics, such as open innovation (Brunswicker and Vanhaverbeke, 2015; Wynarczyk et al., 2013), product innovation (Massis et al., 2015; Maes and Sels, 2014), SMEs networks (Gronum et al., 2012), innovation process (Love and Roper, 2015), internationalization (Raymond and St-Pierre, 2013) and others.

Therefore, considering integration of innovation and sustainability a relatively recent topic in the body of knowledge available in the literature, it is possible to conclude that even more immature is the discussion about eco-innovation, particularly in the SMEs context (Klewitz and Hansen, 2014; Rashid et al., 2015; Del Río et al., 2016) and mainly in emerging markets or low-income economies such as Brazil. Recent studies also corroborated this assumption (Govindan et al., 2016).

Hence, more research that aims to advance the diffusion of eco-innovations in SMEs is necessary (Klewitz and Hansen, 2014). To achieve this goal, a systematic review of the literature on eco-innovation of SMEs is required and relevant for several reasons (Klewitz and Hansen, 2014). First, SMEs are considered a type of enterprise recognized internationally to the economy of nations. According to OECD (2010, p. 3): "SMEs account for approximately 99% of all enterprises and two thirds of employment across the OECD area, their transition to sustainable practices, in both manufacturing and services, is key to the large scale uptake of a green growth model". Second, SMEs as a group contribute to a significant share of overall pollution (UNEP, 2003). Third, SMEs are not simply smaller versions of their larger counterparts (UNEP, 2003). Fourth, SMEs' peculiarities imply that they will innovate differently for sustainability (UNEP, 2003). Fifth, the literature highlighting SMEs' disadvantages (e.g. resources constraints, lack of formalized planning), which may prevent them from engaging proactively in the innovation process, shows reactive behavior toward environmental and social issues (Borghesi et al., 2015; Klewitz and Hansen, 2014).

Based on the body of knowledge available of literature, while debate and research on eco-innovation are more frequent in the international context, in Brazil this topic is still very incipient. Consequently, just a few scarce studies have been developed in recent years. In fact, concerning Brazilian SMEs, the discussion on the adoption of eco-innovation practices still remains in a more immature stage. Findings from the Global Forum on Environment on Eco-Innovation of OECD (2009a,b) reveal that apart from recent initiatives on climate change issues, eco-innovation itself is not a goal in official innovation and technology policies in the Brazilian context. Regarding environmental issues, the Brazilian National Policy on Industry, Technology and Trade explicitly emphasizes biotechnology research in the Amazon region, norms for certified forestry, development of biodiesel and innovation in environmentally sound technologies.

Results also indicate that R&D consequences on environmental performance have decreased, in past years, in the Brazilian context (Motta, 2009). A recent study analyzing the Brazilian context reveals it is necessary to seek new management designs that focus on eco-innovation, to adopt eco-efficient processes and to develop eco-efficient products, as well as to encourage sustainable consumption (Brasil et al., 2016). Consequently, the relevance of our study relies on widening the comprehension of eco-innovation determinants in Brazilian SMEs, seeking to provide a more comprehensive understanding specifically for the small companies' reality. Therefore, factors involving the adoption of eco-innovation need to be better understood in the background of Brazilian economy, aiming to increase the national and international competitivity of Brazilian small industries.

A suitable strategy to better understand this phenomenon and landscape is to analyse which are the determinants for eco-innovation in Brazilian SMEs and whether or not they are similar to empirical results available from the literature. In this sense, this study adopts the following definition for eco-innovation: "the creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and to provide a better quality of life for everyone with a life-cycle minimal use of natural resources (materials including energy and surface area) per unit output, and a minimal release of toxic substances" (Reid and Miedzinski, 2008 p.2).

In short, based on the gaps in the literature previously discussed, the research question that drives this study is: what are the determining factors to implementing eco-innovation practices in Brazilian SMEs? The methodological procedure adopted started with a systematic literature review on eco-innovation in the main scientific databases to identify and analyse these determinants. Next, a semi-structured questionnaire was applied to Brazilian experts with the goal of identifying the determinants to eco-innovation in Brazilian SMEs. Lastly, the results of the literature review were compared against the answers of Brazilian experts aiming to identify similarities/differences and intersections/overlaps. The main scientific value of this study is to contribute to future research on the implementation of eco-innovation practices in SMEs located in emerging economies such as Brazil as well as in other nations. The originality of our study may also contribute to providing a common identity for the scientific and industrial community interested in the eco-innovation field. In our opinion, these research lines will contribute to a better understanding and clearness of the scope of eco-innovation in emerging economies.

The remainder of the paper is organized as follow. After presenting the research problem and justification in the Introduction, section two shows the theoretical framework of eco-innovation definitions and the eco-innovation determinants extracted from the

Table 1
SMEs versus Large companies.

SME	Large companies
Dominant role of the entrepreneur/owner	Delegated management control between board of directors and shareholders
Resource poverty (capital, time, knowledge and skilled personnel)	Economy of scale, resource abundance
Flexibleorganizationcapacities	Bureaucratic rigidity
Focus on short term	Focus on mid to long term
Strong local/regional focus and customer needs orientation	Strong (inter)national focus and looser ties with customers
Lowdegreeofformalization	High degree of formalization

Scopus, Web of Science and Ebsco databases. The section Research Method details the methodology procedures to collect and analyze the data covering the literature review and the validation with Brazilian experts in this theme. The next section details the Results and the Discussion of outcomes. The analysis of results was made comparing the determinants found in the literature with the factors highlighted by the specialists. Furthermore, similarities/differences and intersections/overlaps about the results were identified in a specific section of the paper. Section six shows the Conclusions and the key research directions to this research field.

2. Defining eco-innovation

Bos-Brouwers (2010) affirms that the most part of available research on innovation and sustainability applies to large companies, whereas the innovation process for SMEs is different. As a consequence, it is possible to state that the most common difference between large companies and SMEs is the number of employees. However, others characteristics can be summarized (Bos-Brouwers, 2010) (Table 1):

Maçaneiro and Cunha (2010, 2012) demonstrate that eco-innovation differs from the concept of innovation as it relates to the reduction of environmental impacts. As such, eco-innovation consists in changes to the environmental performance and improvements based on the dynamics of ecologizing products, processes, business strategies, markets, technologies, and systems of innovation. The authors make such differentiation between several Eco-innovation definitions (Table 2).

On the whole, it is possible note that there is some variation between the concepts proposed from 1997 through 2009. In a comparison between the definition of James (1997) and the definition of OECD (2009a) in the Oslo Manual, the idea of an effective reduction of environmental impact is highlighted. Barbieri et al. (2010) corroborate such statement as it puts forward some definitions and expresses that the eco-innovation concept is not only about reducing negative impacts; it includes the achievement of net benefits as well. The condition emphasized – comparison of pertinent alternatives – is essential to the concept of sustainable innovation since the desired benefits must be significant or non-negligible in the three dimensions of sustainability (social, economic and environmental).

Foxon and Andersen (2009) point out that eco-innovation practices go much beyond the adoption of low carbon technologies; they require learning new things, creating new knowledge and values and searching for rules and capabilities, besides the creative destruction of old practices and capabilities. According to Sehnem et al. (2016) and EIO (2013), the typology of eco-innovation categories often adopted in theoretical and empirical studies are classified in six categories: Product, Process, Organizational, Marketing, Social, and System eco-innovations.

Table 2
Definitions of eco-innovation.

Author	Eco-innovation definitions
James (1997)	Eco-innovation is considered a new product or process that adds value to the business and to the customer, significantly decreasing the environmental impact.
Rennings (2000), Kemp and Foxon (2007), Arundel and Kemp (2009)	It is the productions, application or exploration of goods, services, production process, organizational or management structure or method of business that is new to the company or to the user. The results are the reduction of environmental impact, less pollution or negative impacts from the utilization of resources, compared with corresponding alternatives.
Andersen (2008), Foxon and Andersen (2009)	It is defined as the innovation that is capable of attracting green income in the market, reducing the net environmental impact, and creating value for the organizations.
Reid and Miedzinski (2008)	It is the creation of new and competitive efforts of products, processes, systems, services and procedures conceived to meet the human needs and to provide a better quality of life for everyone, with as little as possible utilization of the life cycle of natural resources and release of toxic substances.
Kemp and Pearson (2008)	It is the production, assimilation or exploration of a product, production process, service or method of management or business that is new to the organization (developing or adopting it) which results, over its life cycle, in the reduction of environmental risks, pollution and other negative impacts from the use of resources, including power, compared with corresponding alternatives.
OECD (2009a)	It represents an innovation that brings about a reduction of the environmental impact whether such effect is intentional or not.

2.1. Eco-innovation determinants in SMEs

This section shows the synthesis of the systematic literature review detailed in the next section of the Research Method, highlighting the determinants to eco-innovation described and pointed out in the select papers. A widely quoted publication in this field is the study of Brio and Junqueira (2003), exploring the implications for public policies of leveraging sustainable innovations in SMEs. By investigating the barriers to eco-innovation and the driving aspects of eco-innovation in Germany SMEs that participate in an innovation network named Ecoprofit, Klewitz et al. (2012) conclude that: (i) the main eco-innovation driving factors are cost-efficiency, proactive contact by external initiatives and the desire for continuous improvement; (ii) cost, cost reduction, and risk management (avoiding negative environmental impacts and legislation compliance) are the primary drivers; (iii) improving energy efficiency, becoming more attractive to employees (creating a common company culture), reputation and brand image, and profit and sales (pressuring suppliers to meet sustainable standards) were other aspects highlighted as well.

Sánchez-Medina et al. (2011), who researched 168 small Mexican handicraft businesses, conclude: (i) there is a positive relation between eco-innovation and the three dimensions of sustainability: economic, social, and environmental; (ii) the factors that better explain sustainability are: type of organization, product innovation, and process innovation; (iii) the age of businesses was not a significant factor to explain sustainability; (iv) the handicraft businesses make sustainable decisions mainly as a result of a desire to maximize profit rather than out of environmental awareness, which can be explained by the neoclassic vision of economy.

Fernández-Viñé et al. (2010) mapped the current state and future prospects for eco-innovation in Venezuelan SMEs. The main conclusions obtained analyzing 54 SMEs were: (i) SMEs understand the legal environmental regulations affecting SMEs, but do not perceive the influence of external forces such as the customer demand for green products or fiscal tax incentives; and (ii) sustainable-oriented practices are not perceived as an incentive to improve the competitiveness. The environmental strategies are usually adopted aiming to cut down on costs and avoid sanctions and negative effects to the company.

The results of the survey and in-depth interviews applied in Bos-Brouwers (2010) with 26 plastics industry SMEs in Holland brought to light the following barriers to the adoption of eco-innovation: lack of resources (capital, knowledge and competencies), short term management focus and difficulty to radically innovate. Data from two surveys conducted in 257 SMEs from diverse industrial segments in Italy demonstrated the following factors: structural variables of the business (scale economies can support innovative strategies), R&D with focus on sustainability, pressure from the environmental policies and cost of complying with the rules, past performance of the business (capital expenditure, direct/indirect cost, other innovations – techno-organizational non-environmental) and quality and nature of the work relations (Mazzanti and Zobloi, 2008). Robinson and Stubberud (2013) analyzed data from 96 thousand Germany SMEs identifying the main environmental innovations: reduced energy use per unit of output, reduced energy use to end-user, reduced soil, water, noise or air pollution, recycled water or materials and others.

Vasilenko and Arbačiauskas (2012) compared SMEs with experience in implementation of sustainable innovations and SMEs without such experience identifying a list of eco-innovation drivers. The research in Cagno and Trianni (2013) highlights the importance of public financing for energy efficiency interventions, the importance of external pressures, the need of long term benefits of eco-innovations, evidence of their willingness to adopt seemingly radical solutions when these are able to improve their long-term competitiveness, the presence in SME of people with ambition and entrepreneurial mind for environmental practices.

Hansen et al. (2002) conclude that the eco-innovative capability of SMEs is conceived as the result of an interplay between the competencies, the network relations and the strategic orientation of the company, indicating that policies to support SME's adoption of eco-innovations have to take an integrated form, i.e. addressing and developing competence, networks and strategic orientation of SMEs simultaneously whilst remaining systemic and context sensitive. Bocken et al. (2014) investigated the initial phase of the eco-innovation process and the pointed drivers were: the potential revenues, technological advancements, personal reasons, positive experiences and improvement of the SME corporative image. Investigating 5222 managers in SMEs of European Union, Triguero et al. (2013) found that SMEs should see the eco-innovation strategy as a suitable way to increase their potential benefits taking into account the growing environmentally consciousness of European consumers. The relationship between supply and demand factors could also affect market relations, pressures for change, corporate image and reputation, information flows and cooperation/collaboration/networks, influencing the eco-innovation dynamism. The lack of effectiveness of public subsidies/incentives is another mentioned aspect. Table 3 summarizes the 27 drivers of eco-innovation resulting from the literature review in Web of Science, Ebsco and Scopus.

By analyzing the findings in Table 3 adopting the criteria analyses of higher frequency of mention, it is possible to conclude that SMEs should pay attention mainly to: (i) resource constraints (people, time, money); (ii) SME-specific actions, technological assistance, awareness, and training programs that should be taken to enhance the cooperation with external stakeholders (government, universities, other SMEs, research centers); (iii) cost reduction and risk management (avoiding negative environmental impacts and compliance); (iv) eco-innovation as relevant and strategic to the sector and to the customers. Moreover, other 22 determinants were mentioned by two or three authors, indicating that they are also relevant and should not be totally neglected by the SMEs.

3. Research method

This study is based on qualitative exploratory research and has an interpretative nature. Based on the approach adopted in a previous study on eco-innovation in SMEs by Klewitz et al. (2012), we chose a qualitative approach to gain greater understanding of the field of study (e.g. the role of determinants to the Brazilian SMEs context) as this approach makes room for insights that were not anticipated by the researcher (Wolcott, 2009).

The research methodology adopted for data collection was planned and performed in several steps. First, a systematic literature

Table 3
Synthesis of the literature review of eco-innovation determinants to SMEs.

	Triguero et al. (2013)	Bocken et al. (2014) 42	Hansen et al. (2002)	Cagno and Trianni (2013)	Vasilenko and Arbačiauskas (2012)	Brio and Junqueira (2003)	Klewitz et al. (2012)	Sánchez-Medina et al. (2011)	Fernández-Viñé et al. (2010)	Bos-Brouwers (2010)	Mazzanti and Zobloi (2008)	Robinson and Stubberud (2013)	Klewitz and Hansen (2014)
Available resources (qualify people, time, money)	✓	✓		✓	✓✓	✓	✓	✓		✓			✓
Organizational structure less bureaucracy and more flexibility	✓				✓	✓		✓		✓			
Training on environmental issues provided by the management, environmental training and employee awareness	✓					✓	✓						
Long term strategy orientation	✓		✓	✓	✓	✓				✓			
Capability of obtaining radical innovations				✓		✓				✓			
Influence of the production process flexibility on the environmental strategy of SMEs	✓					✓							
Neutrality of regulatory policies	✓					✓						✓	
Actions of technological assistance, awareness and training programs to improve the cooperation with external stakeholders	✓		✓			✓✓	✓		✓	✓	✓		
Desire for continuous improvement				✓			✓✓				✓		
Cost control and risk management to avoid negative environmental impact and compliance	✓						✓			✓	✓	✓	
Improving energetic performance for the company and the market				✓			✓				✓	✓	
Becoming more attractive to employees						✓					✓		
Reputation, brand image and profit margin (pressuring suppliers to meet sustainable standards)	✓	✓					✓						✓
Perception of the strategic relevance of eco-innovation and environmental aspects for the sector and customers		✓			✓		✓	✓	✓		✓	✓	✓

(*continued on next page*)

Table 3 (*continued*)

	Triguero et al. (2013)	Bocken et al. (2014) 42	Hansen et al. (2002)	Cagno and Trianni (2013)	Vasilenko and Arbačiauskas (2012)	Brio and Junqueira (2003)	Klewitz et al. (2012)	Sánchez-Medina et al. (2011)	Fernández-Viñé et al. (2010)	Bos-Brouwers (2010)	Mazzanti and Zobloi (2008)	Robinson and Stubberud (2013)	Klewitz and Hansen (2014)
Product and process innovation		✓						✓			✓		✓
Supplier and customer relations as a source of innovative ideas	✓	✓						✓	✓				✓
R&D department with focus on sustainability										✓	✓		
Structural variables of the business (e.eg. economies of scale can support innovative strategies)											✓		
Participation in networks and governmental projects oriented to eco-innovation (e.g. Ecoprofit)	✓		✓				✓					✓	*✓
Recycling practices and reverse logistics											✓	✓	
Incentives and public financial support (e.g. fee, cost savings associated with implementation of eco-innovations internally)				✓	✓✓								
External pressures of SME sector (e.g. regulation, supplier pressure, rise of energy prices, fees on polluting emissions)		✓	✓	✓									✓
External support (e.g. consultants and experts)				✓									
Obtain long-term benefits to SME				✓									
Motivation and awareness of the founder or management		✓		✓									✓
Use eco-innovation methods and tools		✓											
Capability and competence of organizational learning on eco-innovation issues	✓						✓						✓

Caption: ✓ Cited by the author. ✓✓ Quoted by the author as highly relevant or critical determinant.

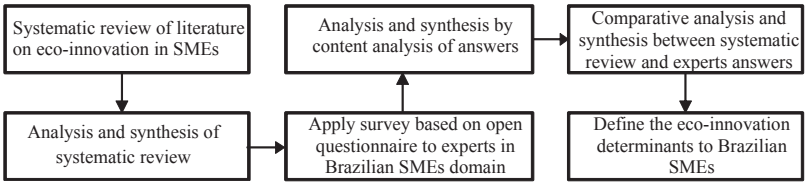

Fig. 1. Research Methodology.

review of the studies available about eco-innovation in SMEs on Web of Science, Scopus and Ebsco was conducted aiming to identify a synthesis of the evidenced eco-innovation determinants.Second, in parallel to this task, an open questionnaire was applied to Brazilian eco-innovation experts from the most important research groups regarding the subject aiming to identify the drivers to Brazilian SMEs economic context. The answers were synthesized by content analysis of results. Third, a comparative analysis was performed to verify matching points between the results of the literature review and the Brazilian SMEs context, in order to identify similarities/differences and intersections/overlaps. Finally, as a result, a list of determinants was obtained for the Brazilian SMEs reality. Fig. 1 shows the sequence of the research methodology.

The steps of the research methodology are detailed as follows. A systematic review of the literature is necessary to understand the state of the art aspects regarding this research topic and to identify pertinent information (Dresch et al., 2015; Tranfield and Denyer, 2003). The research protocol suggested by Dresch et al. (2015) was adopted and the steps are detailed, beginning with the definition of the issue; the conceptual framework is as follows: the purpose of this study is to identify what are the drivers for the implementation of eco-innovation in Brazilian SMEs. The research question of this study is as follows: what are the main determinants for the successful implementation of eco-innovation in Brazilian SMEs? The work team conducting the search process in scientific databases was formed by authors of this study.

The search strategy included the following inputs: keywords, period, databases, inclusion/exclusion criteria and eligibility/coding. To determine keywords, definitions, and Boolean operators, a preliminary search was performed in Scopus in the fields “abstract” and “title.” This scientific database was selected because it has been mentioned in prior studies as a reference regarding the quality and number of publications on eco-innovation.

As a result, we identified a set of keywords in English associated with eco-innovation (‘eco-innovation’, ‘environmental innovation’, ‘sustainable innovation’, ‘green innovation’, ‘innovation ecology’ and ‘clean innovation’). The keywords associated with SMEs were also identified (‘SME’, ‘small and medium-sized enterprise’, ‘small business’ and ‘small enterprise’). All the possible combinations of these keywords were searched using the following fields: title, abstract and keywords of scientific databases. In order to exemplify the research process, one of the different combinations of keywords used for this study was the following: ‘SME’ & ‘eco-innovation’. The period considered for this study was between 1995 and 2015, covering two decades of this research topic. The selected databases included Scopus, Web of Science and Ebsco Business Source Complete. The entire search process reviewed the well-recognized scientific databases, covering more than 35.000 peer-reviewed journals.

The inclusion and exclusion criteria are an important aspect in systematic review studies (Dresch et al., 2015). As for the inclusion criteria, only the studies that fully met one or more of these aspects were selected: (i) peer-reviewed papers that were published in English; (ii) studies regarding systematic review in eco-innovation in SMEs; (iii) studies consolidating results of international projects focused on eco-innovation in SMEs with results of large sample – as an example, there is the PRIMA Project involving 26 SMEs from Europe (Bos-Brouwers, 2010); (iv) studies on multiples case studies involving several SMEs – as an example, there is the study by Sánchez-Medina et al. (2011) involving 168 SMEs. Studies with large samples are best indicated for our research objective, since larger samples may represent determinants globally consolidated. Thus, considering that our objective is to point out determinants for the Brazilian context of SMEs as a whole, this option is the most appropriate.

On the other hand, the exclusion criteria included the following: (i) studies with high quantitative methods and analysis avoiding the capture of qualitative findings on the main determinants; (ii) studies on multiples case studies involving less than three SMEs; (iii) studies with low methodical rigor without a clear presentation of methodological procedures; (iv) studies proposing methodologies, methods, models or tools in this topic. The results of the research process adopted according to Moher et al. (2009) methodology are detailed (Fig. 2).

During the process of search, eligibility and coding, the first search cycle analyzed approximately 40 titles and article abstracts and 26 studies were pre-selected for deeper review. After a detailed content review, 20 articles were selected and assessed for eligibility. Thus, a second search cycle was conducted analyzing the references of studies that were most frequently mentioned in the selected papers and those were incorporated to our research goals. In addition, an internet search was conducted to locate any grey literature using a process similar to the database search. By applying the inclusion/exclusion criteria the search was concluded and 12 studies were selected for this study (Table 4).

In the third stage of the research methodology (Fig. 2), the data collection consisted of an open questionnaire composed by six questions and sent to Brazilian experts on eco-innovation. The questionnaire was structured with the following guiding questions:

1. In your opinion, how can eco-innovation practices contribute to the competitiveness of manufacturing SMEs in Brazil?
2. In your opinion, what competitive advantages could manufacturing SMEs in Brazil have by adopting eco-innovation practices in product, service or process innovation?

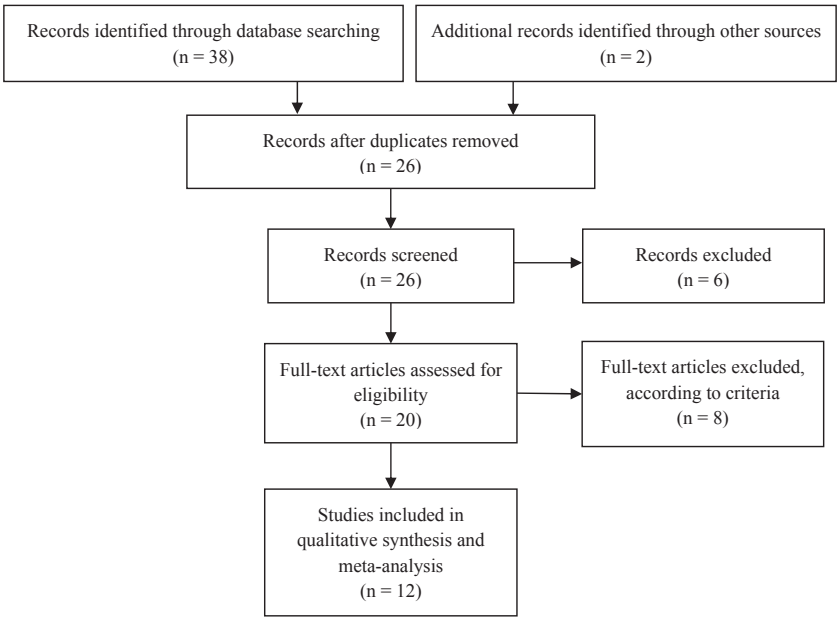

Fig. 2. Synthesis of the research process.

Table 4
Selected studies.

Author(s)/Year	Title of article	Journal
Brio and Junqueira (2003)	A review of the literature on environmental innovation management in SMEs: implications for public policies	Technovation
Klewitz and Hansen (2014)	Sustainability-oriented innovation of SMEs: a systematic review	Journal of Cleaner Production
Klewitz, et al. (2012)	Intermediaries driving eco-innovation in SMEs: a qualitative investigation	European Journal of Innovation Management
Sánchez-Medina et al. (2011)	Environmental Innovation and Sustainability in Small Handicraft Businesses in Mexico	Sustainability
Fernández-Viñé et al. (2010)	Eco-efficiency in the SMEs of Venezuela. Current status and future perspectives	Journal of Cleaner Production
Bos-Brouwers (2010)	Corporate Sustainability and Innovation in SMEs: Evidence of Themes and Activities in Practice	Business Strategy and the Environment
Mazzanti and Zobloi (2008)	Environmental Innovations, SME Strategies and Policy Induced Effects: Evidence for a District-Based Local System in Northern Italy.	The Icfai Journal of Environmental Economics
Robinson and Stubberud (2013)	Green innovation in Germany: A comparison by business size.	Journal of International Business Research
Vasilenko and Arbačiauskas (2012)	Obstacles and Drivers for Sustainable Innovation Development and Implementation in Small and Medium Sized Enterprises	Environmental Research, Engineering and Management
Cagno and Trianni (2013)	Exploring drivers for energy efficiency within small-and medium-sized enterprises: First evidences from Italian manufacturing enterprises	Applied Energy
Hansen et al. (2002)	Environmental innovations in small and medium sized enterprises	Technology Analysis & Strategic
Bocken et al. (2014)	The front-end of eco-innovation for eco-innovative small and medium sized companies	Journal of Engineering and Technology Management

3. In your opinion, what are the limiting factors/difficulties/constraints for manufacturing SMEs in Brazil to succeed in adopting eco-innovation?
4. In your opinion, what factors or variables internal to the company should be considered by manufacturing SMEs in Brazil prior to adopting eco-innovation?
5. In your opinion, what factors or variables external to the company should be considered by manufacturing SMEs in Brazil prior to adopting eco-innovation?
6. General closing question: Please feel free to suggest, question and contribute openly to the research with your point of view on the topic of eco-innovation in manufacturing SMEs in Brazil.

According to Ribeiro and Milan (2007), a semi-structured questionnaire consists of a basic interview plan, a set of questions that will be positioned as the interview evolves. The questionnaire was sent to prospective respondents from the most important research groups regarding the topic, identified in the Brazilian platform of research groups of the Coordination for the Improvement of Higher Education Personnel (CAPES), meeting the following qualification criteria: (i) participation in eco-innovation research groups; (ii)

Table 5
Experts profile.

ID	Experts profile
E1	Coordinator of a research project on eco-innovation in emerging and developed economies. Full professor. Ph.D. and Postdoc in Management.
E2	Researcher on eco-innovation with several papers published. Associate Professor. Ph.D. in Management.
E3	Coordinator of a research project on eco-innovation. Senior researcher. Ph.D. in Innovation Studies & Development
E4	Coordinator of a research group on eco-innovation, with a large number of articles on eco-innovation published. Assistant Professor.
E5	Researcher on eco-innovation with several researches concluded in eco-innovation. Manager of a Brazilian Polo of Technological Innovation. Full Professor. Ph.D. in Production Engineering.
E6	Full Professor and member of a research group on eco-innovation, with books and papers published in eco-innovation.
E7	Senior researcher on eco-innovation with several papers and books published. Full professor. Ph.D. in Management.
E8	Senior researcher on eco-innovation with several papers published. Assistant Professor.
E9	Senior researcher on eco-innovation. Head of Engineering Department. Ph.D. in Engineering.
E10	Coordinator of several research projects on eco-innovation. Head of Department. Ph.D. in Management.

author of article on eco-innovation published in a periodical with Journal Citation Report impact factor higher than one (1,0); (iii) to have supervised Ph.D. research work or have published chapters/books on eco-innovation. The profile of the Brazilian experts who answered the questionnaire is the following (Table 5):

It is important to stress that the construction of the questionnaire followed the guidelines suggested by Hair et al. (2005) for content or face validity, being then validated through a small sample of respondents. Validity is the degree to which a construct measures what it intends to measure. A construct with a perfect validity degree has no measurement errors, and an easy measure of validity would be to check the measurements observed against the true measurement, however, the true measurement is rarely known (Hair et al., 2005).

The questionnaire construction criteria adopted were, in short, the following: the first two questions are intended to relate the connection between the practices and the respective advantages resulting from the eco-innovation. Question three focused on general aspects whereas the next questions are aimed at pinpointing external and internal general aspects. The specialists' responses were analyzed through the content analysis process (Bardin, 2002). Content analysis is another data collection method classified as an observational approach by Hair et al. (2005), which may be obtained by human, mechanical or electronic observation. Following the content analysis, the specialists' responses were analyzed and consolidated in two ways according to Ribeiro and Milan protocol (2007): (i) internal comparison and consensus among the respondents; (ii) external comparison: the results were compared with the literature evidence, serving as a reference to identify determining factors and a posterior comparison with the literature findings. These results are detailed in the next sections.

4. Results and discussion

This section presents the detailed results, in order to meet the objectives of the study. Furthermore, the discussion about the results was performed by analyzing the internal results, the results from the literature and their implications to the SMEs. This section starts presenting the descriptive results, covering the contributions and advantages of eco-innovation to Brazilian SMEs, its barriers, internal and external variables influencing eco-innovation, diffusion strategies for eco-innovation, contributions and eco-innovation determinants to Brazilian SMEs context.

4.1. Descriptive results

Results from the literature analysis of the selected studies allowed the identification of a 27 determinants list. This comprehensive list was consolidated based on several world experiences and the main world projects focused on sustainable innovations in SMEs (Table 6).

Through the analysis of Table 6 it is possible to conclude that: (i) most of the studies on eco-innovation in SMEs context available in the literature were performed in the European Union; (ii) regarding the adopted methodology, semi-structured interviews and questionnaires followed by quantitative analysis are the most common research method; (iii) SMEs of the manufacturing segment are the most frequently investigated samples on the literature.

The impact and dissemination between scholars of these studies also were verified. Hence, the Publish or Perish (Harzing, 2007) software was applied for identifying the total number of the studies mentions selected for analyses (Table 7). Publish or Perish is a software program that retrieves and analyses academic mentions using Microsoft Academic Search and Google Scholar to obtain, analyse and present metrics regarding raw mentions. The following criteria were used for perform the analysis: (i) Total number of mentions denotes the sum of all mentions in all studies; (ii) An average number of mentions per year indicates the number of mentions in the studies divided by the number of years included in the result set. These results were obtained on 11 December 2016.

The study with the largest number of mentions (301) was conducted by Brio and Junqueira (2003). A possible explanation may be the combination of the year of publication and the diffusion of the theme of eco-innovation from the 2000s. The purpose of the study was to collect the most important contributions to the economic literature about the special characteristics of the management of the environmental innovation in the SMEs, showing their strengths and weaknesses about the way public administrations face this situation.

Table 6
Profile of selected studies.

Authors	Project/Data set	Methodology	Region	Sample
Brio and Junqueira (2003)	PRIMA Project	Semi-structured interview with director or manager in sustainable innovation activities	Europe Union	26 rubber and plastics SMEs
Klewitz et al. (2012)	Ecoprofit Project	Exploratory qualitative interview	Germany	7 metal and mechanical engineering SMEs
Sánchez-Medina et al. (2011)	States with the greatest representation of pottery handicraft businesses	Questionnaires and quantitative analysis	Mexico	168 handicraft SMEs
Fernández-Viñé et al. (2010)	SME Observatory of Venezuela	Questionnaires and quantitative analysis. To compare SME opinions in different countries.	Venezuela	54 manufacturing SMEs
Mazzanti and Zobloi (2008)	Data derived from two surveys of regional projects.	Econometric/quantitative analysis	Italy	257 manufacturing SMEs from Northern Italy
Robinson and Stubberud (2013)	Eurostat's (2011) Community Innovation Survey	Questionnaires and quantitative analysis. To compare SME opinions in different countries.	Germany	96.000 answers
Vasilenko and Arbačiauskas (2012)	SPIN (Sustainable Production through Innovation) and APINI (Institute of Environmental Engineering)	Questionnaires and quantitative analysis	Lithuania	30 manufacturing and services SMEs
Cagno and Trianni (2013)	Database of enterprises which had participated in a regional project	Semi-structured interviews. Multiple case-study.	Italia	71 Italian manufacturing SMEs from Lombardy
Hansen et al. (2002)	ENVIS Project	Multiple case-study.	Five countries from EU	20 SMEs of four sectors
Bocken et al. (2014)	Dutch SMEs who applied for the Prize Het Ei van Columbus for sustainability innovations	Questionnaires and two in-depth semi-structured interviews	Netherlands	42 manufacturing and services SMEs
Triguero et al. (2013)	Flash Eurobarometer Project	Questionnaires and quantitative analysis	Europe Union	5222 SMEs' managers

Table 7
Landscape of citations.

Author	Total number of citations	Average citations per year
Brio and Junqueira (2003)	301	23,15
Klewitz and Hansen (2014)	141	70,5
Klewitz et al. (2012)	45	11,25
Sánchez-Medina et al. (2011)	8	1,6
Fernández-Viñé et al. (2010)	41	6,83
Bos-Brouwers (2010)	253	42,17
Mazzanti and Zobloi (2008)	9	1,13
Robinson and Stubberud (2013)	14	4,67
Vasilenko and Arbačiauskas (2012)	15	3,75
Cagno and Trianni (2013)	60	20
Hansen et al. (2002)	69	3,83
Bocken et al. (2014)	47	23,5

Moreover, the study with the largest index of average mentions per year (70,5) was the one by Klewitz and Hansen (2014) that despite being recent, had an exceptional average of mentions per year. This study literature review analyzed the heterogeneous picture research in the past 20 years with a focus on the innovation practices including different types of sustainable innovations and strategic sustainability behaviours of SMEs. The Bos-Brouwers (2010) article study is also highlighted. This research uses insights from innovation theory, sustainable development practice and SMEs characteristics to unlock new knowledge on factors that influence the translation of eco-innovations within SMEs into practice. These may be considered possible emergent studies in this research field.

4.2. Contributions and advantages of eco-innovation to Brazilian SMEs

This section presents outcomes of the content analysis of results of the questionnaire applied to Brazilian experts. The first question is an opening and general question about how eco-innovation practices can contribute towards the competitiveness of small and medium-sized enterprises. The expert E1 stated that eco-innovation contributes to increasing internal efficiency in the use/consumption of resources in SMEs. Besides, it contributes to cost reduction, reliability in production processes, less exposure to price volatility and supply of basic inputs (energy and water), and lower capital commitment of the company with provisions for labor, environmental and civil liabilities. Eco-innovation also improves competitiveness in the development of market niches and enables the positioning in rigorous markets. E4 corroborated arguing that*"SMEs who wish to go into the international market (USA and Europe) have a higher probability of achieving competitive advantages with eco-innovation"*. Based on these results, the challenges for SMEs to increase the diffusion of eco-innovation practices is associated with avoiding the waste generation. In fact, the most effective waste management approach is to avoid generating waste rather than developing even the most effective recycling methods. Eco-innovations particularly focused on improving material and energy productivity can save costs and lower risks by making companies less dependent on imports (EIO, 2013).

The increase in profit margin and differentiation in products/services of small business was observed by several authors (E1, E3, E5, E6, E8). The company image impact in the market was also highlighted. E10 and E8 say that eco-innovation can lead a company to improve its image to the stakeholders. E2 complements affirming that some of the eco-innovation practices require investments to generate gains or reduction of cost while some will not produce financial benefits but rather other types of return (image enhancement). These findings are similar to those of the Eco-Innovation Observatory, which monitors the regional and national levels of efforts and results in eco-innovation in Europe. As a result, developing eco-innovative products, services and technologies may imply fundamental changes to existing designs, which may be costly in the short term but beneficial in the long term (EIO, 2013).

The increase of competitive results was also observed. To E4, eco-innovation contributes to enabling distinct competitive results and to E6, it represents a strategic market positioning. Investing in eco-innovation practices will allow SMEs to achieve distinct competitive results (E4). He also states that few enterprises sectors recognize and value socio-environmental issues in their businesses. However, a possible disadvantage is that SMEs' customers in low economies or developing countries could avoid purchasing products, services or processes due to price increases reflecting the costs involved in the implementation of eco-innovation.

E5 argued that product eco-innovations change the productions method. He also complements stressing that for the world economic system to survive, it will increasingly depend on organizational skills and on the creation and improvement of sustainable economic processes. Eco-innovations also contribute to cost reduction. This is obtained reducing the consumption of natural resources (E7). To E8, the eco-innovation not only minimizes costs but also generates opportunities to engage in projects, programs, receiving seals, awards, and to access other strategic partners (environmental entities, consulting companies, associations, class entities, suppliers, competitors, etc).

Eco-innovation practices may contribute to the consolidation of the environmental management of enterprises, allowing for the concomitant achievement of both economic and ecological gains (E9). Finally, E10 observed the importance of eco-innovation practices to SMEs competitiveness, highlighting the fact that every environmental problem is an efficiency problem.

The second question addressed products, services and processes eco-innovation, analyzing what competitive advantages SMEs could expect to achieve by adopting eco-innovation for products, services, and processes. In this direction, E2 observed that adopting

a significant number of eco-innovations in products, services, and processes generally contributes to the reduction of costs in the medium and long terms, with the reuse/recovery of waste and avoidance of sanctions by oversight. SMEs gain competitive advantage not only by reducing costs but also by anticipating a trending market that will be irreversible in a few years or decades: natural resources are limited and therefore require a great deal over the price of production (E3).

E4 observed that expected competitive advantages to SMEs are related to the differentiation in the medium and long term and to the consolidation of a socio-environmentally compromised image. Nonetheless, this involves investments in technology, research, and development, as well as strategic pro-action partnerships in the consumer market.

One of the main advantages of eco-innovative products, services and processes would be the acquisition of new clients, given the growing importance of the environmental issue in our society. The opening of the company to new markets, a differentiated positioning for suppliers and increased profitability through the gains from the efficient use of its resources can also be considered possible competitive advantages (E6). On the whole, the value added to the enterprise is expected (E5).

Adopting eco-innovation for products, services and processes will also increase the market share and improve the company image for stakeholders (E7). In addition, on leading the SME to having a better image in the market, E9 observed the economic gains coupled with environmental gains, reduction of consumption of toxic raw materials, waste reduction, and reduction of generation and disposal of materials.

E8 stated that products and services can be obtained through serving a market niche that,even being small, will value and pay for products that have a sustainable bias, such as a life cycle of clean development mechanisms or recyclable packaging. In short, on the processes perspective, the competitive advantages are primarily based on resource savings and on the ‘green marketing’ that can be generated from innovative and sustainable processes.

4.3. Barriers to eco-innovations in Brazilian SMEs

This section presents the results regarding the point of view of experts on the third question that inquired what are the limiting factors, difficulties or constraints for Brazilian SMEs to succeed in adopting eco-innovation. As a result, it was possible to obtain a list of factors that blocked the diffusion of eco-innovative practices. Based on the responses, it was possible to conclude that the mindset vision of SMEs’ managers is an important barrier to the dissemination of eco-innovation in SMEs. To E1, there is a managerial myopia about the importance of innovation and sustainable innovation as an element of business strategy. He also adds that SMEs tend to consider the expenses with eco-innovations as a cost rather than as an investment. Finally, the Brazilian consumer market, in many segments, still does not recognize the importance and nor is it willing to pay more for a sustainable product. Besides the necessary investment costs, the lack of capacity/knowledge and cultural issues should also be considered (E2). E3 mentioned the lack of resources and complemented saying that it may be more difficult to perceive (or amortize) the value of investment in SMEs that invest in eco-innovations initiatives.

Among the limiting aspects, E4 highlighted that: (i) in general, owners of small and medium-sized Brazilian companies adopt a reactive stance to the market, waiting instead of developing a proactive stance; (ii) there is no culture of investment in innovative technologies and R&D in SMEs through agreements with universities and research centers, for example; (iii) there is a predominance of the thought that returns should be obtained in the short term; (iv) there is a low awareness about the need to invest in socio-environmental aspects. And when it occurs, it is motivated by the mandatory legislation in view of the specific sector in which the company operates; (v) due to the fact that Brazil is a rich country in terms of natural resources, its population and the entrepreneurs themselves are generally not yet sufficiently concerned about the nature limits.

For E5, the main factors that can represent difficulties are: (i) lack of qualified personnel to plan and implement eco-innovation practices; (ii) the manager’s understanding of the concept and applicability of eco-innovation; (iii) the manager's view on the economic and social benefits prior to the adoption of eco-innovative practices; (iv) immediacy of the manager to obtain economic results; (v) the resistance to investment in a new type of professional within the company to implement the tool, and (vi) the resistance to innovation, that is, to change the way in which products have always been designed and produced.

As well as E4 and E5, the expert E6 highlights the lack of knowledge about how to incorporate eco-innovations as a constraint. He adds up that unfolding strategic environmental objectives into actionable actions is a challenge to SMEs. The aspects related to costs are also relevant to small enterprises: “*It is common for SMEs to work with low-profit margins, which leads to the prioritization of other issues*.”

E7, however, argues that these barriers are very similar to those of traditional innovation practices. The need for effective implementation of innovation regulations and laws, the need for an eco-system of innovation (seed money, incubators, and technology parks), and the shift of emphasis from schools (mainly in engineering schools) to the integration of projects between universities and companies are the mains limitations. E8 corroboratesthis opinion and adds: (i) the lack of public policies; (ii) the lack of cooperation between SMEs, universities and other research institutes; (iii) the lack of information sharing among the agents of the same activity, branch, business, production chain; (iv) high cost for SMEs to carry out technology development and R&D; (v) the lack of culture of entrepreneurs and managers who, according to the national Innovation Research (PINTEC) carried out by the Brazilian Institute of Geography and Statistics (IBGE), in their vast majority see innovation only as the acquisition of machines, software and equipment.

Besides financial limitations, E9 suggests the internal culture of employees regarding change and an innovative position of SMEs, the lack of professionals with knowledge in eco-innovation, and especially, sustainability and environmental management. Likewise, E10 concludes stating that a higher level of ecological awareness and a less innovative tradition may be an obstacle. The resistance to hiring qualified professionals to implement eco-innovation in SMEs was apparently not previously linked in the literature with the

Table 8
Barriers to adoption of eco-innovation.

Barriers	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
The awareness and understanding of SMEs about eco-innovation proposal	✓				✓				✓	
Consider eco-innovation spending as a cost and not as an investment	✓									✓
The necessary costs to implement eco-innovative practices and the financial standing of the SMEs		✓				✓				
The need for skilled professionals to plan for and implement eco-innovation		✓			✓				✓	
Owners of SMEs with reactive attitude to the market and not one proactive				✓						
The need to invest in innovative technologies, research and development (R&D) in conjunction with universities, research centers, and external agents				✓				✓		
The SMEs management's immediatist culture to achieve quick results and a short term vision of management				✓	✓					
Low awareness of SME on benefits of eco-innovation and the need to invest in socio-environmental aspects and when this occurs is motivated by the mandatory legislation				✓	✓					
Cultural resistance to innovating and doing things differently					✓					✓
The inclusion of eco-innovation into the strategy of SME						✓				
Costumers acceptance, cultural aspects and awareness of customers on sustainable products	✓	✓								
The existence of an ecosystem of eco-innovation (seed money, incubators, technology parks)							✓	✓		
The need of change of emphasis in schools (mainly Engineering schools) for the integration of projects between university-companies							✓			
Lack of public policies encouraging the SME cooperation with universities and research centers								✓		
Lack of information sharing among agents of the same activity, branch, business or productive chain								✓		

common reality of lack of economic conditions of SMEs. This kind of resistance, as well as the resistance to change the way in which products have always been designed and manufactured, can be related to the lack of the managers' understanding and awareness about the eco-innovation concept and its benefits.

To summarize and complement these findings, Table 8 presents the summary of barriers and limitations pointed by specialists that may block the diffusion of eco-innovation in Brazilian SMEs.

The analyses of these consolidated results made it possible to identify fifteen main barriers related to the Brazilian scenario. The lack of an innovation culture in Brazilian entrepreneurs and managers may be illustrated according to PINTEC (IBGE) reports. These data reveal that entrepreneurs, in their vast majority, comprehend the innovation as the acquisition of machines, software and equipment (E8). Based on these findings, it is possible to consider that the level of awareness on sustainability among SMEs' managers and society, as a whole, in emerging markets such as the Brazilian one, as still being in an early stage if compared to first world countries.

As a consequence, some barriers to the adoption of eco-innovation may be considered more critical to the Brazilian context in particular. In this direction, the compliance between the results literature review and the specialists demonstrated that the awareness and understanding of SMEs about the eco-innovation proposal leads them to consider the eco-innovation spending as a cost and not as an investment, the immediatist culture to achieve quick results and a short term vision of management, the low awareness of SMEs on the benefits of eco-innovation, the costumers acceptance and the sustainable awareness may be considered the main barriers.

The barrier 'need for skilled professionals to plan for and implement eco-innovation' can be mitigated with the adoption of organizational eco-innovations (Sehnem et al., 2016). In this case, the SMEs should prioritize strategies to the introduction of organizational methods and management systems to deal with environmental issues in production and in products/services. The barrier 'Costumers acceptance, cultural aspects and awareness of customers on sustainable products' is directly associated with social eco-innovations (Sehnem et al., 2016). In this case, SMEs need to consider the behavioural dimensions in their business process based on the market and on the change of lifestyle and consumption patterns. The monitoring of these factors will result in the demand for goods and green services. Understanding the environmental impacts across the life-cycle is essential, especially considering the complexity of upstream and downstream direct and indirect impacts (EIO, 2013).

This comprehensive set of factors identified can be highlighted as the more influencing constraints for the diffusion of eco-innovation practices in an emerging economy such as Brazil. Thus, it is possible to state that the main contribution of these limitations lies on the consolidation of the main factors that should be considered by SMEs, not only in an internal perspective, but also by policy makers, in an external perspective, in order to increase the adoption of eco-innovation in small companies.

4.4. Internal variables influencing the eco-innovation in Brazilian SMEs

The fourth construct of the questionnaire sought to identify what factors or internal variables should be considered by Brazilian SMEs in order to implement eco-innovations. The primary objective of this question was to obtain a consensus on the strategies that should be prioritized by companies to minimize the effects of the previously identified barriers. According to E1, three internal variables should be considered by SMEs regarding eco-innovation. The first is regarding human capital. That is, it is necessary that people within small businesses understand and comprehend the meaning of the sustainability concept. As a consequence, this must be considered by SMEs a fundamental element in the strategic, tactical and operational plan of enterprise. The second is R&D. There is a need to develop an internal and fundamentally external R&D structure (relationship with institutes and universities) for the development of innovation projects in this area. Currently, multiple development agencies support research resources in companies, so it is possible to think about R&D in small and medium-sized companies. Third, are the internal processes in all areas that value and

promote sustainability practices within companies.

The most relevant internal factor is the comprehension that adopting eco-innovations is an investment that will generate benefits that are often not measurable economically (E2). In this same direction, to E3 it is necessary that the management of SMEs be open to the changes, involving the actions under the paradigm of environmental responsibility. After that, the values related to this paradigm must be communicated to all of the company.

Corroborating E1, according to E4, the company must have a permanent internal policy of allocating budgetary resources for the development of new eco-innovative products, services and processes, either by an own R&D department or by partnering with other companies or by an agreement with universities/institutes. Nevertheless, it depends on the perception and awareness of the entrepreneurs that they will have a return on the investment made there and on them overcoming the resistance of sharing their knowledge, experiences and control over their resources externally with other companies and stakeholders. Similar variables were related by E5, who observed the existence of qualified personnel, the capacity to invest in project and re-design, the time destined for the encouragement and orientation of the team of employees to implement the philosophy of eco-innovation and the reorganization of production processes as factors to be considered. He also added an interesting aspect related to the analysis of the marketing team's ability to plan campaigns to promote new products based on eco-innovation in the market.

Structural internal variables typically found in SMEs were related as a priority by specialist E6. He pointed the financial condition of the company as an important factor to be considered, because the monetary gains from eco-innovations may not be achieved in the short term. Thus, this aspect is not interesting, because the most part of the SMEs has of short budget. Furthermore, the size of the company also has a relevant weight, since small enterprises have few financial, technological and human resources, making it difficult to allocate resources to the company's innovation projects. The existence of a motivated member concerning the environmental issue (Environmental Champion) must also be considered. Finally, the position of the small firms in the value chain should be evaluated. Those closer to the end of the supply chain tend to suffer greater external pressures to adopt sustainable practices in their process, leveraging eco-innovation practices in the firm.

Corroborating previous findings, E7 also underlines that creating an internal culture of innovation is an important determinant. According to E9, changing the managerial culture and culture collaborators for innovation and sustainability are a foundation of a very well consolidated environmental management; as well as professionals with experience on entrepreneurship, innovation and sustainable actions (processes and products). Finally, to E10, internal variables that should be considered by SMEs towards eco-innovation are the teamwork, the work cooperation, every human resource management policy, the existence of a transformational leadership (agreeing with E6), the strategic integration, the good communication between departments and a strong R&D department.

4.5. External variables influencing the eco-innovation in Brazilian SMEs

Several external variables affect the successful adoption of eco-innovative practices in Brazilian SMEs. Particularly, the national and international legislations have changed and become increasingly rigorous with business practices and their impacts on society and the ecosystem around the company (E1, E3, E6, E8, E10). This changes the competitive conditions between companies, making it possible for competitors to adopt the same paradigm (E3, E6). Therefore, the SME should ask itself ‘how are my competitors (re) acting on sustainable issues?’ Furthermore, the environmental pressures of stakeholders should be evaluated, such as changes in the behavior of the supply chain in which the SME is positioned (E6). These findings corroborated the statement of theEco-Innovation Observatory on the status of eco-innovation in Europe. The key challenges related to supply chain management include coping with the rising volatility of commodity prices, dealing with uncertain supply of materials, as well as meeting customer demand for an improved transparency of supply chain (EIO, 2013, p.32).

Regarding the costumer perspective, results highlighted that there is an on-going change in the behavior and in the way consumers interact with companies and their products, where sustainable issues have become qualifying criteria (E1, E5, E8, E9). It is necessary for SMEs to find on the market the desire to absorb sustainable products. Only in this way will the entrepreneur invest in this type of innovation (E9). According to another expert (E5), external factors or constraints are: (i) consumer acceptance of sustainable products; (ii) the existence of materials in sufficient quantity to supply production based on eco-innovation, and (iii) the valuation of qualified professionals to act with eco-innovation initiatives within companies.

Another well related external variable is the available resources to Brazilian SMEs to perform eco-innovation projects. There are international and national investment funds through development banks that provide resources to eco-innovative projects (E1). However, the access to funding sources needs to be facilitated and less bureaucratized (E2). Furthermore, the SMEs should work collaboratively on networks to access knowledge and other resources needed to minimize the lack of access to financial resources (E7).

That is, SMEs need to open their processes to the external environment to obtain knowledge and information. Consequently, one of the SMEs challenges is to perform the monitoring emerging trends that may influence their value proposition (EIO, 2013). This is a necessary cultural and mindset change. In this direction, a relevant external factor to the companies in the process of adoption of eco-innovations is narrowing the gap between businesses and the academic sector. Universities and companies do not have the same rhythm and do not always adopt the same language. In addition, their goals are distinct and the approach is laborious and requires tolerance and abdication of status and power of both parties (E4).

4.6. Enhancing the diffusion of eco-innovation in Brazilian SMEs

Lastly, the closing question of the questionnaire provided an opportunity for comments and general contributions of experts. In this direction, E1 affirms that the periodical survey (PINTEC) carried out by the Brazilian Institute of Geography and Statistics (IBGE) should include small and medium-sized spending on eco-innovation in their periodical reports. Moreover, understanding the motivations, results and diffusion of eco-innovations in small companies is something that can contribute to the literature, as well as to how to discuss and address cases of failure

E3 highlights that it is important to reflect on the impact of eco-innovation on business return. Is it necessary to assess whether this impact is tangible or measurable, or if it will be intangible for a period and will bring profits only in the long term. It is important to understand how entrepreneurs faced this challenge. He concludes stating: "*In my opinion, having long-term thinking should bring more positive impacts to eco-innovation in the company than otherwise.*"

There are opportunities for further studies on overcoming the gap between research centers, academy and SMEs to successful develop eco-innovations. On the one hand, researchers are distant from the practical application of their experiments on the market. On the other hand, entrepreneurs are expecting a quick return on their investments and are adopting a waiting stance with consumers instead of proactively facing the market (E4).

Eco-innovation is based on an evolutionary perspective of innovation in which innovation emerges through a systemic process that refers to the interrelationship and dynamic interaction between different agents and internal and external factors that influence the innovation process. These assumptions motivate the exploration of the wide range of eco-innovation, as well as the analysis of changes in various dimensions of eco-innovation, consisting of design, user, product and process aspects. The definitions of eco-innovation are very general, and for this reason, many types of innovation can be considered eco-innovations. This situation results in an important question of how to classify eco-innovation to better understanding its characteristics and turning them into differentials for the industry to become sustainable (E5).

E8 suggests that some of the factors that could promote the diffusion of eco-innovation are information sharing and technological cooperation. In Brazil, many initiatives work well in some segments and take a long time to expand to others. This was the case of biodigesters, which had been used in swine for 30 years and only recently were used in the chain of products derived from manioc. Another aspect is the lack of a specific entity to publish the results (cases of success and best practices) that are often published in academic papers, but do not reach the public really interested. Just as Enterprise of Technical Assistance and Extension Rural (EMATER) and Brazilian Agricultural Research Corporation (EMBRAPA) are responsible for the promotion of agricultural technical knowledge. And similarly, the Brazilian Service of Support to Micro and Small Enterprises (SEBRAE) is the only responsible for supporting SMEs business. According to E8, a dedicate governmental entity is necessary in order to foster eco-innovation. To conclude, E10 states that eco-innovation is supported on local circumstances and on global management and that both aspects must be integrated.

4.7. Contributions of eco-innovation

Initially, the specialists' responses were consolidated in order to identify convergence and divergence points about eco-innovation practices and their respective advantages and general factors, internal and external to Brazilian SMEs. Table 9 consolidates the specialists' view about the topics related to the practices and main advantages of eco-innovation.

An analysis of Table 8 demonstrates that specialists agree about the potential advantages associated with increased competitiveness, cost reduction, brand enhancement and improved company image and about the possibility of deploying different strategies of cost and differentiation. Nevertheless, a possible disadvantage observed is that SMEs customers in low economies or developing countries could avoid purchasing products, services or processes due to price increases regarding the costs involved in implementing eco-innovation. This appointment is conflicting with the following aspect resulting from another expert's point of view: some of the eco-innovation practices require investments to generate gains or reduction of cost while some will not produce financial gains but rather other types of return (company image enhancement).

Regarding the advantages of adopting eco-innovation presented on the second question, results shown that increase profit margin and market share and improved image to stakeholders are the most common advantages. These related advantages are achieved by obtaining new customers due to the growing importance of the environmental issue in our society; in products/services, it may be

Table 9
Contributions of eco-innovation to SMEs.

Major eco-innovation contributions to SMEs context	Author
Increasing internal efficiency in the use and consumption of resources	E1, E5
Cost reduction and reliability in the production processes	E1, E2, E3, E7, E8, E9
Less exposure to price volatility and supply of basic inputs (e.g. energy and water)	E1
Lower capital commitment of the company with provisions for labor, environmental and civil liabilities	E1
Eco-innovation of products, services, business, and management processes increases competitiveness and the development of new markets, mainly in international markets.	E1, E4, E5, E6, E10
Increase profit margin and in differentiation in products/services in the medium and long term	E1, E3, E4, E5, E6, E8
Improves the brand and image of SME.	E2, E8, E10

Table 10
Internal and external determinants.

Internal and external determinants	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
The need for skilled professionals to plan for and implement eco-innovation practices	✓				✓				✓	✓
The need to invest in innovative technologies, research and development (R&D) in cooperation with universities, research centers and external agents.	✓			✓						
Internal culture and processes promoting and encouraging eco-innovation practices	✓		✓	✓	✓		✓		✓	
The understanding of the SMEs about eco-innovation concepts		✓								
Awareness on economic, social and environmental benefits from eco-innovation		✓	✓						✓	
Internal policy of allocating budgetary resources for the development of new eco-innovations	✓			✓	✓					
Structural internal variables of SME such as short budget, size and technological resources						✓				
The existence of an "eco-innovator leader" or "Environmental Champion" leading the diffusion of eco-innovative practices						✓				✓
The SME's position in the supply chain: enterprises closer to the end of the chain are more liable to suffer external pressure to adopt sustainable practices in their processes, leveraging eco-innovation						✓				
Participating in cooperating SME networks							✓			✓
Changes in national and international legislations and regulation of the sector where the SME operates	✓		✓			✓		✓		✓
Awareness of consumers to buy green products and incentives to buy eco-innovative product/services	✓				✓	✓		✓	✓	
The existence of raw materials in sufficient quantity to supply production based on eco-innovation					✓					
The access to international and national investment funds in eco-innovation	✓	✓								
Resistance to innovate doing things differently and owner' mindset			✓	✓						
Capacity of the marketing sector to divulge new eco-innovative products				✓						

achieved by serving a niche market that, even if small, values and pays more for products that have a sustainable bias. Moreover, new markets, differentiated positioning for suppliers and increased profitability can be obtained through gains from the efficient use of resources. Generally, the differentiation and the consolidation of a socio-environmentally compromised image organizational are achieved in a medium and long term perspective. And this trajectory includes investments in technology, research and development, as well as strategic partnerships within the market and strategic supply chain alliances.

The increase in value aggregation and the cost reduction in SMEs might be obtained as a result of the reduction of use of natural resources and the green marketing generated from innovative and sustainable processes. The cost reduction generally occurs in medium and long term and also minimizes the possibilities of penalties coming from inspectorate entities. Finally, the adoption of eco-innovation in SMEs takes the anticipation of a global trend that will be irreversible in a few years or decades due to the scarcity of natural resources. That is, considering that the natural resources are limited and contribute significantly to the costs of production and sales. And also that the current level of consuming tends to increase in parallel with the resources scarcity, the infusion of eco-innovations will, in advance, carry out the potential in to minimize these undesirable effects.

5. Main Determinants and implications to the Eco-innovation in Brazilian SMEs

Furthermore, findings derived from the fourth and fifth questions presented the internal and external variables related to SMEs that should be considered by Brazilian enterprises aiming to successfully implementing eco-innovation practices. This collection of variables might consider the most relevant determinants to minimize the existence of barriers to the Brazilian context, as discussed previously (Table 10) and might be considered as attention points to others emerging economies.

In a nutshell, the analysis of internal and external determinants shows the importance of the financial condition of the small company as a factor to be considered, since gains from eco-innovation may not be short-term, which is not interesting for companies with low budgets. Besides, small companies generally have scarce financial, technological and human resources, which make it harder to allocate resources for the company's innovation practices. For this reason, the cooperation with universities, research centers and external agents, or the participation in cooperating SME networks can be underlined as crucial determinants and pathways to these Brazilian companies.

Besides, other internal determinants are related directly to the conditions and internal culture of Brazilian SMEs. The first is the lack of internal culture and processes promoting and encouraging eco-innovation practices. The second is the internal policy of allocating budgetary resources for the development of new eco-innovations. The third is related to hiring skilled professionals to plan for and implement eco-innovation projects.

Conversely, several external determinants small companies have no control of significantly affect the potential of diffusion of eco-innovative practices. For that reason, changes in the national and international legislations and regulations of the sector in which SMEs operate, raising the awareness of consumers to buy green products, and incentives to buying eco-innovative product/services must be mitigated with governmental programs. In the same line, the access to international and national investment funds for eco-innovation should be facilitated with governmental proactive programs/actions.

5.1. Comparing the results with the literature

Another interesting comparative analysis performed in our study is the comparison between the findings from the specialists' opinion against the determinants found in the literature review on SMEs as a whole, and mainly in SMEs hosted in European Union,

as previously discussed (Tables 3 and 6). The outcome of this analysis demonstrates that, for some determinants, there is a relative degree of similarity between the Brazilian context and the previous literature. In the internal perspective, the determinants related to both the Brazilian context and the literature are: the organizational structure (less bureaucracy and more flexibility are better), available resources and structural variables of small business (qualified people, time, money), the motivation/awareness of the SME' owner/management, long term strategy as dominant orientation, the perception and awareness of the strategic relevance of eco-innovation and environmental aspects of the sector and of the customers, the presence of a R&D department with focus on sustainability, and the capability/competence of organizational learning of SME on eco-innovation issues.

On the other hand, the determinants found on the external perspective both to the Brazilian context and in the literature available are the following: the lack of neutrality of regulatory policies may affect the balancein favour of large companies and in detriment of the SMEs, the existence of specific actions of technological assistance, awareness and training programs in order to improve the cooperation of SMEs with external stakeholders, the reputation, the brand image and profit margin (pressuring suppliers to meet sustainable standards) and the impact of external pressures of the SMEs segment (e.g. regulation, supplier pressure, rise of energy prices, fees on polluting emissions).

The comparative results among Brazilian experts and the results from the literature review also allowed for the identification of a collection of determinants found in the literature review but not directly matched to the ones mentioned by the specialists. Among them are highlighted the following determinants: the capability of obtaining radical innovations, becoming more attractive to employees, performing cost control and risk management to avoid negative environmental impact and compliance, improvement of the energetic performance for the company and the market, adoption of recycling practices and reverse logistics and the adoption of eco-innovation methods and tools.

The above results may particularly suggest that some of these determinants (become attractive to employees, performing cost control and risk management to avoid negative environmental impact and compliance, and energetic performance) are directly related to the larger maturity and the more consolidate scenario of regulations of the European Union on sustainable practices in comparison with the context of developing countries such as Brazil. This can be partially explained by the several projects funded by European Union on this theme performed in the past decade and in the present.

In contrast, the results also present a set of determinants found to Brazilian SMEs context, but without a direct match to the determinants of the literature. In this sense, it is possible to say that the diffusion of an internal culture/process promoting/encouraging eco-innovation practices and allocating budgetary resources, the existence of an “eco-innovator leader”, the lack of an ecosystem facilitating eco-innovation activities in SMEs, and the access to international/national investment funds to implement eco-innovations reflect, in a wide perspective, on the immature stage of diffusion of the eco-innovation concept in Brazil. Comparing these results to the classification of eco-innovations proposed in the recent research by Sehnem et al. (2016), it is possible to conclude that the culture/process promoting/encouraging eco-innovation practices and allocating budgetary resources and the presence of an eco-innovator leader are associated with the organizational eco-innovations. This finding contributes with insights to extend the current set of determinants to the SMEs context available in the literature, particularly to the one on eco-innovation focused in developing countries.

These findings reinforce previous results on the Brazilian eco-innovation context, aside from the importance of the systematic implementation of various aspects of product, process and organizational types of eco-innovations. Moreover, the vast majority of studies on innovation focus on technological aspects and neglect social systems, requiring a systemic view in which the organizational efforts are supplemented by technological efforts (Brasil et al., 2016).

5.2. Comparing the results with the eco-innovation typologies

The results also promote a discussion on the determinant related to eco-innovative products. Specifically about the importance of green products to leverage the diffusion of eco-innovation in SMEs, a recent research topic discussing the integration between Lean and Green practices has been gaining attention in the literature. Measuring the influence of different methods derived from both the Lean and Green approaches, Fercoq et al. (2016) concluded that integrating their results enables for a solid waste minimization program in manufacturing.

In this same direction, Johansson and Sundin (2014) concluded that a stronger focus on value creation for customers, as advocated in Lean Product Development (LPD), is positively associated with Green Product Development (GPD) implementation. Furthermore, both concepts share a number of similarities that indicate a synergistic relationship and none of the concepts present limitations regarding industrial applicability. Larson and Greenwood (2004) also found synergies between lean production and eco-sustainability initiatives. Similarly, Kurdve et al. (2014) found several contributions of Lean green enabling eco-innovations analyzing experiences from the Swedish industry. Vinodh et al. (2011) discussed tools and techniques for enabling sustainability through lean initiatives, and several business models integrating lean and green for efficient and sustainable improvements enabling eco-innovations were analyzed in Aguado et al. (2013) and in Duarte and Cruz-Machado (2013).

Therefore, several evidence from the literature suggest that LPD and GPD might be linked as methodology enablers of sustainability, resulting in eco-innovations due to the ability of reducing several kinds of wastes and continually searching for perfection and waste elimination. This culture can potentially leverage environmental innovation in process and eco-friendly products. As a consequence, SMEs can benefit from the potential applications of Lean and Green approaches to help society make the transition to more sustainable societal patterns. This implies that investments in green products or green R&D can be a bottom line to a more fluid transition to eco-innovation practices in Brazilian manufacturing SMEs context. This may leverage the diffusion of product and process eco-innovations according to Sehnem et al. (2016) and the EIO (2013) classification.

In short, the overall findings obtained with the literature review and the internal comparison of Brazilian SMEs context with the literature have brought to light a comprehensive and structured list of determinants that SMEs should take into account when implementing eco-innovation practices. Moreover, our findings offer distinct determinants suggested to Brazilian SMEs. To conclude, our research expands the current collection of determinants available in the literature on this subject. All in all, it is possible to state that the primary objective proposed at the beginning of this research has been successfully achieved. The main scientific contribution of this research, in turn, is the indication of a set of critical determinants that have been frequently mentioned by specialists and are also present in the literature review. These research contributions can drive governmental programs, investments and internal management practices to increase the diffusion of eco-innovation in Brazilian SMEs.

6. Conclusions and research directions

The discussion on eco-innovation, although recent, has been achieving increased relevance in the international context. The present study has proved that this debate is still incipient as a general theme, mainly in connection with the particular impact of eco-innovation in Brazilian SMEs. Based on the literature review on eco-innovation, an initial list of critical factors was organized. The content analyses of the specialists' point of view allowed for the finding of similarities, overlaps and exclusion aspects between the determinants.

Outcomes showed that several difficulties hinder the diffusion of sustainable innovations in Brazilian SMEs context. In addition, a clear disadvantage to small businesses is that most of the existent literature focus is mainly directed to large enterprises, overlooking the significant contribution of SMEs to the global economy. Filling this research gap, the practical implication of this research is to generate new knowledge on the factors that influence the translation of eco-innovations within SMEs into practice to emerging markets, such as Brazil. As a result, our study contributes to scientific research discussing a set of alternatives aiming a more fluid internalization of eco-innovation to Brazilian SMEs context. Academics and professionals from other emerging economies may also use the results of our research to obtain research-oriented and practical-oriented insights for the dissemination of eco-innovations in their nations.

Another important contribution of our research is the identification of opportunities and themes for future researches on this emergent field. The first research avenue is the development of pragmatic methods in SMEs to create internal processes and product eco-innovations. The second is the proposition of frameworks, models and methods aiming to drive the implementation process within SMEs. It is suggested that such a model or method should contemplate the diverse constituting elements of eco-innovation eco-system such as institutions, public and private organizations, market, education and infrastructure.

The third is the validation of suitable systemic indicators of SMEs-oriented and empirical research-based innovations. The fourth research avenue is related to strategies to disseminating the practice of technology transfer offices (bridging institutions) across the country. These agencies may work as promoters of eco-innovation and mediators between universities and enterprises. Benefits of this initiative include the dissemination of eco-innovative practices and improved technological competitiveness of the country through the patent deposit. Another research opportunity is the proposition of models and strategies for disseminating the scientific culture of meeting the demands of enterprises and society through the education and training of young researchers. Finally, researches focused on the identification of the major obstacle to the dissemination and implementation of eco-innovative projects have emerged as an opportunity for research, since such barriers are associated to technical questions and to the perception of the environmental issues by the scientific and business community.

Some limitations of research also need to be mentioned. The first limitation is regarding the process of review of the literature, primarily based on the Scopus, WoS and Ebsco databases. Further researches could include different scientific databases not contemplated. A second aspect is the decision to include only peer-reviewed papers that were published in the English language. Studies in others languages could be inserted in new researches to expand the analysis. The third aspect was the inclusion of studies consolidating results of international projects focused on eco-innovation in SMEs showing results of an extensive set of sample and multiples case studies. Studies covering individual case studies may also be added to further research in this theme.

The outcomes showed the lack of researches focusing on the factors that prevent SMEs from achieving the same levels of competitive advantage in sustainable innovations of large organizations. Therefore, to explore this research gap is a significant opportunity for further studies in this field. Furthermore, our findings indicated that the classification of the eco-innovation topic needs to be better understood.

Hence, a good starting point to achieve this goal would be identifying the existing typology in theoretical research and the respective impact of the typology according to the following key points: is the production aimed at end consumers or at other companies? Are these SMEs new entrants in a particular market or well-established organizations? Finally, a research on how to integrate local/regional circumstances and the global management is suggested. To conclude, it is possible to state that the practical contribution of this study is on the consolidation of a comprehensive framework of eco-innovation to emerging markets, such as Brazilian SMEs. This study provides important insights and the challenges to academics, policy makers, and practitioners to improve the diffusion of eco-innovative practices.

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References

Aguado, S., Alvarez, R., Domingo, R., 2013. Model of efficient and sustainable improvements in a lean production system through processes of environmental innovation. J. Clean. Prod. 47, 141–148.
Andersen, M.M., 2008. Eco-innovation: towards a taxonomy and a theory. In: DRUID Conference 25. Copenhagen, DK. pp. 1–16.
Arundel, A., Kemp, R., 2009. Measuring Eco-Innovation, UNI-MERIT Research Memorandum. pp. 2009–2017.
Barbieri, J.C., et al., 2010. Innovation and sustainability: new models and propositions. RAE 50 (2), 146–154.
Bardin, L., 2002. Content Analysis.Lisboa: Edições 70.
Blackburn, W.R., 2007. The Sustainability Handbook: The Complete Management Guide to Achieving Social, Economic and Environmental Responsibility. ELI Press, Washington, DC.
Blackburn, W.R., 2008. The Sustainability Handbook. Environmental Law Institute, Washington.
Bocken, N.M.P., Farracho, M., Bosworth, R., Kemp, R., 2014. The front-end of eco-innovation for eco-innovative small and medium sized companies. J. Eng. Technol. Manage. 31, 43–57.
Borghesi, S., Crespi, F., D'Amato, A., Mazzanti, M., Silvestri, F., 2015. Carbon abatement, sector heterogeneity and policy responses: evidence on induced eco innovations in the EU. Environ. Sci. Policy 54, 377–388.
Bos-Brouwers, H.E.J., 2010. Corporate sustainability and innovation in SMEs: evidence of themes and activities in practice. Bus. Strategy Environ. 19, 417–435.
Brasil, M.V.O., Abreu, M.C.S., Silva Filho, J.C.L., Leocádio, A.L., 2016. Relationship between eco-innovations and the impact on business performance: an empirical survey research on the Brazilian textile industry. Revista de Administração 51, 276–287.
Brio, J.A., Junqueira, B., 2003. A review of the literature on environmental innovation management in SMEs: implications for public policies. Technovation 23, 939–948.
Brunswicker, S., Vanhaverbeke, W., 2015. Open innovation in small and medium-sized enterprises (SMEs): external knowledge sourcing strategies and internal organizational facilitators. J. Small Bus. Manage. 53 (4), 1241–1263.
Cagno, E., Trianni, A., 2013. Exploring drivers for energy efficiency within small-and medium-sized enterprises: first evidences from Italian manufacturing enterprises. Appl. Energy 104, 276–285.
Carrilo-Hermosilla, J., Gonzales, P.D.R., Konnola, T., 2009. Eco-Innovation: When Sustainability and Competitiveness Shake Hands. Palgrave Macmillan, New York.
Del Río, P., Peñasco, C., Romero-Jordán, D., 2016. What drives eco-innovators? A critical review of the empirical literature based on econometric methods. J. Clean. Prod. 112, 2158–2170.
Dresch, A., Lacerda, D.P., Antunes Jr., J.A.V., 2015. Design Science Research: A Method for Science and Technology Advancement. Springer, pp. 161.
Duarte, S., Cruz-Machado, V., 2013. Modelling lean and green: a review from business models. Int. J. Lean Six Sigma 4 (3), 228–250.
EIO, 2013. Europe in Transition: Paving the Way to a Green Economy Through Eco-Innovation. European Commission/DG Environment, Brussels.
Fercoq, A., Lamouri, S., Carbone, V., 2016. Lean/green integration focused on waste reduction techniques. J. Cleaner Prod. 137, 567–578.
Fernández-Viñé, M.B., Gómez-Navarro, T., Capuz-Rizo, S.F., 2010. Eco-efficiency in the SMEs of Venezuela: current status and future perspectives. J. Clean. Prod. 18 (8), 736–746.
Foxon, T., Andersen, M.M., 2009. The greening of innovation systems for eco-innovation – towards an evolutionary climate mitigation policy. In: DRUID Summer Conference – Innovation, Strategy and Knowledge. Copenhagen, DK.
Fussler, C., James, P., 1996. Driving Eco-Innovation: A Breakthrough Discipline for Innovation and Sustainability. Pitman Publishing, London.
Govindan, M.E., Tseng, M.-L., Geng, Y., 2016. Sustainable consumption and production in emerging markets. Int. J. Prod. Econ. 181, 261–265.
Gronum, S., Verreynne, M.L., Kastelle, T., 2012. The role of networks in small and medium-sized enterprise innovation and firm performance. J. Small Bus. Manage. 50 (2), 257–282.
Hair Jr, J.F., Babin, B., Money, A.H., Samouel, P., 2005. Research Methods in Management. Editora Bookman, Porto Alegre.
Hansen, O.E., Sondergard, B., Meredith, S., 2002. Environmental innovations in small and medium sized enterprises. Technol. Anal. Strategic Manage. 14 (1), 37–56.
Harzing, A.W., 2007. Publish or Perish. (Available from: http://www.harzing.com/pop.htm).
James, P., 1997. The Sustainability Circle: a new tool for product development and design. J. Sustainable Prod. Des. 2, 52–57.
Johansson, G., Sundin, E., 2014. Lean and green product development: two sides of the same coin. J. Clean. Prod. 85, 104–121.
Kemp, R., Foxon, T.J., 2018. Tyology of Eco-Innovation. MEI Project: Measuring Eco-Inovation. (In: www.merit.unu.edu/MEI/deliverables/MEI%20D2%20Typology%20of%20eco-innovation.pdf).
Kemp, R., Pearson, P., 2008. Measuring Eco-Innovation, Final Report of MEI Project for DG Research of the European Commission.
Klewitz, J., Hansen, E.G., 2014. Sustainability-oriented innovation of SMEs: a systematic review. J. Clean. Prod. 65 (15), 57–75.
Klewitz, J., Zeyen, A., Hansen, E.G., 2012. Intermediaries driving eco-innovation in SMEs: a qualitative investigation. Eur. J. Innov. Manage. 15 (4), 442–467.
Kurdve, M., Zackrisson, M., Wiktorsson, M., Harlin, U., 2014. Lean and Green integration into production system models?Experiences from Swedish industry. J. Clean. Prod. 85, 180–190.
Larson, T., Greenwood, R., 2004. Perfect complements: synergies between lean production and eco-sustainability initiatives. Environ. Qual. Manage. 13 (4), 27–36.
Love, J.H., Roper, S., 2015. SME innovation, exporting and growth: a review of existing evidence. Int. Small Bus. J. 33 (1), 28–48.
Maçaneiro, M.B., Cunha, S.K., 2010. Eco-Innovation: a framework for future research. In: XXVI Innovation Management Symposium. ANPAD, Vitória, BR.
Maçaneiro, M.B., Cunha, S.K., 2012. Eco-Innovation: a reference framework for future research. Revista Innovare 13 (1), 266–289.
Maes, J., Sels, L., 2014. SMEs' radical product innovation: the role of internally and externally oriented knowledge capabilities. J. Small Bus. Manage. 52 (1), 141–163.
Massis, A.D., Frattini, F., Pizzurno, E., Cassia, L., 2015. Product innovation in family versus nonfamily firms: an exploratory analysis. J. Small Bus. Manage. 53 (1), 1–36.
Mazzanti, M., Zobloi, R., 2008. Environmental innovations, SME. strategies and policy induced effects: evidence for a district-based local system in northern Italy. Icfai J. Environ. Econ. 6 (1), 7–34.
Mendonça, A.T.B.B., Cherobin, A.P.M.S., Cunha, S.K., 2012. Sectorial Systems Sustainable Innovations: analysis of categories, types and measurement measures. In: XXVII Innovation Management Symposium. ANPAD, Salvador, BR.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2009. The PRISMA group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 6 (7), e1000097. http://dx.doi.org/10.1371/journal.pmed1000097.
Motta, R.S., 2009. Global Forum on Environment on Eco-Innovation. OECD, Paris. 4–5 November. Available in: http://www.oecd.org/env/consumption-innovation/44053422.pdf.
OECDS, 2018a. Policy Brief Sustainable Manufacturing and Eco-innovation: Towards a Green Economy. (June 2009. Available in: http://www.oecd.org/dataoecd/34/27/42944011.pdf).
OECD, 2009b. Sustainable Manufacturing and Eco-innovation: Framework, Practices and Measurement. Synthesis Report. OCDE, Paris(In: http://www.oecd.org/dataoecd/15/58/43423689.pdf).
OECD, 2010. Working Party on SMEs and Entrepreneurship (WPSMEE), 'Bologna + 10' High-Level Meeting on Lessons From The Global Crisis and the Way Forward to Job Creation and Growth. Issues Paper 3: SMEs and Green Growth: Promoting Sustainable Manufacturing and Eco-innovation in Small Firms. (Available in: https://www.oecd.org/cfe/smes/46404383.pdf).
Ozaki, R., Shaw, I., Dodgson, M., 2013. The coproduction of sustainability negotiated practices and the prius. Sci. Technol. Human Values 38 (4), 518–541.
Rashid, N., Jabar, J., Yahya, S., Samer, S., 2015. State of the art of sustainable development: an empirical evidence from firm's resource and capabilities of malaysian automotive industry. Procedia – Social Behav. Sci. 195, 463–472.

Raymond, L., St-Pierre, J., 2013. Strategic capability configurations for the internationalization of SMEs: a study in equifinality. Int. Small Bus. J. 31 (1), 82–102.
Reid, A., Miedzinski, M., 2008. Eco-innovation: Final Report for Sectoral Innovation Watch. Technopolis Group, Brighton(Available in: www.casi2020.eu/app/web1/files/download/eco-innovation.pdf).
Rennings, K., 2000. Redefining innovation – eco-innovation research and the contribution from ecological economics. Ecol. Econ. 32, 319–332.
Ribeiro, J.L.D., Milan, G.E., 2007. Entrevistas Individuais: Teoria E Aplicações. FundaçãoEmpresaEscola de Engenharia da UFRGS.
Sánchez-Medina, P.S., Corbett, J., Toledo-Lopez, A., 2011. Environmental innovation and sustainability in small handicraft businesses in Mexico. Sustainability 3, 984–1002.
Sabadie, J.A., 2014. Technological innovation, human capital and social change for sustainability: lessons learnt from the Industrial Technologies Theme of the EU's Research Framework Programme. Sci. Total Environ. 481, 668–673.
Schumpeter, Joseph A., Opie, Redvers (1983) [1934]. The theory of economic development: an inquiry into profits, capital, credit, interest, and the business cycle. Transaction Books, New Brunswick, New Jersey. ISBN 9780878556984. Translated from the 1911 original German, Theorie der wirtschaftlichen Entwicklung.
Sehnem, S., Lazzarotti, F., Bencke, F.F., 2016. Sustainable practices and eco-innovations adopted by industrial companies. Int. J. Innov. 4 (2), 42–58.
Tranfield, D., Denyer, D., 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. Br. J. Manage. 14 (3), 207–220.
Triguero, A., Moreno-Mond, L., Davia, M.A., 2013. Drivers of different types of eco-innovation in European SMEs. Ecol. Econ. 92, 25–33.
UNEP. 2003; Available in: http://www.uneptie.org/division/media/review/vol26no4/IE26_4-SMEs.pdf.
Vasilenko, L., Arbačiauskas, L., 2012. Obstacles and drivers for sustainable innovation developmentand implementation in small and medium sized enterprises environmental research. Eng. Manage. 2 (60), 58–66.
Vinodh, S., Arvind, K.R., Somanaathan, M., 2011. Tools and techniques for enabling sustainability through lean initiatives. Clean Technol. Environ. Policy 13 (3), 469–479.
Wolcott, H., 2009. Writing Up Qualitative Research, 3rd ed. Sage Publication, Thousands Oaks, CA.
Wynarczyk, P., Piperopoulos, P., McAdam, M., 2013. Open innovation in small and medium-sized enterprises: an overview. Int. Small Bus. J. 31 (3), 240–255.