

PRODUCT INNOVATION AND SUSTAINABILITY: A BIBLIOMETRIC APPROACH

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Abstract

The purpose of this paper is to identify the key discussion and challenges on the literature regarding innovation and sustainability. The methodological approach is a systematic review of the literature, based on the bibliometric and social network analysis. The database chosen for the selection of the article sample was the ISI Web of Knowledge (Web of Science). The research suggests that much of the available literature involving the theme of innovation and sustainability refer to product development, technological and service innovation considering mainly on the economic pillar of the Triple Bottom Line (TBL). Although environmental issues are significant in the analyzed article sample, the social perspective of innovation management is still not much discussed in the literature. The results also suggest that a key challenge lies in exploring the theme of sustainability and innovation from TBL perspective.

Keywords: Innovation; New Product Development, Sustainability; Sustainable Development; Bibliometric approach.

Área: GDP e Sustentabilidade

1. INTRODUCTION

In 1987 the World Commission on Environment and Development presented a document called "Our Common Future", or the Brundtland Report. According to this report, sustainable development is the development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Sustainability in recent years has been considered a key issue and of increasing interest in the agenda of academia, public policy makers and entrepreneurs (VERBONG; GEELS, 2010). The sustainable development and environmental modernization of the economy include environmental policies implementation, which connect environmental management to technical environmental innovations and to improved economic performance (RENNINGS, et al. 2006).

More specifically from the perspective of organizations, sustainability has also received different approaches. Some authors investigate how sustainability affects or are incorporated into new product development process. For example, Sharma and Iyer (2012) investigate the process of developing "green" products and the trade-off between price and sustainability objectives. Tsai et al. (2012) focus on the development of process technologies for cleaner and with less environmental impact. Furthermore, Vachon and Klassen (2007) discuss the adoption of environmental technologies for supply chain management.

The above mentioned authors focus on sustainability and innovation management. The concept of innovation can be understood as the invention and implementation of a management practice, process, structure or technique that is new to the state of the art and is intended to promote organizational goals (TIDD; BESSANT; PAVITT, 2005). The challenge to innovate, develop new products and generate profit from it is different for each company. Some firms are able to identify good ideas, but at the same time face several difficulties to bring them to market (HANSEN; BIRKINSHAW, 2007).

Innovation in product, process and technology development is able to minimize the negative impacts that can affect sustainable development, especially on the triple bottom line (TBL) perspective. That is because the TBL logic is based on the interrelationship between the three pillars (social, environmental and economic) and can be understood as a new approach or for existing processes. In this context, the discussion about sustainable development can contribute greatly to the innovation discipline, applying the triad society, economy and environment into the new product development process.

Considering the TBL approach of sustainability, innovations should generate economic results and, at the same time, causing minimum social and environmental negative impacts.

It is a challenge especially in cases of radical innovation with high novelty level, given the uncertainties brought by innovative developments. The economic effects are relatively easy to predict, as there are a considerable number of consolidated tools already used by innovative companies. The social and environmental effects are more difficult to assess in advance, because they involve more variables, uncertainties and interactions. The new product development considering sustainability requires a combination of technological and social changes, since they are highly related (SCHOT; GEELS, 2008).

In this context, this paper aims to apply a bibliometric approach analyzing papers that have coverage on both issues: sustainability and innovation. Based on a quantitative approach of articles sample analysis, we identify the main discussions at the interface of these two topics, raising main trends and gaps, as well as most important authors and papers about these themes.

The paper is structured in four sections. Section 2 describes the methodology of sample selection and the steps followed to analyze the data collected. Section 3 presents the results of research and discussion, followed by conclusions in section 4. We hope that the findings can contribute to the academy and practitioners in order to meet the challenges faced by the sustainability.

2. RESEARCH METHODOLOGY

The bibliometric approach has wide applications in different areas in order to increase performance or to evaluate research trends, investigating publication features such as: authors, research sources, topics, content analysis, social networks, geographic origins, and citations/co-citations (SMALL, 2003). In order to process and prepare data analysis, two softwares were adopted: Sitkis (SCHIDT, 2002) and UCINET (BORGATTI et al, 2002).

Data analysis was done in three steps. In the first, the primary data of the sample were treated, seeking a quantitative view of the publications regarding publication year, journal, number of citations, among others. Since the database itself provides the information needed for such analyzes in a reasonable manner, its implementation was made possible through a treatment in electronic spreadsheets.

In the second stage of data analysis, the software used to support bibliometric data treatment is called Sitkis. With free license, the program is a Java-based tool that enables the creation of social networks between a given publication sample, as well as among the keywords used in this initial sample. Thus, it is possible to identify related clusters, as well as interesting conclusions permitted by graphic programs and associated Ucinet Netdraw. Through graphical results linking the units in the sample, it is possible to identify the most relevant

publications and how they interrelate. Therefore, we used the citation networks, co-citations and keywords.

The last step of data treatment is based on the concept of sustainability widespread in both the academic and public-enterprise of the Triple Bottom Line (TBL). Thus, by reading the abstracts and eventually the entire article, the classification was made between economic, environmental and social. Clearly these issues intertwine significantly, so that the combinations between the three pillars were also considered in the classification.

The initial sample was obtained from searches on ISI Web of Knowledge (Web of Science). That is because its scope is very significant, since it is possible to find information of all journals indexed, whose indices are calculated by the Journal Citation Report (JCR), regardless of their home base. Moreover, this base is able to provide data in order to address not only the initial sample, but also their references, allowing further analysis of the information extracted from the database.

In March 2013, the initial sample was obtained from the filter showed in Table 1.

Table 1 - Steps of sample selection

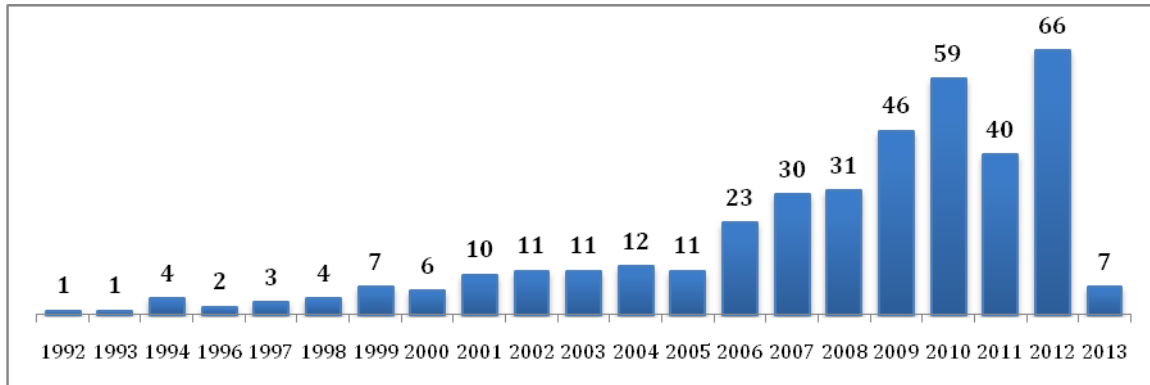
| Step | Quantity | Topic | Refined by | Categories |
|------|----------|--|------------|---|
| 1 | 940 | sustainability or "sustainable development" and innovation* | Articles | Environmental Sciences or Environmental Studies or Management or Business or Planning Development or Economics or Engineering Multidisciplinary |
| 2 | 385 | sustainability or "sustainable development" and innovation* or service* or product* or technology* | Articles | Environmental Sciences or Environmental Studies or Management or Business or Planning Development or Economics or Engineering Multidisciplinary |

This first step resulted in a large number of articles, more than 940 papers, step 1. Restricting these publications with a new filter, step 2, the database identified 385 papers, contemplating the various types of publications. The samples in both step 1 and step 2 were selected in only publications such as "articles". Thus, the number of papers in the sample used for analysis is 385.

3. DISCUSSION AND RESULTS

Verifying the number of articles published dealing with the issue of sustainability and also related to innovation, there is the presence of papers since 1992. It is noteworthy that there is a clear increase since 2006, especially 2010 and 2012 (Figure 1).

Figure 1 - Distribution over the years



Analyzing the journals, Figure 2 shows that the Journal of Cleaner Production has a large number of publications. It can be justified because the scope of the journal is related to environmental issues, topics related to sustainability and also encourages industrial innovation, new and improved products and the implementation of cleaner processes, products and services. So its scope is close to the theme proposed in this paper. Figure 2 shows only the journals, in which the articles in the sample were published more than or equal to five times.

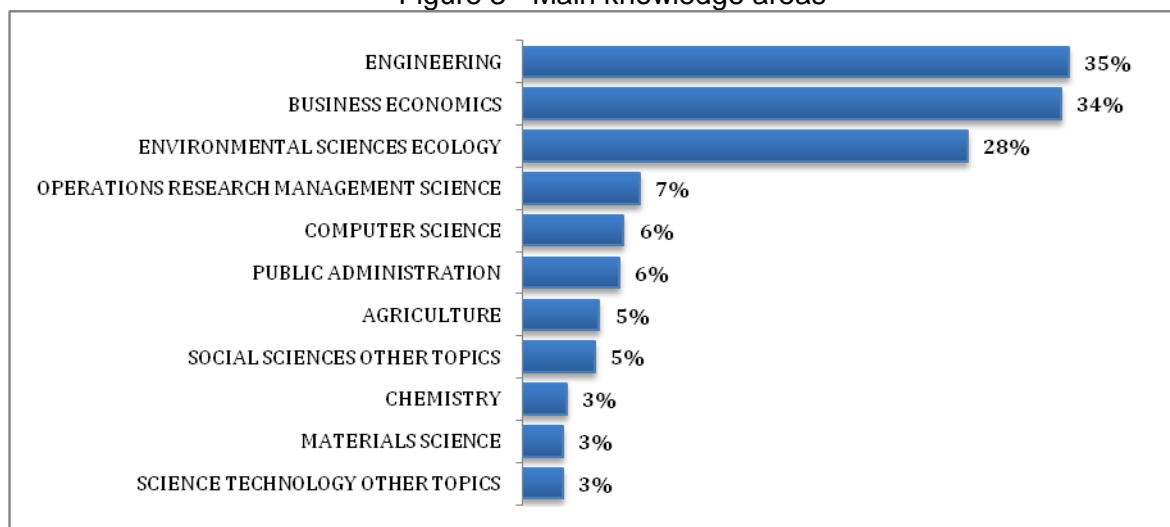
Figure 2 - Main journals



The areas that stand out in number of publications on the topic are: Engineering, Business Economics and Environmental Sciences Ecology (Figure 3). It is important to note that an item may be classified in more than one area.

Regarding the most cited authors, Figure 4 and Figure 5 shows the fifteen most cited authors in the sample, and the present growth trend that address topics related to green supply chain management practices (ZHU; SARKIS, 2004), sustainability and economic globalization (MEYFROIDT; LAMBIN, 2011), green innovation performance (CHEN, LAI; WEN, 2006) and ecodesign in SMEs (VAN HEMEL; CRAMER, 2002).

Figure 3 - Main knowledge areas



Also in Figure 4, the authors that are frequently referenced over the years, addressing the following topics: a Sustainability Science framework (WAGGONER; AUSUBEL, 2002), green and competitive product development (PUJARI, WRIGHT; PEATTIE, 2003), strategic approach to the development of sustainable products and services (MANZINI; VEZZOLI, 2003).

In Table 2 the most cited authors in the sample can be seen and are presented only authors with over 40 citations.

Figure 4 - Yearly citation distribution for the 15 most cited articles

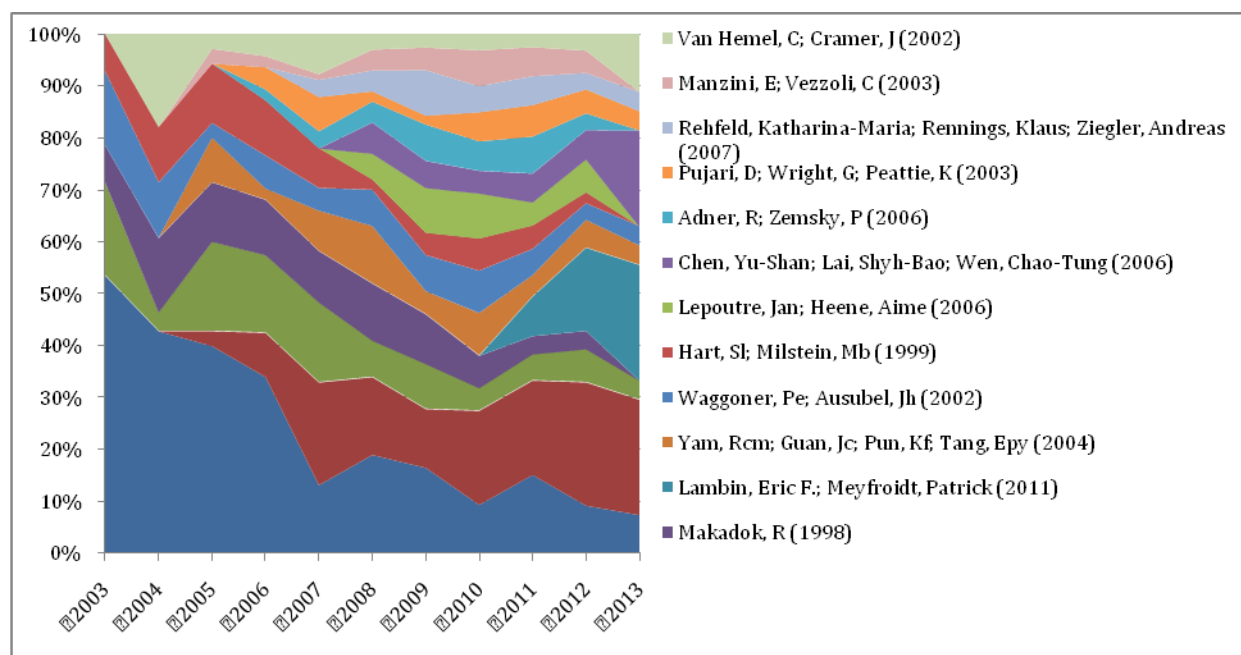
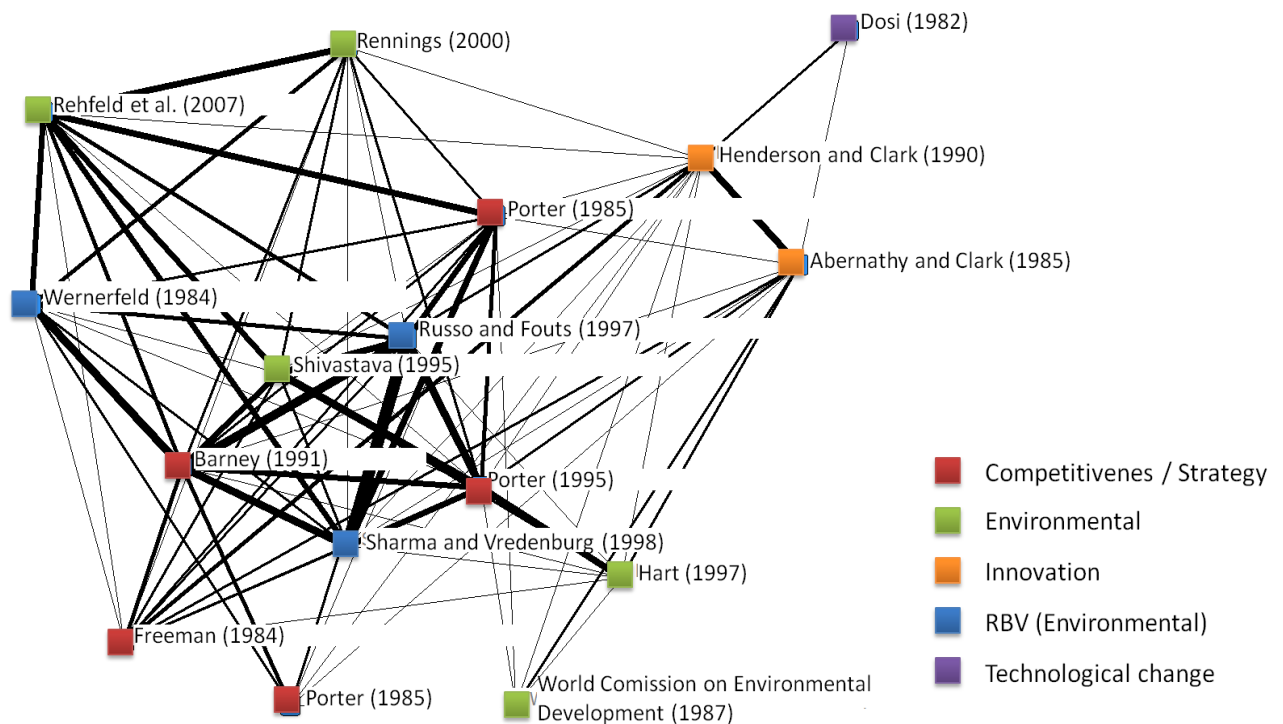


Table 2 –Most cited articles

| Authors | Total Citations | Publication Year |
|---|-----------------|------------------|
| Walley, N; Whitehead, B | 258 | 1994 |
| Zhu, QH; Sarkis, J | 189 | 2004 |
| Elias, MJ; Zins, JE; Graczyk, PA; Weissberg, RP | 86 | 2003 |
| Makadok, R | 85 | 1998 |
| Lambin, Eric F.; Meyfroidt, Patrick | 66 | 2011 |
| Yam, RCM; Guan, JC; Pun, KF; Tang, EPY | 64 | 2004 |
| Waggoner, PE; Ausubel, JH | 63 | 2002 |
| Hart, SL; Milstein, MB | 59 | 1999 |
| Lepoutre, J; Heene, A | 56 | 2006 |
| Chen, Y; Lai, Sh; Wen, Ch | 51 | 2006 |
| Adner, R; Zemsky, P | 48 | 2006 |
| Pujari, D; Wright, G; Peattie, K | 47 | 2003 |
| Rehfeld, KM; Rennings, K; Ziegler, A | 46 | 2007 |
| Manzini, E; Vezzoli, C | 46 | 2003 |
| Van Hemel, C; Cramer, J | 43 | 2002 |

Figure 5 - Co-citation network

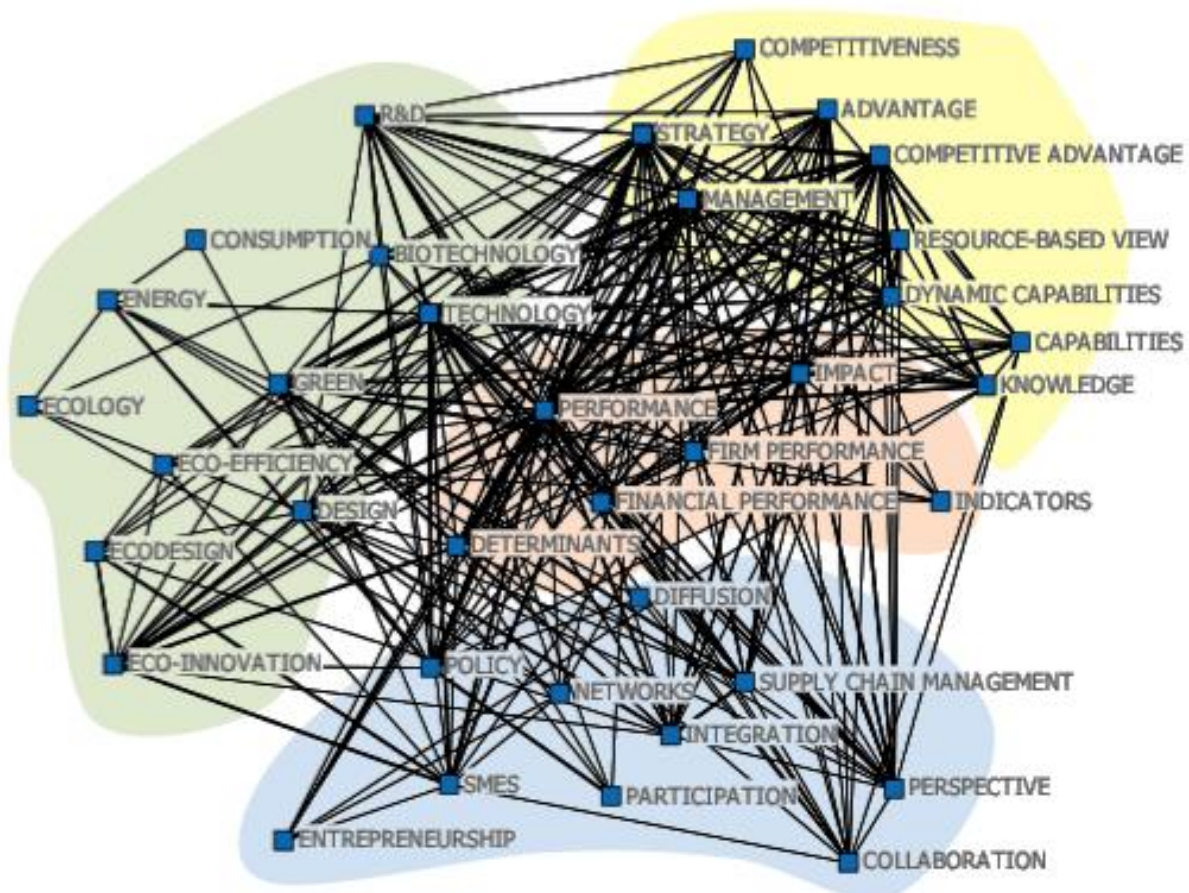


Note: The squares represent the references of articles in the sample that were jointly cited at least six times. The thickness of the lines represents the strength of the bonds between the pair of references.

The Figure 5 shows the co-citation network, which illustrates the relationships between the references used by the sample articles. The network was built based on the condition that two nodes are connected, when at least six articles in the sample used these both references in their papers. The thicker lines in Figure 5 represents that several articles used the references together, representing a stronger connection between the nodes. Considering the core issues discussed in the references presented in the co-citation network, five categories were found: competitiveness / strategy (FREEMAN, 1984; PORTER, 1985; BARNEY, 1991; PORTER, 1995), environment (WCED, 1987; SHRIVASTAVA, 1995; HART, 1997; RENNINGS, 2000; REHFELD AT AL., 2007), innovation management (ABERNATHY; CLARK, 1985; HENDERSON; CLARK, 1990), resource based view (RBV) with focus on environmental resources (WERNERFELT, 1984; RUSSO; FOUTS, 1997; SHARMA; VREDENBURG, 1998) and technological change (DOSI, 1988). As shown in Figure 5, articles on environmental issues (with or without RBV approach) are strong related to competitiveness and strategy management. It is an evidence on the importance of environmental aspects in product innovation processes, when the firm is aiming for more competitiveness and strategic differentiation. The innovation management and technological

change references are also connected, but not as strong as the three previously categories. It can be an evidence of weak combined discussion between innovation management itself and environmental aspects of product development. Furthermore, considering the triple bottom line mindset, it is also worth noting that none reference with focus on social issues was relevant enough to appear in the co-citation network. Regarding the financial sustainability pillar, it can be considered to be contemplated on competitiveness and strategic issues, since revenue and profit can be considered implicit in these discussions.

Figure 6 - Keyword network



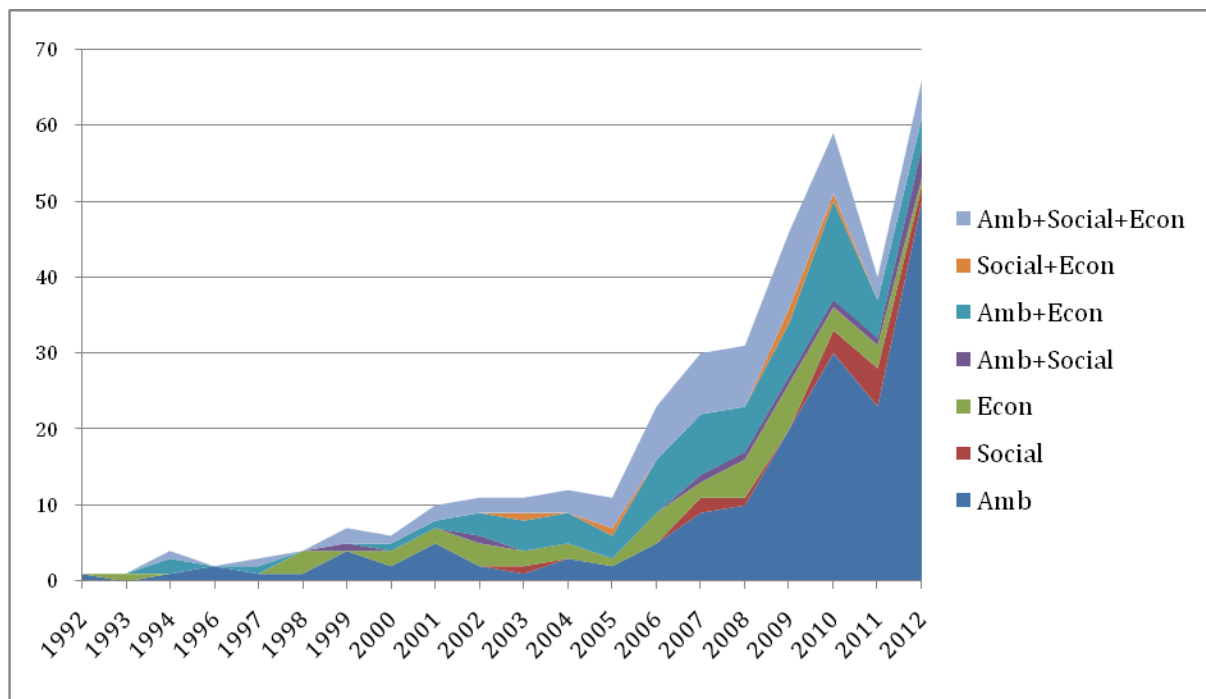
Note: The squares represent the keywords of the sample articles that were jointly cited at least seven times. The thickness of the lines represents the strength of the bonds between the pair of keywords.

In order to have an overview on the content of the article sample, the keyword network was also drawn with help of Ucinet and NetDraw softwares (Figure 6). Considering the interrelationship between the nodes given by the choice of these keywords by the same article at least seven times, four groups of issues can be identified (Figure 6). The central issue is the performance, since it is intensively connected to several other keywords, highlighting the challenge of measuring the performance of product innovation on a context aiming for sustainable development. Several articles found relevant to point out issues

related to competitiveness, strategy and RBV (Figure 6), as already identified in Figure 5. Still regarding management issues, the keyword network also brings discussions on capabilities and knowledge on the context sustainability challenges in product innovation. The literature studied discusses also challenges related to small-medium enterprises and entrepreneurship, as well as to integrating different stakeholders from different stages of the supply chain. As also already pointed out by the co-citation network (Figure 5), environmental issues are also relevant matters studied in the literature. For example, with focus on technology development for energy and efficiency benefits. In contrast to the other three group of issues identified in the article sample, which present a softer approach to the literature on product innovation for sustainability, the last one focuses on a more technical (and consequently harder) approach on the subject.

In Figure 7, we classify the sample articles on the triple bottom line pillars: Environmental, Social and Economics. The data indicate a constant presence of articles with main focus on economic sustainability.

Figure 7 - Behavior of the pillars of sustainability over the years



Note: Amb (Ambiental), Econ (Economic) and Social (Social).

As shown in Figure 7, most articles analyzed have environmental focus and present growing trend. Some sample articles discuss the development of a specific technology (PAHL-WOSTL ET AL, 2003; LEE ET AL, 2007; KEIJBETS, 2008; GALEMBECK, BARBOSA; DE SOUZA, 2009 AND CAVANI, BALLARI; LUCIANI, 2009). In general, these articles discuss

the technologies to reduce the consumption of natural resources (raw materials, energy, water etc.). Still considering the environmental approach, some articles have more managerial focus (RABE, 1996; ZHU; SARKIS, 2004; LORDKIPANIDZE, BREZET; BACKMAN, 2005; CHEN, LAI AND WEN, 2006; DEMAID; QUINTAS, 2006 and others) analyzing innovation as a management tool for product and process development.

There are also articles that discuss the interaction of triple bottom line (BARBERA; BUTERA, 1992; PATERMANN, 1999; ADAMS; GHALY, 2007; ULHOI, 2008; MURESAN, 2009; MALYSHKINA; NIEMEIER, 2010; BOONS, BAUMANN; HALL, 2012; HANSMAN, MIEG; FRISCHKNECHT, 2012). Analysing this sample we can propose that there is potential to explore in further studies considering the three sustainability pillars in the innovation management discussions, because most of the analyzed articles focused only on environmental pillar.

Furthermore, articles analyzing the social pillar were underexplored presenting another potential for future studies. So, future studies could discuss the development of new technologies that could improve the welfare of society and/or improve the activities of the worker.

4. CONCLUSIONS

The study aimed to draw an overview of the main issues discussed in the literature of innovation and sustainability. That is because innovation in product, process and technology development has potential to minimize the impacts that can affect sustainable development, especially under the triple bottom line perspective. Analysis of publications on the subject contribute strongly in identifying knowledge gaps to be filled in the future.

The research identified that the most relevant articles (in terms of citations) deal with sustainability in a more specific way (the economic pillar perspective) and not how innovation relates to the triple bottom line. Furthermore, we conclude also that the area of engineering, business economics and environmental science ecology is quite influential in this discussion and that there is a large presence of articles related to technology and innovation management.

In this context, theories of technology development, product development and innovation processes have a strong relationship with sustainability, serving as a connection point between the groups mentioned above.

As shown in this paper, the number of articles on sustainability and innovation is growing in the last two decades, specially from 2006. During this period, publications on economic sustainability were always present in some way. Meanwhile, the environmental approach as well as the triple bottom line perspective have been gaining strength over the past 6 years,

with significant growth trend. Accordingly, there is plenty of opportunity to explore further studies about innovation management under perspective of the three pillars of sustainability, since most articles focused more on environmental pillar. In addition, articles analyzing the social pillar were underexplored, presenting another potential for future studies.

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