Industrial Engineering, Operations Management and Sustainability: an overview

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Abstract

Several authors have been devoted their research projects to understand and map research topics and themes studied in the field of Industrial Engineering (IE), particularly those related to Operations Management (OM). This study examines the knowledge frame regarding about the topic of sustainability research in the field of Industrial Engineering (IE), particularly the knowledge related to Operations Management (OM). Bibliometrics analysis were performed using information collected from 495 selected papers in nine international databases related to the OM field, based on the keywords "Sustainability" and "Operations Management". Results point to the evolution of the subject over the past two decades, the relationship between authors in the network of research and its effect on productivity in this specific topic, and the related research topics. Also it provides some indications on the main developing issues, authors, institutions and journals more dedicated to the topic and the contribution of the studies with the establishment of the OM as a discipline in Industrial Engineering. Thus, this study contributes with an overview of trends for future research in sustainability concerning the OM field.

Keywords: industrial engineering; operations management; sustainability; bibliometrics analysis.

1 Introduction

Over the last years, several studies were dedicated on mapping the intellectual structure and defining the field of Operations Management (OM) in the context of research in Industrial Engineering. Analyzing the origin of the OM discipline in business schools, Sprague (2007) found a strong interface between the disciplines of Business and Engineering training in the field of OM, but with methodological and thematic dimensions still in training. The author points out that this interface makes difficult the establishment of xx boundaries in the research of the OM.

Based on the scientific production published by the International Journal of Operations & Production Management (IJOPM) between 1994 and 1997, Heyes and Pilkington (1999) indicated difficulties and their causes in the recognition of the OM as a legitimate academic discipline, emphasizing the need to differentiate the OM from the fields of Operations Research (OR) and Management System (MS).

Pilkington and Fitzgerald (2006) extended the analysis on IJOPM production between 1994 and 2003, mapping the social relations established in the communities of study and their research topics. Once more, the authors indicated the concern to define the OM as a discipline and the requirement to establish the knowledge generated in the field as a practical tool to determine its relationship with other management areas. Among the major topics related to the OM the authors presents 'manufacturing strategy' and 'resource-based view'. Based on the scope of the inclusion of sustainability, it was identified the emergence of the topic "sustainable resource view in papers from 1995, Hart (1995), and Porter and van der Linde (1995), showing the trend of including sustainability in studies of the OM.

Bayraktar *et al.* (2007) also conducted a study dedicated to the evolution of the OM through the themes and characteristics of research communities in Europe and North America, noting that the field has its core in the design and management of the transformation processes that create value for organizations

and society, thus revealing the ability of the OM to the study of the processes and more sustainable technologies.

Extending the research, Pilkington and Meredith (2009) analyzed the academic production between 1980 and 2006, dedicated efforts to map the intellectual structure of the OM, checking the drive for more strategic issues, integrated and macros. In addition to the analysis covered IJOPM content of the Journal of Operations Management (JOM) and Production Operations and Management (POM). Through the method of analysis of the social networks, the authors presented a map of the clusters formed by researchers and how they were changing over the years, concluding that the OM field is a dynamic field and has undergone significant changes, using theories from other fields and developing new research methods.

Taylor and Taylor (2009) also gave their contribution to the study of the field. Verifying IJOPM papers published between 2004 and 2009, indicating the research methods commonly used (e.g. survey and case studies), the main topics (e.g. supply chain management and operations strategy) and some other information for researchers in the OM field. As Bayraktar *et al.* (2007), but more emphatically, check for the presence of the topic of sustainability as a potential topic in the research of the OM.

Other studies are also dedicated to the study of the OM field and deserve mention, such as Sower et al. (1997) and Sprague (2007). Most of these the studies cited - devoted to map the intellectual structure and trends in the OM - were performed with the support of the bibliometric data. It reaffirms the concept of McIntire (2006), which says that you can follow the development of a field by means of academic production published by using the bibliometrics data that can be extracted as author, title, citation, date, keywords, among others.

Thus, the set of bibliometric data extracted from an article grouping makes it possible to evaluate the stage of evolution of a research field, assists in finding the research themes and relationships between researchers and the formation of communities, as well as allowing finding lacks in research and/or trends (Powell *et al.*, 2005, White *et al.*, 2004).

This paper is a contribution with OM studies focusing on the analysis of the "sustainability" insertion in the OM field. Its provides information on the integration of sustainability concepts in the OM field, taking as a premise that this sub-theme is emerging and it is relevant according to the number of publications in this area. To establish the positioning of the manner the aspects concerning the sustainable development are being worked according to the operations has become relevant to the researchers interested in such a topic, because it provides some indications on the main developing issues, authors and schools more dedicated to the topic, main journals and, especially, the contribution of the studies with the establishment of the OM as a discipline in Industrial Engineering.

As time parameters, papers published from 1995 till the first half of 2011 were selected from nine OM-related databases, and the keywords “sustainability” and “operations management” were chosen as the metasearch criteria. It represents a contribution to the studies on the OM field evolution, even though it applies only to the sample of 495 papers. The structure of this paper covers the literature review with some details of the research undertaken, after then the methodology for defining the basis of papers and the methods for analysis, the results obtained in bibliometric analysis and descriptives statistics and their respective considerations and, finally, conclusions and directions for future research.

2 Literature review

The report of the World Commission on Environment and Development (WCED, 1987) brings the most widespread definition of sustainable development as "[...] meets present needs without compromising the ability of future generations to meet their own needs”.

The limitation of the planet's natural resources to supply the high industrial demand, and excessive consumption and the increase in world population are rapidly promoting resource depletion and

environmental degradation, reflecting a growth model unsustainable. The impacts are being felt faster than the first predictions. They stated, according to Almeida (2007), that, out of the 24 ecosystem services assessed by the Millennium Ecosystem Assessment (MEA) related to human survival, 60% are in the stage of accelerated degradation .

It is worth mentioning that the globalization movement also encouraged discussions about sustainability, creating a new context for the strategies of the OM. Corroborating with the aim of this study, there is the statement of Taylor and Taylor (2009) on the inclusion of the sustainability in the OM:

> "We have commented upon potencial new OM research topics including sustainability, the role and significance of HRM in operations servitisation and applications of OM in new contexts, such as the not-for-profit sector. We are confident that operations management will continue to be relevant for the problems and challenges of tomorrow's world" (TAYLOR; TAYLOR, 2009, p. 1338).

Taking as reference the above studies, contact that sustainability is now part of the list of emerging sub-themes related to the evolution of the OM, indicating the formation of a community dedicated to the study of application of the concepts linked to the sustainable development of production systems and other traditional areas of the OM field.

The use of bibliometric methods enables to assess the scientific contributions in specific settings and behavior developed in the social networks created by the authors. The shared information in one group tends to be validated according to its replications and, through the citations, the articles form a knowledge network (PINHEIRO; SILVA, 2008). Several studies were conducted to map the field studies of the OM and its evolution, many of them were directed by the pursuit of the most influential authors and research topics and methodologies with the highest rate of occurrences. This study highlights just a few of those already mentioned in the introduction, mentioning more explicitly to introduce the theme of sustainability in the OM field.

Pilkington and Fitzgerald (2006), using the techniques of statistical and bibliometric analysis in 829 articles between 1994 and 2003, extracted a set of information indicating a central field of study focused on manufacturing strategy and a group of researchers forming a community around this theme, including Hayes and Wheelwright (1984) and Skinner (1969, 1974). According to the authors, the entry of the new theme sustainable resource view of the firm "[...] is a new entrant to the significant sub-field, and again revels to the openness of the OM emerging debates in the subject of strategic management ".

Analyzing a longer period, from 1980 to 2006, Pilkington and Meredith (2009) collected articles in three journals related to the OM and traced the evolution of the field over the decades. Again, Manufacturing Strategy appears as the most recurrent theme, along with Quality and Metrics and Statistical Methods. However, the authors point out that Supply Chain and Quality have been gaining ground over the years and the increased interest in statistical and qualitative methods shows the trend of increasing the accuracy of the results and empirical research.

Bayraktar *et al.* (2007) had pointed out the tendency for studies in supply chain, and according to the authors a good supply chain management provides competitive advantage to the company's global business environment.

The studies directed to the OM intellectual mapping show the field movement towards more tactic issues and identify that, until 2009, the main topics comprehended the areas of operations strategy, supply chain management, performance management, performance measurement and service operations.

In the study by Taylor and Taylor (2009) the theme 'supply chain management' appears as the main topic of research articles published by IJOPM between 2004 and 2009 (Figure 1), confirming the trend indicated in the study by Bayraktar *et al.* (2007).

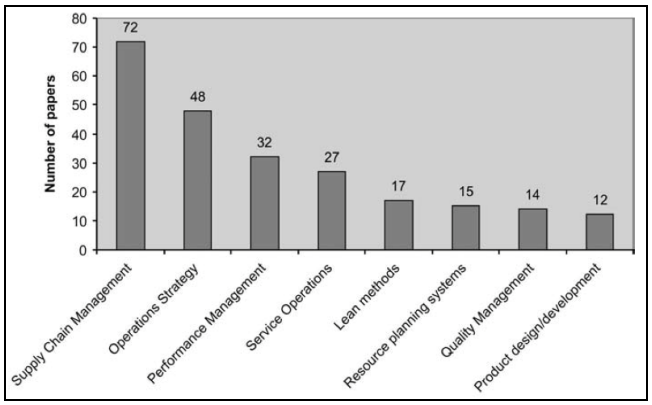

Figure 1. Main themes publised in IJOPM – 2004/2009. Source: (TAYLOR; TAYLOR, 2009).

Models of operations management are facing the challenge of inserting an awareness of sustainability in their practices. Some researchers and practitioners have focused their decision models based on the concept of the Triple Bottom Line (TBL), both for new research and for the design of processes and daily practices (Wilkinson *et al.*, 2001; Porter; Kramer, 2006; Hutchins, Sutherland, 2008, Ueda *et al.*, 2009).

Westkamper, Alting and Arndt (2000, p. 505) state that in terms of sustainable development, the task of Production Engineering is necessary to encourage the industrialization process with a high level of automation and production technologies.

According Kleindorfer *et al.* (2005) Sustainable Management of Operations is defined as the sum of skills and concepts that allow companies to structure and manage their business processes to achieve competitive returns on their capital assets, without compromising the legitimate needs of internal and external stakeholders, taking into account the impact of operations on people and the environment.

Bayraktar *et al.* (2007) emphasize that the models of the future operations will be directed by management measures, criteria and environmental policies, responsiveness and sustainability of the company for the future and efficient use of scarce resources.

Lima, Costa and Bahr (2008, p. 1) complement this view by stating that the new strategic vision of the production is "[...] the interaction environment within the company and its essence and that is the great challenge of modern business." As the researchers cited other research groups have also been devoted to the study of sustainable management in various areas of the OM as, for example, Kleidondorfer *et al.* (2005), Gold *et al.* (2010), Platts (2007) and Selinger (2007).

3 Data Collection

This paper is a documental and exploratory research. The analyses cannot be taken as complete interpretations, due to the difficulties in capturing, quantifying and visualizing all the collected data. In order to diminish the impact of the limitations, the processes and criteria defined to the collection were strictly followed, as well as the established methodology. According to Garfield (1997) inferring solely on the first author may incur in some deficiency so, in this study, all authors were regarded as so important as the first author.

The steps and results comprising the development of the articles selection are described in the Table 1.

Table 1: Steps of research

Step	Action	Results
1	General search on the ISI Thompson, Scopus and "CAPES journal site" bases, in order to select academic bases connected to the OM.	Academic Search Premier/ EBSCO, Emerald, IEEE Xplore, Informs, Oxford Journals, Science Direct, Springer Verlag, Taylor and Francis and Wiley Interscience.

2	General search of papers by keywords "sustainability" and "operations management" on the selected bases and on a second phase filtering of papers by relevance, content and interactions with issues connected to the keywords.	1,000 selected papers in the first phase. 495 select in the second phase
3	Organization and refining (repeated items, synonyms and others not related to this study) of keywords from 496 selected papers - performed with the support from Mendeley Ap. and extracted / organized manually in EXCEL® worksheets.	1,000 keywords – after refining and grouping, sample of 589 words was organized according to synonyms and semantics.
4	Organization of other bibliometric information performed with the support from Mendeley Ap. and extracted / organized manually in EXCEL® worksheets.	categorization of bibliometrics information - name of all authors, institution of the authors, countries, nature of partnerships (international, national (Brazil) or multinational (Brazil and other countries), research methodology, year of publication
5	Citation matrix (137 x 137) and generation of social network by software UCINET/Netdraw app.) .	production of the author's network graph

It is important to clarify that this study does not regard the limitations of the analysis on quotation and co-quotation presented by Taylor and Taylor (2009), presenting the favoring occurring when some author quotes another authors motivated by the prestige of more experienced researchers, with longer careers, controversial articles and other reasons which make the quotation be less valuable.

4 Results and Discussion

Based on the categorization and organization of information extracted from 495 papers, this study sought to present a generic study mapping on the sustainable management of operations, in order to examine opportunities for future research and trends among researchers. A first relevant information is about the growth in the number of published articles about the subject. It is possible to see the continuous growth from 2008 to 2010 (Figure 2), when the number of publications represents about 49% of the total.

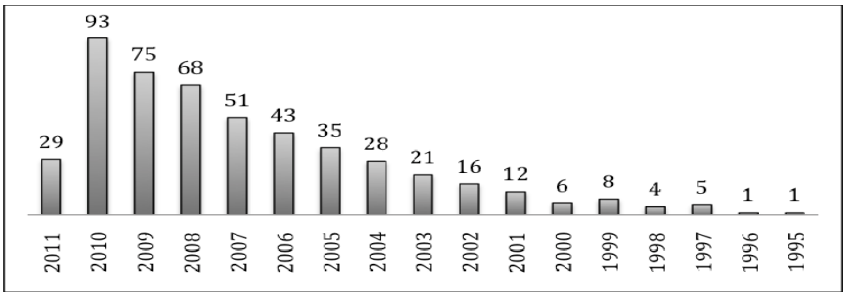

Figure 2 - Evolution of the number of articles

The evolution of the published papers indicates that the increase in the period can be mainly attributed to the evolution of discussions on environmental management systems, supply chain management and corporate social responsibility in the context of sustainability. A quantitative keyword analysis points out these inferences (Table 2).

Table 2: Main keywords (extracted by selected papers)

Keywords	no. of occurrences
Sustainable Development	82
Environmental Management	73
Supply Chain Management	61
Sustainability	41
Corporate Social Responsibility	38

Analyzing the set of papers, it is possible to see a relationship between the words presented in Table 2, where 'sustainable development' is more often associated with 'environmental management', 'supply chain management' is found associated in a balanced way to the words 'environmental management' and 'corporate social responsibility', 'sustainability' and 'corporate social responsibility' both linked more often to 'supply chain management'.

These results corroborate the studies of Taylor and Taylor (2009) on the strength of the supply chain studies in the OM and also with those of Seuring and Muller (2008), in which authors performed a literature review on sustainable supply chain management. According to Seuring and Miller (2008), the environmental dimension is present in more articles on sustainable supply chain driven primarily by strong global pressure characterized by legal demands / regulation, customer demands and response to stakeholders.There are also some theories that have been linked to the study of sustainability in the OM, such as the Life Cycle Assessment (LCA), Sustainable Manufacturing, Corporate Social Responsibility (CSR), and Environmental Management. Validating the results of Pilkington and Meredith (2009), concluding that the OM field is a dynamic field using theories from other fields and developing new research methods.

The past year covered in this research demonstrates a drop in numbers of publications and this event could be indicated that most authors have focused their efforts on specific topics related to the OM and sustainability, leaving behind the generality presented so far. However, a more assertive about this drop in productivity of the field will only be possible in future analyses on research trends.

The selected papers are spread into 139 journals. The multidisciplinarity of the listed journals also ratifies the OM interface with the engineering and business disciplines, but also points out to the current trend that includes the sustainable perspective into several areas, thus enlarging the applicability and validation limits of this subtopic in scientific communities. Table 3 shows the 10 main journals (by number of papers relating to the topic), and the distribution of papers per year of publication.

Journals listed in Table 3 can be considered representative for the OM field, because the set includes more than 40% of all productivity-related themes, which indicates their relevance in the diffusion of the topic, the inclination to studies about sustainability in the OM and their preference by the authors.

Table 3: Main journals

Journal	Papers published in the perspective of sustainability and the OM	% in the total of productivity	The year of publication of the selected papers (number per year)
Journal of Cleaner Production	58	12%	2001 (2), 2003 (1), 2004 (1), 2005 (2), 2006 (7), 2007 (3), 2008 (17), 2009 (9), 2010 (14), 2011 (2)
International Journal of Sustainability in Higher Education	27	5%	2000 (1), 2002 (2), 2003 (1) 2004 (2), 2005 (5), 2006 (4), 2008 (3), 2009 (2), 2010 (2), 2011 (5)
International Journal of Operations & Production Management	26	5%	1995 (1), 1996 (1), 1998 (1), 1999 (1), 2000 (4), 2001 (5), 2002 (1), 2003 (1), 2004 (1), 2005 (2), 2006 (2), 2007 (2), 2008 (1), 2009 (1), 2010 (1), 2011 (1)

Business Strategy and the Environment	25	5%	2004 (2), 2005 (2), 2007 (4), 2008 (5), 2009 (3), 2010 (7), 2011 (2)
Supply Chain Management: An International Journal	14	3%	2005 (1), 2006 (1), 2009 (9), 2010 (3)
Benchmarking: An International Journal	13	3%	2003 (2), 2005 (3), 2008 (1), 2010 (7)
Corporate Social Responsibility and Environmental Management	13	3%	2002 (1), 2005 (1), 2006 (2), 2007 (1), 2008 (2), 2009 (1), 2010 (3), 2011 (2)
International Journal of Physical Distribution & Logistics Management	11	2%	2003 (1), 2005 (1), 2008 (3), 2009 (1), 2010 (5)
International Journal of Production Economics	11	2%	1999 (1), 2007 (1), 2008 (6), 2009 (1), 2010 (2)
Ecological Economics	9	2%	2002 (1), 2004 (1), 2008 (2), 2009 (4), 2010 (1)
Total	207	42%	----------

It appears that the majority of publications takes place from 2000 and, at a greater number from 2008, indicating that the latest issue can be considered recent within the OM field and also indicating a greater interest among journals, remarked with the occurrence of Special Issues on the subject, for example, special issue "Sustainability and Supply Chain" (v. 16, issue 12, 2009) Journal of Cleaner Production and a special issue "Sustainability" (v. 21, issue 12, 2001) of the International Journal of Operations & Production Management - IJOPM.

Looking at the point of view of frequent publications, IJOPM in constant regarding to publication period and it is considered a precursor in publications relating to the OM and sustainability (1995). This fact may be relevant to the development of field studies, because according to Heyes and Pilkington (1999) an evidence of the difficulty in establishing the OM as a discipline was related to the low participation of researchers in journals devoted to the OM.

From the 927 compiled authors, the sample was taken from 137 of them, responsible by the production of 397 papers (80% out of total produced), selected based on the production of at least two topic-related articles. The objective was the generation of a quotation square matrix, used by UCINET software and by the Netdraw application in order to graphically illustrate the network formed by the authors dedicated to the topic (Figure 3).

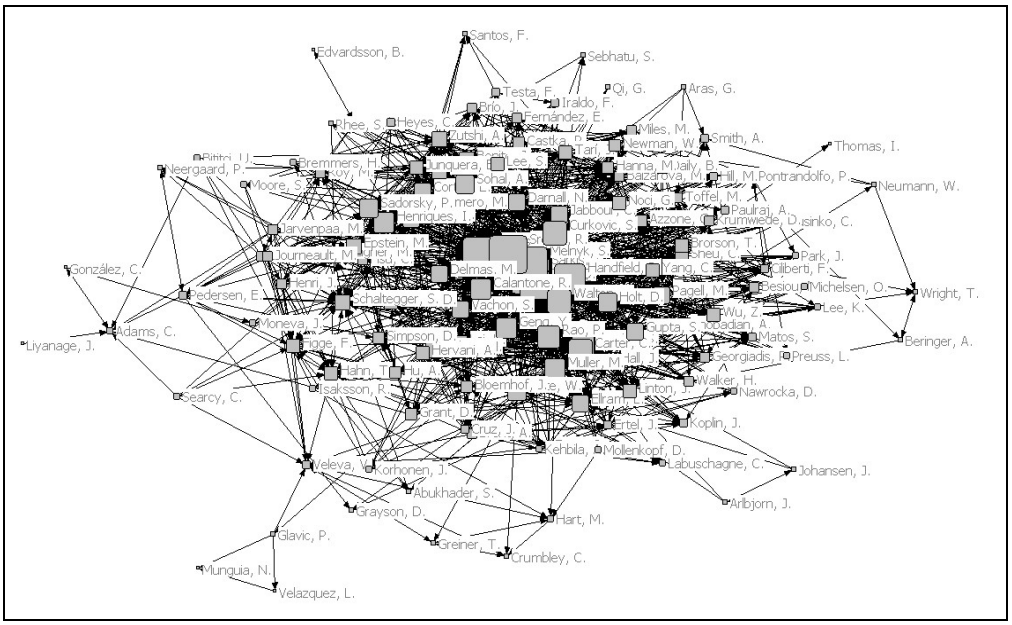

Figure 3 - social network formed by 137 authors

According to the graph, it is verified the formation of a compact community, with some authors away from the network. It can indicate that the research is more guided, in its majority, towards some common topics. Table 4 shows the top 10 authors (according the number of papers found on the main subject) and their respectives institutions, research interests (extracted by personal or institutional website) and statements (compiled based on the analysis of papers).

Table 4: Top 10 authors (by number of papers published in the specific thematic of OM and Sustainability)

Authors	Nº. papers	Institution	Research Interests	Statements
Sarkis, J.	19	Graduate School of Management, Clark University, USA.	Management of Manufacturing Technology; Agility and Agile Manufacturing; Environmentally Conscious Manufacturing; Supply Chain Management; Multicriteria; Green Supply Chain Management; Decision Making Performance Measurement	- Strategies for Green Supply Chain Management; - Stakeholder pressure and environmental management.
Zhu, Q.	12	Dalian University of Technology - School of Management, China.	Supply chain management; game theory; Enterprise environmental management.	- Strategies for Green Supply Chain Management; - Link between Quality Management and Environmental Management; - Strategies for Eco-design.
Seuring, S.	8	University of Kassel - Department of International Management,	Sustainability; Supply Chain Management; Sustainable Supply Chain Management; Supply Chain Controlling.	- Strategies for sustainable supply chain management.
Klassen, R.	7	Richard Ivey School of Business, University of Western Ontario, CA.	Operations Management; Business Administration; Sustainable Development; Management of Technology	- Environmental management in operations; - Strategies for sustainable supply chain.
Azorín, J.	6	University of Alicante - Department of management – Spain.	Strategic management.	- Sustainability, performance management and firm performance.
Castka, P.	6	University of Salford, UK.	Quality management; Corporate social responsibility.	- Corporate social responsibility and management systems; - Maintenance of ISO 14001.
Cortés, E.	6	University of Alicante - Department of management, Spain.	Strategic management and human resources management.	- Sustainability, performance management and firm performance.
Handfield, R.	6	College of Business Management, North Carolina State University, USA.	Supply Chain Management; Strategic Sourcing.	- Strategies for Green Supply Chain Management.
Jabbour, C.	6	University of Sao Paulo - Business Administration and	Environmental management; Sustainability.	- Environmental Management studies applied in different

		Accounting, Brazil.		areas.
Walton, S.	6	Emory University - Goizueta Business School, USA.	Electronic commerce; Technologies for environmental and supply chain management; Environmental impacts of supply chain management; Applications of qualitative research methods.	- Strategies for environmental management and supply chain; - Strategies for green supply chain management

Analyzing the keywords in the areas of interest and statements of authors, it is remarkable the direction of subjects and, especially, a tendency to include the principles of sustainability in models of the OM that have previously being defined by the authors themselves or by the field of the OM - as the main research themes listed by Taylor and Taylor (2009) - in order to adapt them into the new scenario of sustainable development.

Another data can be discussed using the example of Joseph Sarkis (Clark University, USA) and Qinghua Zhu (Dalian University of Technology - China), who have 10 articles written in partnership representing, respectively, about 50% and 80% of the productivity of each author in this thematic. This partnership is characterized by being international, and according to Glanzel (2001) international co-authorship is often cited more than purely domestic papers, highlighting the importance of establishing relationships with other authors in the production of scientific research. It became significant for this study to analyze the origin of the authors, however it is not intended to actually consider whether international partnerships are most often cited, although it is believed so, aiming to map the origin of production on the theme. Future research may examine the partnerships according to the concept of Glanzel (2001).

Based on the criteria of international production, the papers were categorized into three types: (a) International - foreigners and authors partenership from diferent countries; (b) Brazil - only Brazilians authors; (c) Multinational - Brazilians authors with foreigners. A total of 482 papers was written by an international collaboration, 12 by Brazilian researchers and only one published by a multinational collaboration. Due to the presence of Brazilian researchers, it became relevant to complement the information about the origin of the authors (considering all authors), in order to know the country (Table 5) and institutions (Table 6) that have a higher number of researchers contributing to the field of study.

Table 5: Main countries (by number of papers published in the specific thematic of OM and Sustainability)

Countries	**nº. papers**	**Countries**	**nº. papers**
1. USA	278	7. Italy	45
2. UK	158	8. China	40
3. Spain	96	9. The Netherlands	40
4. Canada	73	10. Sweden	36
5. Germany	52	11. New Zealand	33
6. Australia	49	12. Brazil	27

Table 6: Represents institutions (by number of researchers dedicated to the theme)

Institution / Country	**nº. of researchers**	**Main subthemes in OM and sustainability**
University of Alicante (Spain)	22	environmental management
Clark University (USA)	20	environmental management; green supply chain management
Dalian University of Technology (China)	17	green supply chain management
Michigan State University (USA)	15	green supply chain management; environmental management; supply chain management; design for environment

University of Strathclyde (UK)	15	CSR, performance measures, operations management
Erasmus University (The Netherlands)	13	sustainable supply chain, environmental management, supply chain management
University of California (USA)	12	environmental management, reverse logistics
University of Sao Paulo (Brazil)	11	environmental management
Lund University (Sweden)	10	environmental management; supply chain management
Universidad de Oviedo (Spain)	10	environmental management
University of Tennessee (USA)	10	supply chain management
Wageningen University (The Netherlands)	10	environmental management; supply chain management

Looking at the representativeness of Brazil in the evolution of this research field, Brazil occupies the 12th place. Analyzing the total of 20 Brazilian authors, the University of São Paulo has a significant group of researchers (11), devoted to the issues of 'environmental management' and 'social dimension' in the OM, and Charbel Jabbour, on the list of 10 authors higher productivity on the subject (Table 4). It was also considered authors in other Brazilian universities, such as the University of Rio Grande do Sul (UFRGS), Federal University of São Carlos (UFSCAR), São Paulo State University (UNESP), Federal University of Espírito Santo (UFES) and the Federal University of Viçosa (UFV).

5 Conclusion

Based on the results and analyses, it is possible to demonstrate that the topic of sustainability has a community dedicated to the study of the sustainability in the OM field, which has been evolving across the years, mainly addressing the areas of '*supply chain management*', '*environmental management*' and '*corporate social responsibility*'. The evolution on the number of studies in areas regarded as relevant to the OM also points out that the field follows the trend of researching more strategic and contemporary issues to the organizations. Such factors have contributed to the establishment of the OM as a discipline.

Brazil appears as an important participant in the evolution of the studies, occupying a prominent position among authors and among the institutions represented, however, it appears that such participation could be more representative if the Brazilian community would strengthen its network with international authors, promoting more multinational partnerships.

According to its main purpose, this paper presents information in order to contribute to the develop of OM field and provide some directions for research topics, such as carrying out studies on the OM involving the three dimensions of sustainability and not only the environmental dimension, expansion of bibliometric analyzes (including multivariate data), involving the relations between authors and possibly formed cluster, and create subsidies to encourage more Brazilian researchers to devote themselves to the theme.

References

ALMEIDA, F. (2007). *The challenges of sustainability* (in portuguese: Os desafios da sustentabilidade). Rio de Janeiro: Elsevier.

BAYRAKTAR, E.; JOTHISHANKAR, M.C.; TATOGLU, E; WU, T. (2007). Evolution of operations management: past, present and future. *Management Research News,* v. 30, n. 11, p. 843-71.

ELKINGTON, J. (1997). *Cannibals with forks: the triple bottom line of 21st century business*. Capstone, Oxford,

HAYES, R.H; WHEELWRIGHT, S.C. (1984). Restoring our competitive edge: competing throught manufacturing. New York: John Wiley.

HUTCHINS, M., SUTHERLAND, J. (2008). An exploration of measures of social sustainability and their application to supply chain decisions, *Journal of Cleaner Production*, 16(15), 1688-1698.

GARFIELD, E., (1997). Citation indexing – Its theory and application in science, *Technology and Humanitied*, Institute of Scientific Information, ISI Press Philadelphia.

GAVRONSKI, I., FERRER, G. & PAIVA, E. (2008). ISO 14001 certification in Brazil: motivations and benefits. *Journal of Cleaner Production*, 16(1), p.87-94. Available at: http://linkinghub.elsevier.com/retrieve/pii/S095965260600415X [Accessed October 24, 2010].

GLÄNZEL, W. An introduction to principle differences between citations and sitation links. A methodological and mathematical approach. In: 6th Nordic Workshop on Bibliometric. Disponível em:< http://www.umu.se/inforsk/6thNordicBibliometric.htm>. [Accessed July: 10, 2011].

GOLD, S., SEURING, S. AND BESKE, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review, *Corporate Social Responsibility and Environmental Management*, 17(4), 230-245.

GUNGOR, A; GUPTA, S. (1999). Issues in environmentally conscious manufacturing and product recovery: a survey. *Computers e Industrial Engineering*. Vol.36, n.4, p. 811-853.

GUTBERLET, J. (2000). Sustainability: a new paradigm for industrial production. *International Journal of sustainability in higher education*, 1(3), p.225-236.

HART, S. (2005). *Capitalism in the crossroads*, Wharton School Publishing Co., Philadelphia.

HUTCHINS, M., SUTHERLAND, J. (2008). An exploration of measures of social sustainability and their application to supply chain decisions, Journal of Cleaner Production, 16(15), 1688-1698.

ILGIN, M. & GUPTA, S. (2010). Environmentally conscious manufacturing and product recovery (ECMPRO): A review of the state of the art. *Journal of environmental management*, 91(3), p.563-91. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19853369.

KLEINDORFER, P.R.; SINGHAL, K.; VAN WASSENHOVE, L. N. (2005). Sustainable Operations Management. *Production and Operations Management*, v. 14, n. 4, p. 482-492.

LIMA, E. P; COSTA, S. E. G.; BAHR, A. B. (2008). Development of a conceptual framework for the strategic management of operations based on principles of corporate social responsibility (in portuguese: Desenvolvimento de um marco conceitual para a gestão estratégica de operações baseada em princípios da responsabilidade social corporativa). In: *XXVIII ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, 2008*. Disponível em: <http://www.abepro.org.br/

LINDE, C; PORTER, M.E. (1995). Green and Competitive: Ending the Stalemate. *Harvard Business Review*, Boston, Sep.-Oct.1995.

MCINTIRE, J.S. (2006). *The clothing and textile research base: an author cocitation study*, Master Degree dissertation, Faculty of the Graduate School, University of Missouri.

PLATTS, K.W. (2007). Strategies for sustainable manufactuting, International Conference o Industrial Engineering and Operations Management – ICIEOM 2007, *Plenary Lecturer*, Foz do Iguazu, Brazil.

PILKINGTON, A., LISTON-HEYES, C. (1999). Is production and operations management a discipline? A citation/co-citation study. *International Journal of Operations and Production Management*, 19, 7–20.

PILKINGTON, A., FITZGERALD, R., (2006). Operations management themes, concepts and relationships: a forward retrospective of the IJOPM, *International Journal of Operations and Production Management*, 11, 1255–1275.

PILKINGTON, A., MEREDITH, J. (2009). The evolution of the intellectual structure of operations management –1980–2006: a citation/co-citation analysis, *Journal of Operations Management,* 27, 185-202.

PINHEIRO, L. V.; SILVA, E. L. (2008). The cognitive networks in information science in Brazil: a study in scientific papers published in journals (in portuguese: As redes cognitivas na ciência da informação brasileira: um estudo nos artigos científicos publicados nos periódicos da área). *Ciência da Informação*, v. 37, n.3, p.38-50.

PORTER, M.E., KRAMER, M.R. (2006). The link between competitive advantage and corporate social responsibility, *Harvard Business Review*, 84(12), 1-14.

POWELL, W.W.; WHITE, D. R.; KOPUT, K. W.; OWEN-SMITH, J. (2005). Network Dynamics and Field Evolution: The Growth of Interorganizational Collaboration in the Life Sciences. American Journal of Sociology, v. 110, n. 4, p. 1132-1205.

SKINNER, W. (1969) Manufacturing: the missing link in corporate strategy. Harvard Business Review, Boston.

SKINNER, W. (1974). The focused factory, Harvard Business Review, May-June, p.136-45

SELIGER G. (2007). Sustainability in manufacturing, recovery of resources in product and material cycles. Springer: New York

SEURING, S. AND MULLER, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, v.16, n.15, p. 1699-1710.

SOWER, V., MOTWANI, J., SAVOIE, M. (1997). Classics in production and operations management, *International Journal of Operations & Production Management*, 17(1), p.15-28.

SPRAGUE, L. (2007). Evolution of the field of operations management, *Journal of Operations Management*, 25, 219-238.

TAYLOR, A., TAYLOR, M. (2009). Operations management research: contemporary themes, trends and potential future directions", *International Journal of Operations & Production Management,* 29(12), p.1316-1340.

THE MENDELEY SUPPORTING TEAM. (2011). Getting Started with Mendeley, London: Mendeley Ltd.; 2010:1-14. Acessed in:< www.mendeley.com>.

UEDA, K., TAKENAKA, T., VÁNCZ, J., MONOSTORI, L. (2009). Value creation and decision-making in sustainable society, *CIRP Annals - Manufacturing Technology*, 58(2), p. 681-700.

UNEP. *United Nations Environment Programme* (2007). Sustainability and Life Cycle Thinking: a business guide to sustainability.

VELEVA, V. et al. (2001). Indicators of sustainable production. *Journal of Cleaner Production*, 9(5), p.447-452.

VELEVA, V. & ELLENBECKER, M. (2001). Indicators of sustainable production: framework and methodology. *Journal of Cleaner Production*, 9(6), p.519-549. Acessed in: http://linkinghub.elsevier.com/retrieve/pii/S0959652601000105.

WCED - World Commission on Environment and Development. (1987). *Our Common Future*, Oxford University Press, Oxford.

WESTKAMPER; ALTING; ARNDT. Life Cycle Management and Assessment: Approaches and Visions Towards Sustainable Manufacturing (keynote paper). *CIRP Annals - Manufacturing Technology*. Volume 49, Issue 2, 2000, Pages 501-526.

WHITE, D. R.; OWEN-SMITH, J.; MOODY, J.; POWELL, W. W. Networks. (2004). Fields and Organizations: Micro-Dynamics, Scale and Cohesive Embeddings. *Computational & Mathematical Organization Theory*, v. 10, p. 95-117.

WILKINSON, A., HILL, M., GOLLAN, P. (2001). The sustainability debate, International *Journal of Operations & Production Management*, 2(12), 1492-1502.