



Success factors for environmentally sustainable product innovation: a systematic literature review



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ARTICLE INFO

Article history:

Received 29 June 2011

Received in revised form

12 August 2013

Accepted 29 August 2013

Available online 13 September 2013

Keywords:

Innovation

Product development

Sustainability

Green products

ABSTRACT

The growing awareness regarding environmental sustainability has fully reached business reality. Consumers and companies alike are looking for alternatives to mitigate pressing environmental demands resulting from continuous population and economic growth. On the other hand, companies must deal with an increasingly competitive scenario where innovation is regarded as a survival need in most markets. It is thus clear that systematic academic research is paramount to guide companies to succeed in environmentally sustainable product innovation. In this context, this paper (i) consolidate extant research and aggregate findings of different studies on environmentally sustainable product innovation through an interpretative framework of published literature on the topic, and (ii) map critical success factors that drive the success of product innovation developed in this new logic of production and consumption. To achieve these objectives, a systematic literature review on environmentally sustainable product innovation was conducted. Results show that there are four main critical success factors for environmentally sustainable product innovation: market, law and regulation knowledge; interfunctional collaboration; innovation-oriented learning; and R&D investments. The factors identified in this research and corresponding variables were subjected to a brief empirical test by professionals. The test allowed a preliminary approval of the developed framework and identification of the most important variables within each factor. A research agenda based on the state-of-the-art on the topic is also proposed.

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1. Introduction

Innovation means change or novelty (Tidd et al., 2001). At the beginning of the 20th century, Schumpeter (1939) stated that economy expansion is directly dependent on innovation. According to him, innovation can take the form of new products, new production processes or methods, new markets or even new sources of supply. Since then, the concept of innovation has been extensively discussed and improved upon (see, for instance, the recent interest in the concept of business models documented by Boons et al., 2013; Schneider and Spieth, 2013), but the core aspect of novelty as determinant of change and economic progress has been preserved.

Given the increasingly competitive context of the contemporary economy, as well as equivalence in terms of offering in many market segments, it is argued that innovation can support differentiation and generate sustainable competitive advantage for

organizations. However, other than developing strategically and economically viable novelty, innovation nowadays is understood as a latent need that has to be undertaken in a way that social and environmental issues are also contemplated. This particular aspect validates the sustainability triple bottom line approach, concept introduced by Elkington (1997) according to which an organization's results must be measured against the interrelated environmental, economic and social dimensions.

Thus, the quest for environmentally sustainable performance levels is relevant not only to environmentalists and ecologists, but also to social, political, economic and managerial scientists and practitioners. In this context, government, society and market are driving forces towards the increase in both consumers' and companies' ecological awareness (Roberts, 2003; Matos and Hall, 2007; Gold et al., 2010). This is why organizational management must acknowledge not only prescriptive models and deliberate strategies, but also descriptive models and emergent strategies that contemplate organizational growth through low environmental impact practices (Sharfman et al., 2009). Considering that several companies face growth limits because of environmental issues, the practice of sustainable innovation deserves even greater importance (Zsidisin and Siferd, 2001; Handfield et al., 2005; Zhu et al.,

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Table 1
Papers in each search and journal.

Journals	Search 1	Search 2	Search 3	Search 4	Selected papers
Business Process Management	0	0	0	5	1
Design Studies	2	5	22	4	0
Ecological Economics	41	41	14	339	10
Ecological Modelling	4	0	0	58	0
Environmental Management (NY)	8	8	1	56	0
Environmental Modelling & Assessment	0	0	1	9	0
Environmental Quality Management	18	25	7	35	0
Environmental Research	0	0	0	7	0
Environmental Science and Technology	77	18	7	132	0
Environmental Science & Policy	4	6	1	87	0
European Business Review	1	5	1	12	0
European Journal of Innovation Management	1	5	1	31	2
European Management Journal	10	12	3	9	0
Harvard Business Review	2	5	0	12	1
Industrial Marketing Management	9	11	5	11	1
International Journal of Operations & Production Management	6	11	4	19	4
International Journal of Production Economics	4	29	24	37	4
International Journal of Production Research	1	25	18	14	2
Journal of Business Ethics	20	55	4	111	11
Journal of Business Research	11	19	0	17	1
Journal of Cleaner Production	161	129	212	378	20
Journal of Environmental Management	21	17	18	162	2
Journal of Economic Behavior & Organization	0	2	0	6	0
Journal of International Business Studies	0	0	0	0	0
Journal of Product Innovation Management	0	2	0	0	0
Journal of the Academy of Marketing Science	0	0	0	14	1
Management of Environmental Quality	0	8	6	0	0
Management Science	1	2	0	1	1
Research Policy	8	14	3	23	2
Science of the Total Environment	7	9	7	55	0
Technological Forecasting & Social Change	9	11	3	72	1
Technovation	7	14	4	12	3
Total	433	488	366	1726	67

2008; Sharfman et al., 2009). To face this pressing issue, dissemination of technological and organizational innovation oriented towards improving life quality and considering both current and future environmental needs is required.

Thus, although consumption increase can be considered an environmental risk, when analyzed through an ecoefficiency paradigm that contemplates the reduction of natural resource use, it can generate opportunities for sustainable innovation diffusion (Freeman, 2003; Berchicci and Bodewes, 2005).

In this sense, there are already important academic research contributions regarding development of green innovation products (Geffen and Rothenberg, 2000; Zhu et al., 2005; Zhu and Sarkis, 2007; Vergheze and Lewis, 2007; Ras and Vermeulen, 2009) and proposal of reference models capable of identifying and aggregating competences for sustainable innovation (Bowen et al., 2001; Berchicci and Bodewes, 2005; Handfield et al., 2005; Vachon and Klassen, 2008). However, there is still ample room for research in this area.

Among the existing gaps, the lack of a validated set of success factors driving market performance of environmentally sustainable products stands out (Green et al., 1996; Christmann, 2000; Darnall and Edwards, 2006). It can be argued that methods to measure market performance of traditional products may be not enough to capture the success dynamics for products developed within an environmentally sustainable approach, that is, green products (also known as eco-friendly or environmentally sustainable products). Green products are those that hold the potential to aggregate long-term benefits, reduce consumer stress and ameliorate customer environmental responsibility while maintaining its positive qualities (Maxwell and van der Vorst, 2003; Cambra-Fierro et al., 2008; Triebswetter and Wackerbauer, 2008). In this context, the objective of this paper are: (i) to consolidate extant research on

environmentally sustainable product innovation through an interpretative framework of published literature on the topic, and (ii) to map critical dimensions of success factors that drive the success of products developed in this new logic of production and consumption. These objectives are achieved through a systematic literature review.

This paper is structured as follows. First, methodological procedures employed in the systematic literature review are discussed in Section 2. Results of the systematic literature review on critical success factors for environmentally sustainable product innovation follow in Section 3, where an interpretative framework mapping the main domains of research in environmentally sustainable product innovation success factors is proposed. Finally, a consolidated list of critical success factors for green product innovation is proposed in Section 4 and conclusions are presented in Section 5.

2. Method

To identify critical success factors for environmentally sustainable product innovation and consolidate published research on the topic, a systematic literature review was conducted. Systematic reviews are characterized by a planned and structured approach to reviewing published academic research by using organized and replicable methods to identify, select, and critically assess literature searches (Tranfield et al., 2003; Jones, 2004). As the method allows for relatively high procedural and analytical objectivity and replicability, systematic reviews are increasingly being employed in management literature (Hallinger, 2013).

The methodology followed for the literature review included two main phases: selection and analysis. The selection phases comprised gathering a comprehensive set of publications in the desired areas, while the analysis phases consisted of a careful and

critical examination of the publications to identify patterns and recurrent themes. In particular, the systematic review followed a five-step scheme based on recommendations by [Margarey \(2001\)](#), [Tranfield et al. \(2003\)](#), [Jones \(2004\)](#), and [Thorne et al. \(2004\)](#) that included: (i) problem definition; (ii) selection of journals; (iii) selection of studies; (iv) critical appraisal and evaluation; and (v) synthesis. The description of these steps follows next.

First, in line with the overall objective of the research, the aim of the systematic review was to identify factors and variables that drive market success of environmentally sustainable product innovation, with special emphasis on practices actually implemented in industry.

Given the stated research objective, the selection of journals was conducted next. Key data source was limited to peer-reviewed journals, as they can be considered established and validated knowledge elaborated through rigorous scientific method. Using as selection criteria the alignment between stated aim and scope of each publication and the objective of the research, a total of 32 journals from Business, Management, Economics, Finance and Engineering were included in the key data source ([Table 1](#)).

For the next step, selection of studies, a search was conducted within the 32 journals in the data source with the following combination of keywords: 'environmentally sustainable product innovation'. The keyword combination was used as selection criteria for the 'title', 'keywords', and 'abstract' fields in each paper. Types of documents included in the search were 'articles' and 'reviews', and no time limits were established. The first search resulted in a sample of 433 publications. Additional searches were conducted with the keyword combinations "environmentally friendly products", "eco-design" and "environmental sustainability". The additional searches produced a total of 2580 papers. After duplicates were removed, the abstracts and metadata of all papers were independently analyzed by three researchers oriented to select only papers whose research questions and results were directly related to success factors for environmentally sustainable product innovation. Book reviews, non-academic papers, industry reports and papers that did not relate to the issue at hand were excluded. The whole sample was divided between the three researchers. At the end of this stage, the pool of publications was narrowed down to 67 papers that effectively addressed the issue of success factors for environmentally sustainable product innovation. This set of publications was then subjected to critical appraisal and evaluation by the researchers. The analysis was focused on the identification of factors that positively impact market performance of organizations that make available environmentally sustainable innovation in different economy sectors as measured by the level of diffusion of innovative products.

Finally, for the data synthesis stage, an aggregative approach was employed in order to summarize findings of the reviewed studies. Such aggregative approach relies heavily on the researcher's subjective interpretation about the reviewed papers. This is so because, as [Tranfield et al. \(2003, p. 212\)](#) aptly put it, "there tends to be low consensus concerning key research questions in management research". Thus, a certain degree of subjective latitude must be given to the researcher conducting the review, as the specificities of each study must be considered and compared to the other studies in order to derive shared meanings and to abstract an interpretation scheme useful for the declared purposes of the review. Given that the aim of the review is to provide a conceptual understanding of factors that drive innovative green product success, as measured by their level of diffusion in the market, results were analyzed using pattern-matching techniques ([Tharenou et al., 2007](#)). The results of this aggregative approach include both the analytical framework that maps the main domains of research in environmentally sustainable product

innovation success factors and the identification of the critical success factors that drive the success of environmentally sustainable product innovation.

3. Overview of research on environmentally sustainable product innovation

In this section and the next, results from the systematic literature review are reported. In particular, this section presents a general overview of the research on environmentally sustainable product innovation and proposes an interpretative analytical framework synthesizing the 67 main contributions along five research domains. It should be highlighted that one of the key concepts that guide this research is that of product innovation, that is, innovation that bring new products and/or technologies to the market ([Lukas and Ferrell, 2000](#)). In this context, environmentally sustainable product innovation involves the development of products or technologies that are both market-oriented and cause the minimal environmental impact possible ([Maxwell and van der Vorst, 2003](#); [Baker and Sinkula, 2005](#)).

Factors found in the 67 key studies subjected to critical appraisal and evaluation were classified under an analytical framework comprised by five dimensions. The construction of the analytical framework has resulted from integrating contributions from disparate research areas such as marketing, economics, innovation management, product development and business management. The dimensions of this framework were defined according to research patterns and main results depicted in the 67 key studies.

The first dimension of the analytical framework corresponds to studies aimed at mapping factors and variables that influence green innovation market acceptance. This dimension directly derives from the marketing discipline and its main contribution is to list and prioritize variables that influence consumer attitudes and cognitive processes that drive the buying decision regarding sustainable innovation. In this sense, [Bhate and Lawler \(1997\)](#) observed that the influence of psychographic and situational variables on market acceptance of environmentally sustainable innovation is stronger than the influence of demographic variables, which indicates that consumer age, income, and social class are not decisive factors when considering the acquisition of environmentally sustainable product innovation. This was later confirmed by [Halme et al. \(2006\)](#), [Houe and Grabot \(2009\)](#) and [Yalabik and Fairchild \(2011\)](#). Moreover, [Welsch and Kühling \(2009\)](#) showed that the consumption pattern of reference persons influence buyers' decisions regarding the acquisition of solar energy equipment and organic food.

Similarly, [Byrne and Polonsky \(2001\)](#) concluded that the inclusion of all stakeholders during the whole process of green innovation strongly influences market acceptance of innovation outcomes. [Rennings \(2000\)](#) and [Beise and Rennings \(2005\)](#) further observed that in the case of sustainable products of foreign origin, adoption depends mostly on a proactive behavior by consumers wishing such innovative products coupled with a favorable regulative environment. [Lee et al. \(2006\)](#) showed how the availability of knowledge and information flows about the environment, such as news about local air quality and global warming, help to articulate demand for environmentally sustainable products. It has also been shown that drivers of consumption of eco-friendly products can be strikingly similar to factors that lead to demand of traditional products, such as price and quality ([Brécard et al., 2009](#); [Brouhle and Khanna, 2012](#)).

The second dimension of the analytical framework corresponds to studies whose main goal was to identify drivers of organizational environmental responsibility. The motivation

behind research in this domain is to understand why and how companies decide to invest in environmentally sustainable product innovation. It differs from the first research dimension because its aims are focused on internal organizational factors, whereas research on green innovation market adoption is customer-oriented. Iyer (1999), for instance, analyzed organizational practices related to environmental sustainability and proposed a model to assess their consequences and the level of organizational responsibility. In a similar tone, Zhu et al. (2005), Cetindamar (2007), Chen (2007, 2008) and Aragón-Correa et al. (2008) investigated why companies adopt an environmental responsible attitude. Specifically, Chen (2007) proposed a construct that explains a set of green competences that a company must acquire or develop. These competences include an organizational culture oriented towards an environmentally friendly offering. This cultural approach requires proactive managers with a contingency view of the business that are able to innovate on products and processes and establish value-added partnerships. The importance of involving management in the development of environmentally sustainable product innovation is also highlighted by Jamali (2006) and Rehfeld et al. (2007), while González-Benito and González-Benito (2008) and Zailani et al. (2012) emphasize the role of market orientation in a firm's ability to develop environmentally sustainable innovations.

Also Pujari et al. (2003), Jabbour (2008) and Kammerer (2009) verified the subjacent dimensions behind environmentally sustainable innovation practices, as well as the relative influence of management variables, processes and their interfaces on innovation performance. They found that both organizational maturity level and quality of relationships with partners in the value system are highly important for environmentally sustainable product innovation. Similarly, Pujari et al. (2004) pointed out that organizational antecedents of top management support and functional interface of environmental specialists with design and product managers affect the environmentally responsive behavior in new product development. Besides, Cambra-Fierro et al. (2008) and Carrillo-Hermosilla et al. (2010) ratified the relevance of the integration among organizational areas and between the firm and its main stakeholders. Correspondingly, Mickwitz et al. (2008) studied the role of political tools in environmentally sustainable technology innovation and diffusion and found that both macro-, meso-, and microeconomics issues impact drivers of sustainable innovation. Also Peng and Lin (2008), while conducting an analysis on external environment interference potential, specifically regarding the regional setting where companies are located, confirmed that mesoeconomic issues are especially relevant to promote environmental innovation within organizations.

According to Hemel and Cramer (2002), internal stimuli for environmentally sustainable product innovation are more important than external stimuli. Among the internal stimuli discussed, the authors point out innovational opportunities, expected increase of product quality and new market opportunities as the most influential towards ecodesign. Conversely, Porter and Linder (1995), Horbach (2008) and Horbach et al. (2012) emphasized the role of environmental regulation in fostering environmentally sustainable product innovation. However, as described by Montalvo (2003, 2008), rigorous environmental regulation that does not consider technical change dynamics as well as environmental and economic risk perceptions by firms can actually hinder environmentally sustainable product innovation.

Overall, it was observed that research on drivers of organizational environmental responsibility indicate that flexible and proactive organizational culture and high levels of internal and external integration are the most important enabling competences for green innovation.

The third research dimension refers to methods for the development of sustainable innovation described in literature and adopted in practice. This research dimension is basically a particular subset of product development management literature and is usually oriented towards the understanding of the inner workings of environmentally innovation product development. Up to this stage, this research dimension is still relatively incipient. As thus, studies tend to be mostly case studies or specific proposals for new product development methods that focus on environmental sustainability. A chief representative of this research dimension is Hanssen (1999), who presents the comparative results of six distinct case studies on environmentally sustainable innovation based on the same methodology. Hanssen's (1999) focus was to identify methods and frameworks behind the green innovation process and its consequences. Also Chen (2001), Eder (2003), and Maxwell and van der Vorst (2003) deal with methodologies for developing environmentally sustainable products. Each study proposes a different method, but all have in common the need for mapping market behavioral trends as well as agile adaptation to it and a prompt product development process involving different areas within the organization. Similarly, Foster et al. (2000) identified the similarities between motivational factors for the development of green products and services inferring that organizations should orient their offerings according to market needs, thus reinforcing the importance of market and learning orientation competences. Finally, Carrillo-Hermosilla et al. (2010) proposed an analytical framework to explore the diversity in eco-innovation practices according to design, user, product service, and governance dimensions. The framework was then used to analyze five case studies of sustainable innovation. Results indicate the importance of functional sectors such as R&D, marketing and operations acting together in an integrated way with external stakeholders for developing successful environmentally sustainable product innovation.

The fourth dimension of the analytical framework includes studies that investigate the effects of sustainable innovation on firm competitiveness and performance. As it would be expected, this research domain includes mostly contributions from the business management discipline. Baker and Sinkula (2005) proposed a construct that examines the relationship between environmental marketing and organizational performance. They conclude that environmental marketing positively influences the organization's managerial capabilities such as new product development proactivity, but does not directly influences the achievement of competitive advantage. Walsh and Beatty (2007) and Fraj-Andrés et al. (2009) also tested the effect of environmental marketing on distinct dimensions of organizational performance, while Chen (2009) developed a construct to assess green brands and its implications on performance.

In a similar vein, Chen and Chang (2012) confirmed that green competences such as dynamism, transformational leadership and creativity positively influence green innovation development performance. Chen et al. (2006), Peng and Lin (2008), Brito et al. (2008), Triebswetter and Wackerbauer (2008), Visser et al. (2008), Naranjo-Gil (2009) and Arevalo (2010) all report gains, particularly regarding adding value to the brand, associated with innovations that bring increased sustainability. Similarly, Gonzalez-Benito's (2008) exploratory study mapped the effect that proactivity has on environmental management performance. The results confirm the importance of this competence on environmentally sustainable product innovation success.

Boons and Wagner (2009) discuss the different perspectives available to assess economic and ecologic performance and identify four dimensions of analysis: the firm, markets, production and consumption systems, and economic systems. Vachon and Klassen

(2008) and Albino et al. (2012) argue that interfunctional collaboration directly influences green product performance, while Lin et al. (2013) show that market demand positively affects green innovation and company performance. To Halila and Rundquist (2011), a network with diverse competences supports successful environmentally sustainable product innovation. This network, according to them, is particularly relevant for solving technological issues in eco-innovations.

To Testa et al. (2011), strict environmental regulation impacts competitive performance in the building and construction sector. According to them, a stringent environmental regulation – as measured by the frequency of inspection – provides a positive impulse for increased investments in technology infrastructure and innovative products, which finally impacts business performance. Similar results were also found by Doran and Ryan (2012).

The fifth research dimension include studies investigating how interfunctional collaboration impacts environmentally sustainable product innovation. This research dimension is closely related to knowledge management and organizational learning literature. Its main motivation has been to understand how different organizational resources and methods can be articulated to allow or improve environmentally sustainable product innovation. In this sense, Ellram et al. (2008) found that the coordinated application of the three dimensions of concurrent engineering to new product development process and corporate environmental responsibility brings higher benefits than a piecemeal strategy to challenge single environmental issues one at the time. Similarly, Pujari's (2006) empirical approach to the study of eco-innovation influence on market performance showed the importance of cross-functional integration and coordination, particularly when environmental professionals are included in the process. This was also observed by Aschehoug et al. (2012) and De Marchi (2012), who investigated how environmentally-related information from both internal and external stakeholders qualify the development process for green innovation.

Battisti (2008) studied the dissemination of technologies related to green products, listing gaps such as organizational financial performance versus advances in technology promoted by R&D. Hallstedt et al. (2010) explored the communication and decision-making processes between top management and the teams involved with development of environmentally sustainable

product innovation. They found out that handing out incentives for green innovation development and easing internal communication mechanisms are essential for promoting the integration of organizational areas that deal with environmentally sustainable product innovation. Finally, Jabbour et al. (2012) investigated to what extent green teams qualify the green new product development process. Results reveal that firms whose use of green teams is most intense reap benefits in terms of environmental management quality.

A summary of the interpretative analytical framework synthesizing the 67 main contributions along five research domains is shown in Fig. 1.

4. Environmentally sustainable innovation success factors

Analyzing the contributions of the studies included in the systematic literature review, four factors directly related to the success of environmentally sustainable product innovation were identified: market, law and regulation knowledge; interfunctional collaboration; innovation-oriented learning; and R&D investments. The main contributions related to each success factor are discussed next.

4.1. Market, law and regulation knowledge

According to Iyer (1999), Rennings (2000), Chen (2001), Beise and Rennings (2005), Zhu et al. (2005), Mickwitz et al. (2008), Kammerer (2009), Carrillo-Hermosilla et al. (2010), and Horbach et al. (2012), environmentally sustainable product innovation depends on consumers willing and able to acquire such innovations, environmental-friendly legislation, government incentives, and educational campaigns that disseminate sustainable culture among society. To these authors, organizations will invest efforts towards innovative cleaner technologies and production processes if these three forces are well intertwined and if companies recognize these external factors. Similarly, Yalabik and Fairchild (2011) state that green innovation is driven more by competitive market pressure than by the influence of consumers and environmental regulations. Moreover, according to Köhler et al. (2013) and Kiss et al. (2013), incentive policy programs, comprising financial or information support, may accelerate mass production of sustainable innovation

Research Dimension	References
Factors/variables influencing green innovation adoption	Bhate and Lawler (1997); Rennings (2000); Byrne and Polonsky (2001); Beise and Rennings (2005); Halme et al. (2006); Lee et al. (2006); Brécard et al. (2009); Houe and Grabot (2009); Welsch and Kühling (2009); Yalabik and Fairchild (2011); Brouhle and Khanna (2012).
Drivers behind organizational environmentally responsible behavior	Porter and Linder (1995); Iyer (1999); Hemel and Cramer (2002); Montalvo (2003; 2008); Pujari et al. (2003); Pujari et al. (2004); Zhu et al. (2005); Jamali (2006); Cetindamar (2007); Chen (2007; 2008); Rehfeld et al. (2007); Aragon-Correa et al. (2008); Cambra-Fierro et al. (2008); González-Benito and González-Benito (2008); Horbach (2008); Jabbour (2008); Mickwitz et al. (2008); Peng e Lin (2008); Kammerer (2009); Carrillo-Hermosilla et al. (2012); Horbach et al. (2012); Zailani et al. (2012).
Methods to develop sustainable products and services	Hanssen (1999); Foster Jr. et al. (2000); Chen (2001); Eder (2003); Maxwell and van der Vorst (2003); Carrillo-Hermosilla et al. (2010).
Effects of sustainable innovation in competitiveness and organizational performance	Baker and Sinkula (2005); Chen et al. (2006); Peng and Lin (2008); Walsh and Beatty (2007); Brito et al. (2008); Fraj-Andrés et al. (2009); Gonzalez-Benito (2008); Triebswetter and Wackerbauer (2008); Vacon and Klassen (2008); Visser et al. (2008); Boons and Wagner (2009); Chen (2009); Naranjo-Gil (2009); Arevalo (2010); Halila and Rundquist (2011); Testa et al. (2011); Albino et al. (2012); Chen and Chang (2012); Doran and Ryan (2012); Lin et al. (2013).
Interfunctional collaboration in green innovation development and market performance	Pujari (2006); Ellram et al. (2008); Battisti (2008); Hallstetda et al. (2010); Aschehoug et al. (2012); De Marchi (2012); Jabbour et al. (2012).

Fig. 1. Analytical framework synthesizing current research on environmentally sustainable product innovation.

on products or processes, supporting learning and the development of specific knowledge in organizations.

Complementarily, [Cambra-Fierro et al. \(2008\)](#) and [Fraj-Andrés et al. \(2009\)](#) argue that, when market realizes that organizational practices minimize negative environmental impact, companies tend to obtain benefits related to cost and differentiation. In a similar vein, [Rehfeld et al. \(2007\)](#) noticed that environmental certification positively influences adoption of green innovation. To [Chen et al. \(2006\)](#) and [Chen \(2009\)](#), environmentally sustainable practices add value to a brand as they generate positive awareness towards the brand, as well as increased perceived quality and trust that may positively impact customer satisfaction.

[Hanssen \(1999\)](#), [Baker and Sinkula \(2005\)](#), [Lee et al. \(2006\)](#), [González-Benito and González-Benito \(2008\)](#), [Beise and Rennings \(2005\)](#), [Peng and Lin \(2008\)](#), [Brito et al. \(2008\)](#) and [Naranjo-Gil \(2009\)](#) all confirm that market knowledge and organizational adaptation towards market characteristics are positively related to success of environmentally sustainable innovations. Thus, organizations operating at global levels must adapt processes and products to local demand in order to reap increased profitability. Moreover, according to [Brécard et al. \(2009\)](#), [Brouhle and Khanna \(2012\)](#) and [Lin et al. \(2013\)](#), environmentally sustainable product innovation that meets target consumers' requirements positively influence overall firm performance.

[Foster et al. \(2000\)](#) state that knowledge about buyers' intentions and buyers' level of involvement in production and consumption of green innovation directly impact environmental activities promoted by companies. Also [Pujari et al. \(2003\)](#), [Visser et al. \(2008\)](#) and [Doran and Ryan \(2012\)](#) observed that the development of green innovation and its market success depend on customer behavior analysis, which can generate increased satisfaction, loyalty and positive word-of-mouth. [Cetindamar \(2007\)](#) and [Triebswetter and Wackerbauer \(2008\)](#) also highlight the importance of competitor practice analysis.

Still on the topic of knowledge about buyer behavior and intentions regarding environmentally sustainable product innovation, [Bhate and Lawler \(1997\)](#) found that psychological and situational factors are more influential to the development of environmentally friendly behavior than demographic factors. Similarly, [Halme et al. \(2006\)](#) and [Houe and Grabot \(2009\)](#) showed that when environmentally friendly products increase buyer perceived quality of life, consumers are more likely to acquire them independently of sex, social class, employment and age group. Moreover, when buyer decision making is considered, it is necessary to understand not only buyer's consumption patterns, but also the consumption patterns of reference persons ([Welsch and Kühling, 2009](#)).

4.2. Interfunctional collaboration

Considering interfunctional collaboration, [Byrne and Polonsky \(2001\)](#) identified that synergy among different sectors must happen not only internally, but also among the stakeholders involved in environmentally sustainable product development and delivery processes. According to [Chen \(2007, 2008\)](#), [Triebswetter and Wackerbauer \(2008\)](#), [Vachon and Klassen \(2008\)](#) and [Albino et al. \(2012\)](#), successful environmentally friendly innovation is driven by a mixture of internal and external factors, such as available technology, development costs, consumer pressure and governmental regulations.

In a similar tone, [Jabbour \(2008\)](#) and [Jabbour et al. \(2012\)](#) highlight the importance of both organization maturity level and relationships between organizational areas and other players from the delivery chain (especially those responsible for the logistics) for

an adequate environmentally sustainable product development process. The same trend is observed by [Carrillo-Hermosilla et al. \(2010\)](#), who evidenced not only how marketing, R&D and operations must act systemically, but also the need for key stakeholder involvement and integration in order to implement green innovation. [De Marchi \(2012\)](#) ratifies the importance of integrating external stakeholders like suppliers, educational institutions and research institutes. The author highlights the fact that such integration is more important in environmentally sustainable innovation than in traditional innovation. According to [Aschehoug et al. \(2012\)](#), environmental-related information from external stakeholders can generate positive outcomes in environmentally-oriented innovation projects.

Specifically regarding integration among areas as a success factor for environmentally sustainable product innovation, [Pujari et al. \(2003\)](#) affirm that there is more interaction than conflicts between traditional and environmentally-oriented product development models. [Pujari et al. \(2004\)](#) and [Pujari \(2006\)](#) noticed that integration of environmental specialists in environmental new product development projects positively influences market performance. Similarly, [Maxwell and van der Vorst \(2003\)](#) proposed a method for developing effective sustainable products and services integrated into company strategies, business functions and overall supply chain. [Hallstedt et al. \(2010\)](#) confirmed that superior green product development performance requires the complete incorporation of an environmentally sustainable vision into all areas of the organization, as well as the internal availability of incentives for this approach.

As a last aspect of the factor dealing with interfunctional collaboration, [Ellram et al. \(2008\)](#) identified that concurrent engineering can be an important tool for improving environmentally responsible practices in companies. [Gonzalez-Benito \(2008\)](#) states that widespread proactivity and continuous exchanges among different areas promote a distinctive characteristic that drives sustainable innovation performance improvements.

4.3. Innovation-oriented learning

The last success factor identified – innovation oriented learning – is especially dependent on cultural barriers. As [Eder \(2003\)](#) notices, cultural barriers can be an impediment for seizing market opportunities related to environmentally sustainable product innovation. [Chen \(2007, 2008\)](#), in a similar tone, shows how superior green product performance can be achieved when the whole organization develops a set of green competences that influence management processes. [Chen and Chang \(2012\)](#) found out that creativity in the context of environmentally sustainable product innovation depends on the set of green competences developed and a proactive approach from leadership. [Aragón-Correa et al. \(2008\)](#) have also identified leadership proactivity as one of the relevant variables impacting green innovation performance.

To [Battisti \(2008\)](#), the corporate ability to rethink processes according to different lenses allows to reduce the gaps between technological improvements and economic results. Learning propensity within an organization favors the required integration for successful implementation of the triple bottom line approach ([Jamali, 2006](#)).

To [Jabbour \(2008\)](#) and [Arevalo \(2010\)](#), companies oriented towards developing environmentally sustainable solutions are primarily those that develop a consistent way of learning through critical reflective analysis of their actions. [Hallstedt et al. \(2010\)](#) complement this reasoning by emphasizing companies' support mechanism (chiefly flexibility) among the variables that underpin the success of green innovation.

Table 2
Synthesis of critical success factors and its constituent elements according to the literature review.

Factor	Variable	Principais Autores
Market, law and legislation knowledge	Customer expectation fulfillment	Iyer (1999), Rennings (2000), Chen (2001), Pujari et al. (2003), Beise and Rennings (2005), Zhu et al. (2005), Mickwitz et al. (2008), Visser et al. (2008), Kammerer (2009), Carrillo-Hermosilla et al. (2010), Doran and Ryan (2012) and Horbach et al. (2012).
	Comply with laws and regulations	Rennings (2000), Chen (2001), Beise and Rennings (2005), Zhu et al. (2005), Mickwitz et al. (2008), Kammerer (2009) and Horbach et al. (2012).
	Financial or information support from government	Köhler et al. (2013) and Kiss et al. (2013)
	Knowledge about cultural variables that influence buyer behavior	Hanssen (1999), Baker and Sinkula (2005), Beise and Rennings (2005), Lee et al. (2006), González-Benito and González-Benito (2008), Peng and Lin (2008), Brito et al. (2008) and Naranjo-Gil (2009).
	Knowledge about factors that drive sustainable buying	Foster et al. (2000), Brécard et al. (2009), Brouhle and Khanna (2012) and Lin et al. (2013).
Interfunctional collaboration	Knowledge about consumption patterns of reference persons	Bhate and Lawler (1997), Halme et al. (2006), Houe and Grabot (2009) and Welsch and Kühling (2009).
	Competitor monitoring	Cetindamar (2007), Triebswetter and Wackerbauer (2008) and Yalabik and Fairchild (2011).
	Cultural predisposition towards collaboration	Gonzalez-Benito (2008), Hallstedt et al. (2010) and Albino et al. (2012).
Innovation-oriented learning	R&D, marketing and production integration	Pujari et al. (2003), Pujari et al. (2004) and Pujari (2006).
	Stakeholder integration (suppliers, universities, environment specialists, etc.)	Byrne and Polonsky (2001), Jabbour (2008), Carrillo-Hermosilla et al. (2010), Aschehoug et al. (2012), De Marchi (2012) and Jabbour et al. (2012).
	Elimination of cultural barriers	Eder (2003), Jamali (2006) and Battisti (2008).
R&D Investments	Development of a set of green competences (proactivity, creativity and experimentation)	Chen (2007, 2008), Aragón-Correa et al. (2008), Hallstedt et al. (2010) and Chen and Chang (2012).
	Development of critical reflective analysis capability	Jabbour (2008) and Arevalo (2010).
	Investment in cleaner technology research	Porter and Linder (1995), Hemel and Cramer (2002) and Horbach (2008).
	Investment on/adoption of methods for sustainable product development	Hemel and Cramer (2002); Montalvo (2003, 2008); Horbach (2008) and Boons and Wagner (2009).
	Investment in R&D infrastructure	Montalvo (2003, 2008), Testa et al. (2011) and Horbach et al. (2012).
	Investment in qualified human resources	Montalvo (2003, 2008) and Zailani et al. (2012).

4.4. R&D investments

Porter and Linder (1995) pointed out that organizations willing to embrace environmental sustainability must invest in research to develop new technologies and qualify their productive systems and new product development processes. Hemel and Cramer (2002) and Horbach (2008), whose studies map environmental innovation determinants, support the perception that organizations that wish to succeed in environmental new product development must invest in tools and methods that can support these objectives. Hemel and Cramer (2002) state that, contrary to many studies, internal stimuli are as important as external stimuli as drivers of environmental management. The same authors list the main solutions used by companies that develop environmental innovation: (i) investment in material recycling, (ii) use of recycled materials, (iii) research to extend product lifespan, and (iv) investment in energy consumption.

To Montalvo (2003, 2008) and Boons and Wagner (2009), adequate production systems can improve the performance of environmentally sustainable product innovation. In fact, Montalvo (2003, 2008) argues that not only institutional capabilities but also technological capabilities (such as qualified human resources, laboratories and equipment) are important factors that influence the adoption of greener technologies. Horbach et al. (2012) also state that external factors such as environmental regulation and buyer behavior are not the only factors driving environmentally sustainable product innovation. These authors explicitly point out technological competences and resources available as an important internal factor.

Testa et al. (2011) argue that the higher the control exerted by governmental regulatory bodies, the higher the probability of investments in technology and equipment and, consequently, the higher the probability that environmentally sustainable innovation performs satisfactorily. Similarly, Zailani et al. (2012) found out that the higher the technical capabilities of designers, the higher the

designers' capabilities to efficiently respond to external environment requirements and inputs regarding environmentally sustainable product innovation. Besides, Halila and Rundquist (2011) compared products generated in both environmentally sustainable innovation and traditional innovation approaches and found out that firms that adopt environmentally sustainable innovation practices tend to develop strong partnerships with a range of different stakeholders in order to increase the probability of solving technology-related issues.

4.5. Synthesis of identified factors and variables

Table 2 shows a synthesis of the critical success factors and its constituent elements that influence environmentally sustainable innovation, as well as the authors that support each element.

Regarding market, law and legislation knowledge, results from literature review point out that besides consumer expectations, also society and government expectations must be considered when planning and implementing environmentally sustainable product innovation. Moreover, studies revealed the importance of conducting investigations on consumer behavior, especially concerning situational and psychological variables that may impact choice and usage of green products.

The literature review also supports a number of constituting elements that can be added to the interfunctional collaboration critical success factor. Besides the issue concerning the need for integration of R&D, marketing and production areas, literature emphasizes the establishment of networks connecting stakeholders, pointing out that the success of environmental sustainable innovation can be strongly related to the synergy among supply chain actors.

Moreover, the literature review suggests an additional critical success factor: innovation-oriented learning. This factor is related to the organizational capability to change its own vision, eliminating obsolete procedures and systems (in the present case, the

Table 3

Relevance of variables according to professionals which develop environmental sustainable innovations.

Factor	Variable	Mentions
Market, law and regulation knowledge	Customer expectation fulfillment	07
	Comply with laws and regulations	06
	Financial or information support from government	02
	Knowledge about cultural variables that influence buyer behavior	02
	Knowledge about factors that drive sustainable buying	07
	Knowledge about consumption patterns of reference persons	00
	Competitor monitoring	03
Interfunctional collaboration	Cultural predisposition towards collaboration	01
	R&D, marketing and production integration	08
	Stakeholder integration (suppliers, universities, environment specialists, etc.)	08
Innovation-oriented learning	Elimination of cultural barriers	01
	Development of a set of green competences (leader proactivity, creativity and experimentation)	05
	Development of critical reflective analysis capability	02
R&D investments	Investment in cleaner technology research	02
	Investment/adoption of methods for sustainable product development	06
	Investment in R&D infrastructure	02
	Investment in qualified human resources	05

excessive focus on the economical aspect of the innovation). Thus, key elements for this success factor include eliminating cultural barriers, developing a set of green competences, and developing the capacity for critical reflective analysis as well as flexible decision support mechanisms.

Finally, the R&D investment factor is listed. Concerning this factor, the variables investment in research and new technologies, adoption of methods for developing green products, laboratory and equipment and qualified human resources were widely cited. According to literature, sustainable development cannot be supported without a continuous industrial development, oriented to offer technological packages capable of meeting such social contemporary demand.

To evaluate the proposed framework (see Table 2), an empirical test was carried out. The test involved 10 professionals who work in the product development area of 10 Brazilian companies operating in different areas, such as food industry, agricultural implements and metalworking. After presenting the framework and provide clarification regarding the meaning of the terms, the test comprised two simple questions: (i) 'do you consider the list complete or suggest some inclusion/exclusion?' and (ii) 'please, indicate up to 7 items among this list that you consider critical for environmentally sustainable innovation'.

Regarding the first question, there was no indication by the professionals of inclusion or exclusion of items, which allows for preliminary approval of the developed framework. However, three professionals affirmed that integrating other areas besides marketing, R&D and production, such as logistics and financial, would be beneficial to the success of interfunctional collaboration. The results of the second question, aimed at establishing a preliminary hierarchy of the variables within each factor, are shown in Table 3.

As shown in Table 3, customer expectation fulfillment, comply with laws and regulations, and knowledge about factors that drive sustainable buying are the variables most quoted by interviewees regarding the Market, Law and Regulation Knowledge factor. For the Interfunctional Collaboration factor, internal as well as external integration variables were highlighted. Concerning the Innovation-

oriented Learning factor, five professional signaled the development of a set of green competences among the most relevant items. Finally, for the R&D Investment factor, the variables emphasized were investment in/adoption of methods for sustainable product development and investment in qualified human resources.

5. Conclusions

There are several contributions related to the development of environmentally sustainable product innovation in academic literature. By analyzing the studies that focus on environmentally sustainable product innovation, it can be concluded that these can be organized along a five-dimension interpretative framework according to each study declared research problem. Thus, there are studies that aim to identify factors and variables that influence the green innovation adoption or rejection by the market, while others investigate the reasons and drivers behind environmental responsible behavior by organizations. Moreover, there are studies focused on methods to develop sustainable innovation, studies that analyze the effects of green innovation on competitiveness and studies that investigate aspects related to interfunctional collaboration.

The critical success factors identified in this research were subjected to a preliminary evaluation conducted by professionals who work in the product development area of Brazilian companies that develop environmental sustainable innovations. These factors and their corresponding variables can also be used to conduct diagnostics on company or cluster potential for environmentally sustainable product innovation. This would require the development of appropriate research instruments as well as procedures for collecting and analyzing data. The diagnosis procedure could then be repeated periodically as a supporting tool for organizational strategic planning, especially in companies that wish to further explore the path to environmental sustainability.

In the following paragraphs, a research agenda for the topic of environmentally sustainable product innovation highlighting issues and approaches particularly relevant in this area is proposed. The research agenda follows the five dimensions of the interpretative framework described earlier.

It was observed that the literature on environmentally sustainable product innovation can be divided in five broad groups of studies according to their overall research problem. The first dimension of the analytical framework corresponds to studies aimed at mapping factors and variables that influence market acceptance of green innovation. In this sense, it should be pointed out that current studies do not explicitly consider environmentally responsible customers' willingness to pay for green products. Therefore there is a clear gap for research on the issue of price elasticity versus value perception of environmentally sustainable products. Another gap in current research on environmentally sustainable product innovation regards consumers' decision making processes when facing the choice of buying green versus traditional products including elements such as level of commitment towards sustainability values, attributes of green innovation and factors that drive environmentally responsible buying behavior.

There is also much opportunity for research on the second dimension of the interpretative framework approaching reasons and drivers behind environmental responsible behavior by organizations. Overall, although current research has identified a number of drivers of environmentally responsible firm behavior (e.g., appropriate organizational culture, management proactivity and involvement in environmentally sustainable innovation, and market orientation), there is still much to investigate regarding how these drivers effectively work.

The third dimension in the interpretative framework includes studies on methods for the development of sustainable innovation. Research in this area was shown to be relatively incipient. A main contribution for future research in this area should be towards systematizing the diverse proposals in a consolidated model for environmentally sustainable product innovation development. This gap is particularly important for the service sector, since most of the methods already proposed originate from the manufacturing context.

Research on the effects of sustainable innovation in firm competitiveness and performance constitute the fourth dimension of the proposed interpretative framework. Research in this area could involve understanding the effects of and the interrelationships among the critical success factors for environmentally sustainable product innovation mapped in this paper. Such an understanding could then be applied to establish the relationship between success of environmentally sustainable product innovation and business performance.

The fifth and final dimension of the proposed interpretative framework refers to research on the impact of interfunctional collaboration in green product development and market performance of environmentally sustainable product innovation. New research in this area could encompass measuring to what extent the integration between distinct functional areas within an organization effectively impacts the market performance of environmentally sustainable innovation. Moreover, given that requirements elicited by the market are essential for the success of environmentally sustainable innovation, it is necessary to conduct research on how product development techniques such as Quality Function Deployment (QFD) can contribute to the development of eco-innovations.

Comparing the research agenda proposed in this study to the one elaborated by [Baumann et al. \(2002\)](#), it can be observed that there has been recent progress in studies related to the use and role of tools for the development of environmentally sustainable products. Moreover, studies linking incentive policies, laws and regulation with the practice of developing environmentally sustainable innovations were developed. However, as highlighted by [Baumann et al. \(2002\)](#), further studies are still necessary to draw up a proper systematic perspective from micro issues, such as engineering and strategy, and macro issues such as public policies, technology and social behaviors.

A second result of this study was the mapping of critical success factors for environmentally sustainable innovation, which can be subsumed into four groups: (i) market, law and regulation knowledge; (ii) interfunctional collaboration; (iii) innovation-oriented learning; and (iv) R&D investments.

The marketing, law and legislation knowledge critical success factor includes, basically, the fulfillment of buyers' and society's expectations – covering the drivers for green product consumption – as well as intelligence about competitors' actions and the knowledge about applicable environmental legislation and regulation. Similarly, the interfunctional collaboration critical success factor involves the adoption of a systemic view of sustainable innovation by the firm, which includes the integration of different stakeholders (both internal and external) in the product development process. The innovation-oriented learning critical success factor, on the other hand, refers to the organizational capability for discontinuing processes identified as obsolete. It involves the elimination of cultural barriers that hinder change within the organization, the development of a set of green competences, the development of the capacity for critical reflective analysis by the managers and decision makers and the imbuelement of proactivity, communication, creativity and flexibility abilities on company's work force. Finally, R&D investments critical success factor

comprises variables related to investments in research, infrastructure and specialized human resources necessary to employ greener technologies and to achieve superior market performance, given legal constraints and buyer expectations.

Comparing the mapped factors as drivers for successful innovation of environmentally sustainable products to the factors described for the traditional product innovation by authors such as [Cooper and Kleinschmidt \(1987\)](#), [Montoya-Weiss and Calantone \(1994\)](#), [Griffin \(1997\)](#) and [Cooper \(1999\)](#), we find many correspondences, as well as some differences. The main differences are: (i) in environmentally sustainable product innovation, besides knowledge of customers and competitors, it is stressed the need of knowing regulation and environmental laws as well as policies concerning financial and information incentives oriented to green innovation practices; (ii) regarding the R&D investments factor, the adoption of appropriate methods for developing environmentally sustainable products, as well as research in cleaner technologies, are important variables for innovation success; and (iii) the innovation-oriented learning is a factor specific for the success of environmentally sustainable products. This is supported by [Quist and Tukker \(2013\)](#), who point out that green innovation practices require learning processes involving the synergy of tacit knowledge and theoretical models.

Finally, as the vast majority of the reviewed research was originated in North America, Europe and Asia, it should be pointed out that there is ample margin for extending the research to other parts of the world. Another venue for further research along this topic would be to test and validate the set of critical success factors identified in this systematic literature review through empirical research.

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