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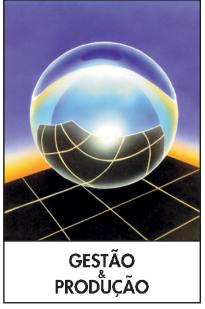

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Analysis of supply chain risk management researches

Perfil de pesquisa sobre gerenciamento de riscos em cadeias de suprimentos

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Abstract: Despite the large number of contributions (some 250 articles) published on Supply Chain Risk Management (SCRM), none of them have developed what can be called research profiling on the theme. This paper aims to analyze the profile of works published on SCRM, that is, to map the field of research on the theme, covering articles published from 2004 to 2015. The authors adopted the research profiling method, which expands the scope of bibliometry by applying text mining. The VantagePoint® software was used to analyze, classify, and organize the data of this study. The results provide several insights into research on SCRM, namely: (i) the key expression "supply chain risk management" only became representative for the theme after 2012; (ii) the most cited authors are not the same as those who have published the most; and (iii) only three periodicals together account for one-third of all the citations in publications on SCRM.

Keywords: Supply Chain Risk Management; SCRM; Research profiling; Systematic literature review.

Resumo: *Nos últimos 10 anos, publicações sobre Gerenciamento de Riscos em Cadeias de Suprimentos (SCRM) cresceram a uma taxa média de mais de 40% ao ano. Trata-se de um tema que vem, rapidamente, ganhando notoriedade na área de Logística, tanto por ser um assunto relativamente novo, inspirando pesquisadores a desenvolverem estudos sobre a questão, quanto pelo potencial de minimizar prejuízos de altas cifras em cadeias de suprimentos. Dada a relevância científica e empresarial da matéria, a presente pesquisa possui como objetivo principal analisar o perfil dos trabalhos publicados sobre SCRM, ou seja, mapear o campo de pesquisas sobre o tema, abrangendo os artigos publicados sobre esse assunto até 31 de dezembro de 2015. Para a consecução desse objetivo, adotou-se o método de pesquisa Research Profiling, que amplia o escopo da bibliometria por meio da mineração de texto. Para a análise, tabulação e organização dos dados, utilizou-se o software VantagePoint®. Como resultados principais, foram respondidas inúmeras questões relacionadas às pesquisas sobre SCRM, das quais se destacam as seguintes: i) cada artigo, apresenta-se, em média, repetido 1,2 vez em outras bases de dados; ii) os autores mais citados não são os que mais publicam; iii) as palavras-chave "Supply Chain Risk Management" só se tornou representativa para esse tema após 2012; iv) apenas três periódicos, juntos, são responsáveis por um terço de todas as citações em publicações sobre SCRM. Como resultado secundário, mas não menos importante, observou-se a falta de consenso entre os pesquisadores quando o assunto diz respeito às etapas que devem ser desenvolvidas no SCRM.*

Palavras-chave: *Supply Chain Risk Management; SCRM; Perfil de pesquisa; Revisão sistemática da literatura.*

1 Introduction

According to Ghadge et al. (2012), the sources of business risks are many and originate both within and outside the organization, so that, as observed by Christopher & Lee (2004), supply chain risk management (SCRM) is becoming an integral part of risk management in general.

As stressed by Colicchia & Strozzi (2012), operational risks are not the only type existing along

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a supply chain, since uncertainty of the business environment and the complexity of supply chains are increasing the probability of ruptures along the chain. In this context, Hendricks et al. (2009) argue that properly managing this type of risk minimizes problems of interruptions, reduces their negative impact on performance and allows faster restoration of the chain to its normal state.

Problems of supply chain management (SCM) can cause large monetary losses, such as happened in the previous decade to Boeing, Cisco and Pfizer, which suffered losses attributed to supply chain problems amounting to US$ 2 billion, US$ 2.25 billion and US$ 2.8 billion, respectively (Hult et al., 2010). Other examples of financial losses due to breakdown of supply chains can be found in Kern et al. (2012) and Sodhi et al. (2012).

According to Colicchia & Strozzi (2012), few areas of interest in the ambit of management have gained such prominence in recent years as SCRM, both from the practical and research perspectives.

The concept of SCRM emerged as a natural extension of SCM, and originates from the intersection of risk management and supply chain management (Blos et al., 2009), as depicted in Figure 1.

SCRM is an important process within SCM and has the main goal of identifying the sources of potential risks, suggesting suitable measures to mitigate them (Singhal et al., 2011) and increasing the supply chain's resilience (Pujawan & Geraldin, 2009). Figure 2 illustrates the growth of research publications on SCRM in international periodicals, in the Scopus, Web of Science, Science Direct, Emerald Insight and Ingenta Connect databases.

Despite the large number of contributions (some 250 articles) published on SCRM from 2004 until the end of 2015, none of them developed what can be called research profiling on the theme. Tang (2006), Khan & Burnes (2007) and Manuj & Mentzer (2008b) all presented extensive reviews on what had been published about SCRM until the respective years of those studies, contributing to identify gaps and to refine a research agenda. In turn, Colicchia & Strozzi (2012) combined a systematic literature review (SLR) and citation network analysis (CNA) to investigate the process of creation, transfer and development of knowledge on SCRM, by analyzing 55 works from the Web of Science database up to 2010.

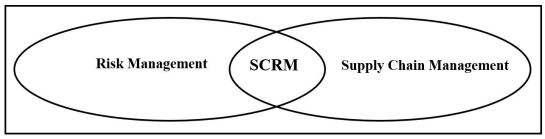

Figure 1. SCRM as the intersection of SCM and risk management. Source: Blos et al. (2009).

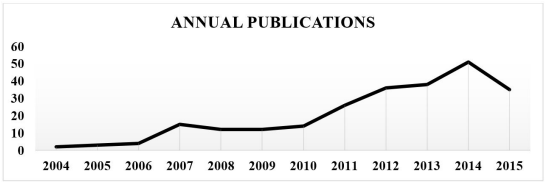

Figure 2. Annual publications on SCRM in selected databases. Source: authors.

The present work aims to shed more light on SCRM, by complementing the review articles mentioned above, covering all the articles published in the Scopus, Web of Science, Science Direct, Emerald Insight and Ingenta Connect databases, with a different slant, to map and analyze the research in the field of SCRM. For this purpose, we selected the research profiling method, which expands on traditional literature review by examining the relevant publications more comprehensively (Porter et al., 2002).

Research profiling seeks to answer four "W" questions: "Who", "What", "Where" and "When", for example: Who are the most cited authors on a determined theme? What article is studied most within this theme? Where are most articles produced? When did each topic first appear in the literature? The use of these questions does not constrain the scope of this method; other questions can be addressed, such as: What countries produce more research on a determined topic? What are the most common keywords utilized by researchers in a given area? How has the volume of publications grown over time?

This study is relevant in at least three aspects: (i) research into SCRM is still in the incipient stage (Lavastre et al., 2012; Narasimhan & Talluri, 2009), especially in countries like Brazil (Blos et al., 2009); (ii) research into SCRM is rapidly gaining importance in the logistics area (Colicchia & Strozzi, 2012; Wieland & Wallenburg, 2012; Singhal et al., 2011); and (iii) the losses caused by supply chain problems can reach huge proportions (Hult et al., 2010; Kern et al., 2012; Sodhi et al., 2012).

This work is organized into five sections including this introduction. The second section covers the methodological aspects; the third presents and discusses the results; the fourth addresses perspectives to advance research on SCRM; and the fifth presents our concluding remarks, followed by the bibliographic references used.

2 Methodological aspects

In this article, we carry out a systematic literature review of supply chain risk management in five databases, using bibliometry and text mining to develop a research profile, called research profiling by Porter et al. (2002).

The first step involved identifying all the articles published from 2004 to December 31, 2015. We did

this on March 1, 2016, by applying the "advanced research" option in each selected base, using the search argument "supply chain risk management" in the title, abstract and keywords. Besides this, to refine the survey, we selected only articles published in scientific periodicals in English.

Table 1 reports the number of articles found in each database.

Two limiting factors deserve mention regarding this first step: (i) periodicals that had not yet published the last edition for 2015 by March 1, 2016 were not included; and (ii) articles not containing the exact expression. "supply chain risk management*"* at least once in the title, keywords or abstract were not selected.

The second step was to define the way to analyze these data. For this we chose the VantagePoint® program. This choice was based on the fact that this software is recognized by researchers for its efficiency and practicality in treating data (Eldridge, 2006; Islam & Miyazaki, 2010; Kim et al., 2012).

The third step consisted of organizing the data for processing by VantagePoint®. The Web of Science and Scopus bases generate files containing all the information necessary for research profiling, so it is only necessary to insert each article in the software. The other bases (Science Direct, IngentaConnect and Emerald Insight) do not provide all the information automatically. This required analyzing each article from these bases individually, with subsequent manual organization of the data collected.

Table 1. Number of articles found in each database.

Database	Number of Articles
Scopus	220
Web of Science	139
IngentaConnect	66
Emerald Insight	63
Science Direct	55
TOTAL	**543**

Source: authors.

During the third step, we noted the existence of intersections (overlaps) between the databases in some cases, i.e., a single article was present in more than one base, as depicted in Figure 3.

Figure 3 shows that most of the articles about SCRM contained in the Science Direct, IngentaConnect and Emerald Insight bases are also present in the Web of Science (WOS) and Scopus bases. Besides this, the figure reveals an intersection of 107 articles between the two largest bases (Scopus and WOS). Finally, it indicates that: (i) 14% of all the articles from Ingenta Connect and 8% of those from Emerald Insight are not in the Scopus and WOS bases; and (ii) all the articles (100%) from Science Direct are present in the Scopus or WOS bases.

Therefore, we used the data files generated automatically by WOS and Scopus, plus a matrix created manually with the data from the articles found exclusively in Ingenta Connect (9 articles) and Emerald Insight (5 articles). Finally, with all the data inserted in VantagePoint®, it was possible to identify repetition of 107 articles common to the files generated by WOS and Scopus. After eliminating these 107 records, 248 articles remained as material for the research profiling about SCRM, or 45.86% of the 543 articles initially identified in the five databases searched. With these articles we began the fourth step.

The purpose of the fourth step was to organize and harmonize the data from the articles, including standardizing the names of the periodicals, the authors, keywords, countries and other items considered in the analysis. This was also accomplished with the VantagePoint® software.

In the fifth and last step, we performed basic examination to identify the relevant information from the data organized by the software and then conducted advanced analyses to observe the patterns of production

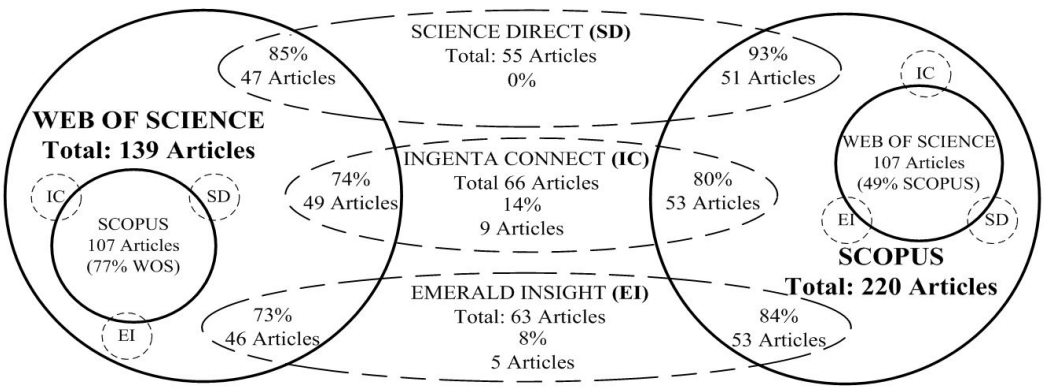

Figure 3. Intersections of databases for publications on SCRM in the period from 2004 to 2015. Source: authors.

of knowledge on the SCRM theme. The purpose of these analyses was to answer the question: What is the dynamic of producing knowledge in the area of supply chain risk management?

To prove more details on the theme, we finalized the work by formulating and addressing the following questions:

1. Who are the most productive authors?
2. What periodicals publish the most articles in the area studied?
3. What institutions are most productive?
4. What countries are most representative in the production in the area?
5. Who are the most referenced authors?
6. What are the most referenced periodicals?
7. What years have seen the largest number of citations?
8. When were the largest volume of articles in the area published?
9. What keywords are most used?

The next section presents the results of the five steps described above.

3 Results of the researh profiling about SCRM

This section organizes the results of the research profiling about SCRM. Since VantagePoint® presents results related to the number of records and/or the number of occurrences, all the figures and tables are ordered by the number of records supplied. For a better understanding of the meaning of this observation, take the following example: a single article can be referenced in five works by the same author, so it will have a single record and five occurrences. The analyses are presented next, in three subgroups.

3.1 "Publishes the Most" subgroup

Here we try to answer the four questions, three of which are represented in Figure 4, where the dependence, relationship and interaction between them can be found.

The authors who are most active in publishing articles about SCRM wind up influencing the bibliometric tallies of the institutions and countries. Table 2 includes the ten institutions that published the most articles from 2004 through the end of 2015.

However, this relation is not proportional, since many articles have multiple authors, often from

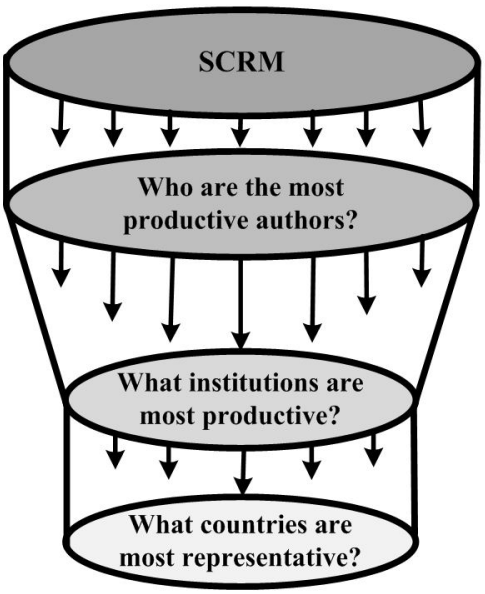

Figure 4. Relations between authors, institutions and countries that are most active in publishing about SCRM. Source: authors.

Table 2. List of the institutions ranked by number of publications on SCRM.

Ranking	Institution	Number of Records
1	University of North Texas	5
2	Cranfield School of Management	4
3	Swiss Federal Institute of Technology	4
4	University of Toronto	4
5	Sepuluh Nopember Institute of Technology	3
6	Hong Kong Polytechnic University	3
7	Indian Institute of Technology Delhi	3
8	Iowa State University	3
9	University of Electronic Science and Technology of China	3
10	Massachusetts Institute of Technology	2

Source: authors.

different institutions. Table 3 lists the researchers who were most active in publishing articles on SCRM in the period studied.

Figure 5, in turn, depicts the evolution of the publications by these authors in the period studied.

With respect to the countries that are most productive in publishing, it can be seen in Table 4 that the United States and China are the leaders in terms of numbers of publications.

3.2 "Most Cited" subgroup

The topic addressed here is the number of citations of authors and periodicals, as well as the years when these citations occurred. Table 5 organizes the 20 authors most often cited in the development of research into SCRM.

Figure 6, in turn, depicts the evolution of the most cited authors during the period studied.

Figure 7 depicts the years most cited by the authors. For example, the 248 articles about SCRM selected

Table 3. List of the 20 most active authors on SCRM.

Ranking	Author	Number of Records
1	Backhurst, J.	6
2	Samvedi, A.	5
3	Wagner, S. M.	4
4	Ekwall, D.	4
5	Khan, O.	4
6	Manuj, I.	4
7	Olson, D. L.	4
8	Wu, D.	3
9	Bandaly, D.	3
10	Banwet, D. K.	3
11	Chen, H.	3
12	Christopher, M.	3
13	Dani, S.	3
14	Devadasan, S. R.	3
15	Elangovan, D.	3
16	Faisal, M. N.	3
17	Goh, M.	3
18	Jain, V.	3
19	Karuppuswamy, P.	3
20	Mentzer, J. T.	3

Source: authors.

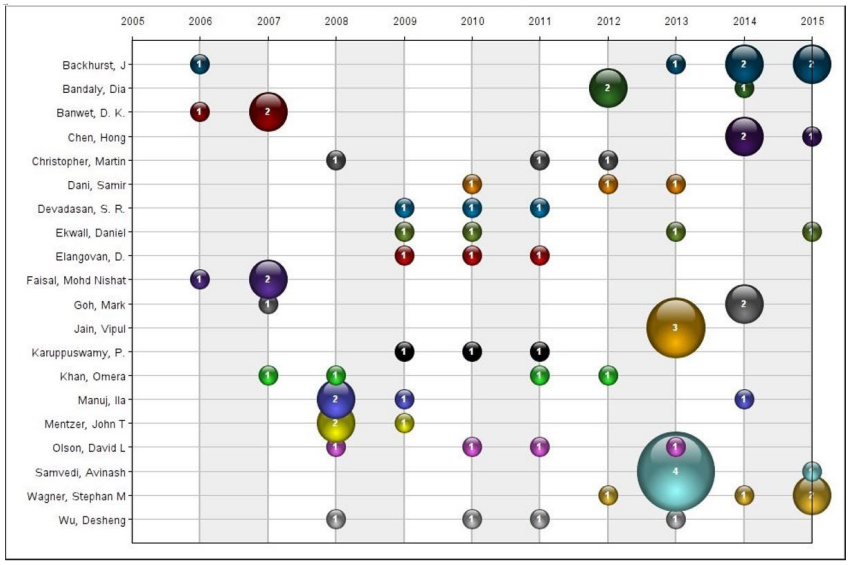

Figure 5. Articles published per author on SCRM from 2004 to 2015. Source: authors, generated by the VantagePoint® software.

contain 212 citations of other articles published in 2004. These citations are related to scientific works in various areas of knowledge, including SCRM itself.

From analyzing Figure 7 and Table 6, it can be seen that researchers interested in the theme of SCRM have been developing theoretical frameworks (bibliographical reviews) for their works based mostly on articles that do not make specific reference to SCRM. For example, in 2004, 2005 and 2006, only nine articles were published about SCRM, but other works from these years are the most cited in the publications of the authors of those nine works, with 611 records (212 in 2004, 200 in 2005 and 199 in 2006).

Table 4. List of the 20 leading countries in the publication of articles on SCRM.

Ranking	Countries	Number of Records
1	USA	69
2	China	37
3	India	26
4	UK	26
5	Germany	24
6	Canada	10
7	Sweden	10
8	Switzerland	10
9	Brazil	8
10	Italy	8
11	Australia	7
12	Singapore	7
13	Finland	6
14	Japan	6
15	Malaysia	5
16	Indonesia	4
17	Iran	4
18	Poland	4
19	Denmark	3
20	France	3

Source: authors.

With respect to the periodicals most often cited by the researchers on SCRM, the standouts are, in this order, *International Journal of Production Economics*, *Journal of Operations Management* and *Supply Chain Management: An International Journal*, with more than 100 citations for each. According to the data in Table 7, for each five citations involving works on SCRM, one citation refers to one of these periodicals. When examining the number of occurrences, the ratio is higher: these three periodicals together are responsible for one-third of all the citations in publications on SCRM.

To finalize this section and trace a parallel with the previous one, of the 20 authors with the most publications (see Table 3) and the 20 most cited authors (see Table 5), only four are present in both analyses. Figure 8 illustrates this question, where the numbers inside each column in black indicate the years when the articles by each author were published.

We believe several factors influence the relation presented in Figure 8, such as type of research (applied or not), the author (whether becoming well known in the field before, during or after the year of

Table 5. List of the 20 authors most often cited, ranked by number of records.

Ranking	Author	Number of Records	Number of Occurrences
1	Christopher, M.	109	204
2	Tang, C.S.	96	127
3	Chopra, S.	91	105
4	Zsidisin, A.	90	182
5	Juttner, U.	81	118
6	Norrman, A.	74	94
7	Peck, H.	74	129
8	Sheffi, Y.	71	103
9	Wagner, S.M.	71	119
10	Hallikas, J.	67	89
11	Kleindorfer, P.R.	67	95
12	Manuj, I.	66	90
13	Hendricks, K.B.	61	95
14	Lee, H.L.	58	81
15	Tang, C.	55	64
16	Blackhurst, J.V.	52	71
17	Craighead, C.W.	52	59
18	Harland, C.	52	57
19	Sodhi, M.S.	52	73
20	Ritchie, B.	50	59

Source: authors.

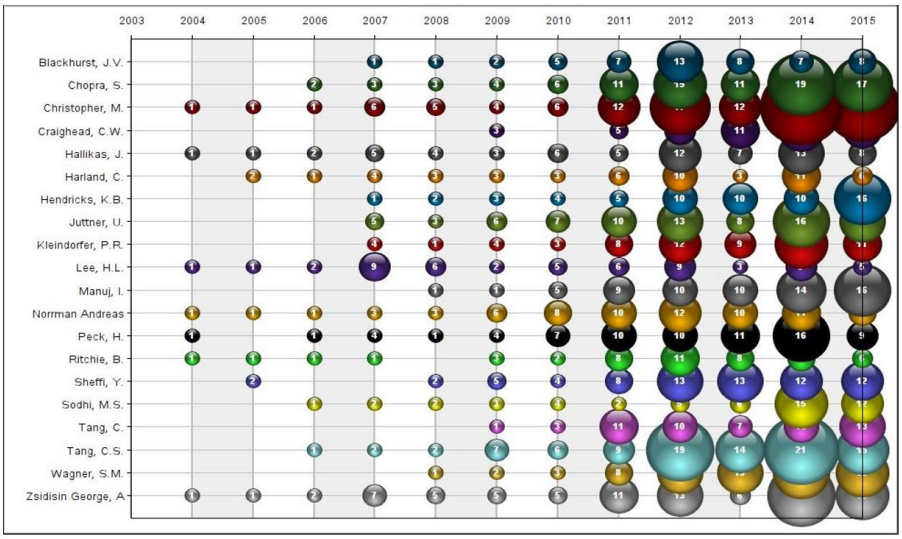

Figure 6. Ranking of citations involving SCRM in the study period. Source: authors, using the VantagePoint® software.

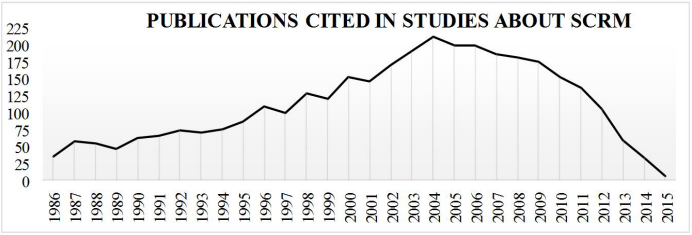

Figure 7. Analysis of the year of the publications cited in studies about SCRM in the past 30 years. Source: authors.

Table 6. Works about SCRM published per year, in the past 12 years.

Year of Publication	Number of Records	Accumulated Frequency
2004	2	2
2005	3	5
2006	4	9
2007	15	24
2008	12	36
2009	12	48
2010	14	62
2011	26	88
2012	36	124
2013	38	162
2014	51	213
2015	35	248

Source: authors.

publication), the year when the study was published (more recent or more remote), among other aspects.

3.3 "Where to Search" subgroup

Here we include the results of the periodicals publishing the largest number of articles about SCRM and the key words or expressions chosen by the authors for their works. We believe it is pertinent to cover these two aspects here in a single section because when a researcher wants to find works dealing with SCRM, he or she will do so mainly through key words or expressions at the sites of the periodicals that most often publish articles on the subject. Table 8 organizes the key words/expressions most often chosen to represent works on the subject of SCRM: data from the 248 SCRM articles that compose the present research were loaded into Vantage Point® to generate the table data, with the keywords most used in the articles from 2004 to 2015.

Figure 9 complements Table 8, indicating year by year the key words/expressions used the most. It can be observed in the figure that the first expressions used were "Risk Management" and "Supply Chain Management". Only after 2012 did the expression "Supply Chain Risk Management" become representative, in terms of absolute numbers, for research into SCRM.

Figure 10 illustrates the evolution of the three most used key expressions, both in terms of simple and accumulated frequency.

With respect to the periodicals that are the most active in publishing articles about SCRM, the standouts are *International Journal of Production Economics*, *International Journal of Production Research* and

Table 7. List of the 20 periodicals cited most.

Order	Periodicals	Records	Occurrences
1	International Journal of Production Economics	137	501
2	Journal of Operations Management	102	324
3	Supply Chain Management: An International Journal	101	333
4	Management Science	95	224
5	International Journal of Physical Distribution & Logistics Management	94	208
6	The International Journal of Logistics Management	91	195
7	Production and Operations Management	88	150
8	European Journal of Operational Research	87	189
9	International Journal of Production Research	86	210
10	Journal of Purchasing & Supply Management	78	127
11	MIT Sloan Management Review	78	115
12	International Journal of Logistics Research and Applications	74	120
13	International Journal of Operations & Production Management	64	116
14	Journal of Business Logistics	63	144
15	Journal of Supply Chain Management	63	106
16	Decision Sciences	59	100
17	Harvard Business Review	59	100
18	International Journal of Physical Distribution & Logistics Management	58	119
19	Computers in Industry	35	37
20	Academy of Management Review	33	48

Source: authors.

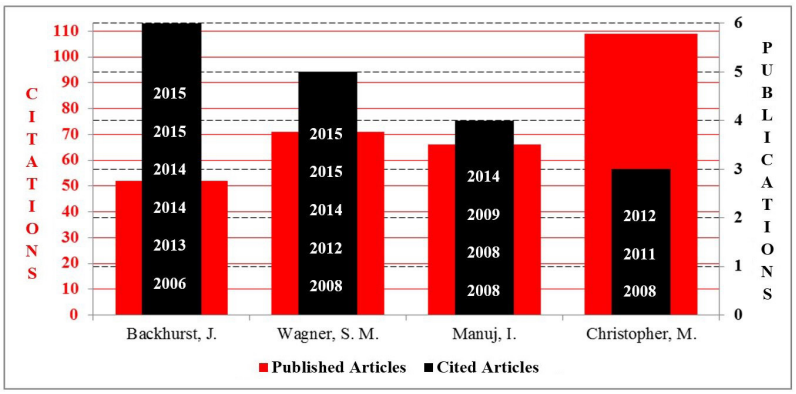

Figure 8. Comparison between citation and publications of an author about SCRM. Source: authors.

Supply Chain Management: An International Journal. Table 9 shows the results of this analysis.

4 Perspectives for progress in studies about SCRM

In order to infer about prospects for future SCRM research, this section was subdivided in four parts. The first subsection (4.1) analyzes the main research carried out in the 2004-2015 period; The second subsection (4.2) analyzes the main SCRM models; In the third subsection (4.3) those models are analyzed and suggestions for improvement of these models are presented; The last subsection (4.4) organizes the suggestions for future research made by the SCRM researchers.

4.1 Main SCRM researches

The articles were separated in two phases so that SCRM research behavior along the time can be analyzed. After separating the articles, a Pareto analysis was performed, based on citation database information, aiming to identify the 20% most cited articles in each phase, in order to present the most representative articles.

In the first phase (from 2004 to 2009), the low quantity of articles, as well as their content, which mostly deal with the creation of risk management models for companies, indicate that the concept of risk management was still under development. An example that synthesizes this period is the article wrote by Finch (2004), where the author analyzes the literature about several knowledge areas to develop

Table 8. List of the 20 key expressions used most.

Ranking	Key Words/Expressions	Number of Records
1	"Supply chain risk management"	113
2	"Risk management"	100
3	"Supply chain management"	62
4	"Supply chain"	49
5	"Supply chain risk"	25
6	"Supply chain risk management (SCRM)"	12
7	"Simulation"	10
8	"Risk analysis"	9
9	"Risk assessment"	9
10	"Supply chain disruption"	9
11	"Case study"	8
12	"Resilient supply chain"	8
13	"Risk"	8
14	"Risk identification"	7
15	"SCRM"	7
16	"Supplier selection"	7
17	"Decision making"	6
18	"Uncertainty"	6
19	"Chains"	5
20	"Conceptual framework"	5

Source: authors.

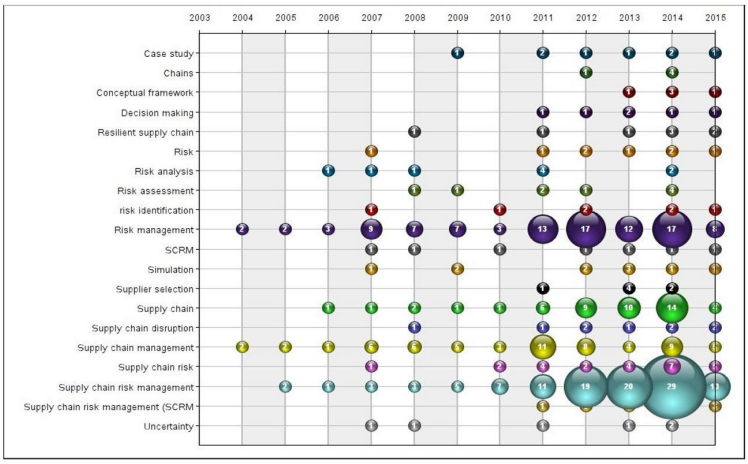

Figure 9. The 20 key word/expressions most often used in studies of SCRM, segmented by years of publication. Source: authors, using the VantagePoint® software.

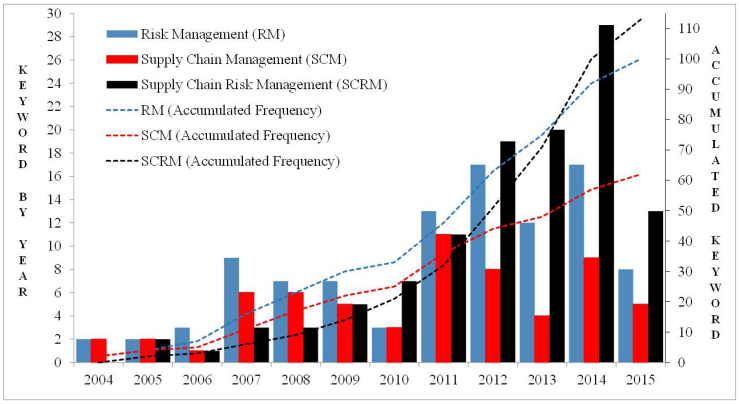

Figure 10. Evolution of the use of the three key expressions used the most to represent studies about SCRM. Source: authors.

a risk management model, pointing out the lack of specific literature on this subject.

The most cited articles of the first period are shown in Table 10, in descending order of quantity of citations.

In the second period (from 2010 to 2015), with the concept of SCRM already consolidated, authors developed more focused risk management researches, in lieu of multidisciplinary researches. Such phenomenon can be explained by the fact that the authors had already availability of massive and comprehensive literature, as well as academic maturity on the subject to make specific revisions on SCRM, instead of conducting multidisciplinary literature reviews, as

Table 9. List of the 20 periodicals that publish the most articles about SCRM.

Ranking	Periodicals	Number of Records
1	International Journal of Production Economics	14
2	International Journal of Production Research	14
3	Supply Chain Management: An International Journal	12
4	CrossTalk Magazine	9
5	The International Journal of Logistics Management	9
6	International Journal of Physical Distribution & Logistics Management	9
7	International Journal of Logistics Research and Applications	5
8	Journal of Risk Research	5
9	Betriebswirtschaftliche Forschung und Praxis	3
10	Business Process Management Journal	3
11	Computers & Industrial Engineering	3
12	Computers & Operations Research	3
13	ICIC Express Letters	3
14	Industrial Management & Data Systems	3
15	International Journal of Operations & Production Management	3
16	International Journal of Information Systems and Supply Chain Management	3
17	International Journal of Integrated Supply Management	3
18	International Journal of Retail and Distribution Management	3
19	International Journal of Services and Operations Management	3
20	Journal of Business Logistics	3

Source: authors.

Table 10. Top 20% most-cited articles in 2004-2009.

Article	Research outcomes
Manuj & Mentzer (2008a)	Explored the phenomenon of risk management and risk management strategies in global supply chains
Manuj & Mentzer (2008b)	Proposed a comprehensive risk management and mitigation model for global supply chains, based on concepts, frameworks, and insights from several disciplines
Wu & Olson (2008)	Compared three types of risk evaluation models within supply chains through simulated data
Goh et al. (2007)	Proposed a model for treating the multi-stage global supply chain network problems, incorporating risk minimization objectives
Wu et al. (2006)	Proposed an integrated methodology to classify, manage and assess inbound supply risk
Trkman & McCormack (2009)	Presented a new approach to the identification and prediction of supply risk, based on supplier's attributes and performances
Ritchie & Brindley (2007)	Proposed a risk management decision framework through the analysis of two cases
Finch (2004)	Presented a literature analysis to identify how small- and medium-size enterprises risk management works
Nagali et al. (2008)	Presented a case study to identify how a company perform the risk management

Source: authors.

observed by Olson & Wu (2011). Another fact is that the SCRM theme was explored in both qualitative and quantitative studies, confirming the complexity and comprehensiveness of the theme.

The most cited articles of this second phase are shown in Table 11, also in descending order of reported citations.

Based on the analysis of those publications, it is expected that future SCRM studies focused on risk management better practices, with work processes well defined, clearly explained and detailed for managerial application purposes. Such scenario would enable the SCRM to be recognized as a business strategy, carrying out proactive actions, with standards of excellence in its practices, making companies and supply chains more robust to face upcoming pressures and regulations, going beyond legal compliance. It is expected to see an increase in SCRM publications, based on a competitive and demanding scenario, technological progress and resources availability.

Table 11. Top 20% most-cited articles in 2010-2015.

Article	Research outcomes
Tang & Musa (2011)	Investigated the research development in SCRM
Sodhi et al. (2012)	Presented an empirical study relating supply chain operation factors to the risk management
Thun & Hoenig (2011)	Studied the supply chain risk management in the automotive industry
Giannakis & Louis (2011)	Developed a framework for multi-agent based decision support system for mitigation of risks supply chains
Jüttner & Maklan (2011)	Conceptualized supply chain resilience, related to SCRM
Christopher et al. (2011)	Studied how managers assess global sourcing risks across the entire supply chain and what actions they take to mitigate those risks
Tummala & Schoenherr (2011)	Proposed an approach for managing risks in supply chains
Schmitt & Singh (2012)	Demonstrated how system resilience help on reducing supply chain risks
Schmitt & Snyder (2012)	Demonstrated the importance of long-term risk analysis on supply chain
Blome & Schoenherr (2011)	Analyzed case studies to identify successful approaches by companies in dealing with risk management
Lavastre et al. (2012)	Performed an empirical study in French companies to identify how they manage their supply chain risks
Colicchia et al. (2010)	Identified a set of approaches for managing risk in globalised supply chains
Kern et al. (2012)	Developed a model for upstream supply chain risk management
Ghadge et al. (2012)	Analyzed the SCRM from a holistic systems thinking perspective by considering the different typologies evolved
Olson & Wu (2011)	Compared the performance of different risk management tools
Wieland & Wallenburg (2012)	Tested the hypothesis that SCRM helps supply chains to cope with vulnerabilities proactively and increases reactive agility
Khan et al. (2012)	Investigated the alignment between product design and the supply chain and how this alignment impacts on a firm's supply chain responsiveness and resilience
Yang & Yang (2010)	Analyzed the implications of the most-common actions to mitigate risks in the supply chains
Samvedi et al. (2013)	Quantified the risks in a supply chain, using a fuzzy AHP method
Vilko & Hallikas (2012)	Analyzed different components in a Finnish multimodal maritime supply chain in order to understand how its risk management works
Diabat et al. (2012)	Created a model which analyses the various risks involved in a food supply chain
Wu et al. (2013)	Developed a model for supply chain outsourcing risk management
Peng et al. (2014)	Proposed a simulation model to help managing supply chain risks
Grötsch et al. (2013)	Developed an empirical study to investigate SCRM proactive actions based on contingency theory
Hofmann et al. (2014)	Developed a multidisciplinary approach to understand what is and how risk management woks, related to the concept of sustainability

Source: authors.

Table 11. Continued...

Article	Research outcomes
Chen & Wu (2013)	Proposed a modified FMEA method and applies the AHP method to select new suppliers from the supply chain risk's perspective
Wagner & Neshat (2012)	Performed an empirical study to measure and and compare supply chain vulnerability for various categories of firms
Sawik (2011a)	Develop a computational program to support supplier selection based on risk assessment
Olson & Wu (2011)	Performed a literature review on SCRM
Tang et al. (2012)	Investigated how risk management works in an environment with specific variables
Thun et al. (2011)	Analyzes the SCRM in small and medium-sized enterprises in German automotive industry
Jia & Rutherford (2010)	Added a relational-cultural dimension to SCRM.
Govindan et al. (2014)	Correlated the green supply chain management to the supply chain risk management
Sawik (2011b)	Applied VaR and cVaR methods to help supply risk mitigation
Lin & Zhou (2011)	Investigated impacts of product design process on supply chain risk management
Chae (2015)	Studied the impact of social media Twitter on supply chain practices and risk management
Dani & Deep (2010)	Presented a case study of risk management in a food sector campany
Sun et al. (2012)	Presented a supplier-related risk management model
Ruiz-Torres et al. (2013)	Developed a risk mitigation model based on optimal allocation of demand across a set of suppliers
Ghadge et al. (2013)	Developed a framework for supply chain risk management and tested it using an industrial case study

Source: authors.

4.2 Main SCRM models

Jüttner et al. (2003) pointed out that events like the so-called "millennium bug", spikes in fuel prices, hoof and mouth disease in the United Kingdom and terrorist attacks in the United States reveal the vulnerability of modern supply chains. They reviewed the existing literature on supply chain vulnerability and risk management and compared the findings with the perceptions of managers of various industrial, retail and logistics firms, collected through interviews.

Aiming to establish an agenda for better understanding and future studies, they proposed four basic constructs: supply chain risk sources; risk consequences; risk drivers (e.g., globalization, the trend for outsourcing, etc.); and mitigating strategies, as shown in Figure 11.

Gaonkar & Viswanadham (2007) also proposed these same four basic constructs for managing supply chain risks. Cases of SC vulnerability were also noted by Norrman & Jansson (2004): flooding of the Daimler-Chrysler factory, fire at the factory of a key supplier of Toyota, sudden drop in demand of Cisco and failures in planning for future demand by Nike were some of the examples mentioned by the authors. They also presented the structure and processes implemented by Ericsson after a fire at the plant of one of its suppliers, which caused severe impacts on the company. The model used by that company is based on processes of risk identification; risk evaluation; risk treatment; and risk monitoring, with treatment of incidents and planning for contingencies as parallel actions.

Kleindorfer & Saad (2005) also described various examples of supply chain ruptures, such as the earthquake in Taiwan in 1999, the terrorist attack on the Twin Towers in 2001 and the blackout in the northeastern United States in 2003. The model proposed by the authors to manage the risk of disruptions and assure greater security of global supply networks includes the establishment of voluntary standards for security; classification of assets and processes in terms of vulnerability; ranking of efforts; and iteration for continuous improvement.

Harland et al. (2003) also pointed to the increasing complexity of products and services and rising outsourcing and globalization as factors making supply chains more complex and vulnerable, aspects also mentioned by Singhal et al. (2011). The latter authors proposed a tool to identify, evaluate and manage risks and tested it in four cases in the electronics industry. That tool, depicted in Figure 12, is divided into six blocks: supply network mapping (structure of the actors, metrics and responsibilities); identification of risks and their location (type and potential losses); risk evaluation (probability of occurrence, life cycle stage, exposure, possible triggers and potential

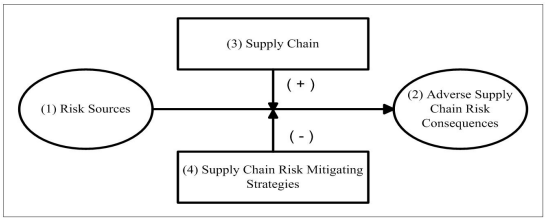

Figure 11. Basic supply chain risk management model. Source: Jüttner et al. (2003).

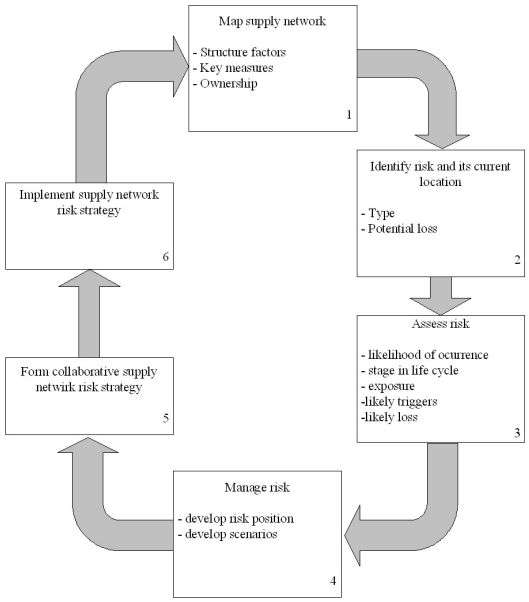

Figure 12. Supply network risk management tool. Source: Harland et al. (2003).

losses); risk management (developing risk positions and scenarios); collaborative strategy making to face SC risks; and strategy implementation.

Also mentioning the complexity of supply chains, Hallikas et al. (2004), Faisal et al. (2006) and Tuncel & Alpan (2010) argued that a typical risk management process is composed of risk identification, risk evaluation; decision and implementation of risk management actions, and risk monitoring.

The model proposed by Ritchie & Brindley (2007) takes a different approach, proposing five components: context of risks and their drivers; factors influencing risk management (including time frames and portfolio); decision makers (perceptions, profile, attitudes and experiences); responses to risk management (acceptance, avoidance, mitigation and monitoring); and final performance (related to profile, strategic positioning and personnel), as shown Figure 13.

In turn, Wu et al. (2006), focusing on the risks of inbound logistics, sought to identify risk factors, also through a literature review and interviews. They proposed a model to manage these risks composed of four components: classification of SC risks (internally controllable, partly internally controllable, internally uncontrollable, externally controllable, partly externally controllable, and externally uncontrollable); identification of risks in suppliers; calculation of risks by applying the analytic hierarchy planning (AHP) method (Saaty, 1994); and computer simulation (O'Kane et al., 2000).

Kern et al. (2012) also analyzed inbound logistics and proposed a model to manage the associated risks, composed of risk identification; risk evaluation; risk mitigation; and performance in facing risks, also examining the impact of the ongoing improvement process on these constructs, as shown in Figure 14.

Matook et al. (2009) focused on upstream risk management. They proposed a model composed of five components: identification of the risks in suppliers; evaluation of the risks in suppliers; reporting and decision regarding the risks posed by suppliers; responses for managing these risks; and measurement of the performance of suppliers in responding to risk.

Blome & Schoenherr (2011) also focused attention on suppliers, using multiple case studies in eight European enterprises to identify successful experiences and approaches, and developed a model for managing risks during financial crises. The proposed model contains the following steps for managing risks in supply chains and in the central company itself: risk identification; risk analysis; risk mitigation; and risk monitoring.

The analysis of risk management at moments of economic downturns was also the focus of the study by Giannakis & Louis (2011), who presented a model of a multi-agent system to support decisions on management of ruptures and mitigation of risks in manufacturing supply chains. The risk management process is composed of four stages: risk identification; risk evaluation; decision and implementation of risk management actions; and optimization.

Cohen & Kunreuther (2007), on the other hand, proposed a more detailed model SCRM, composed of: risk evaluation and analysis; risk modeling; formulation of risk management strategies; and evaluation of strategies, as can be seen in Figure 15.

Manuj & Mentzer (2008a), who unlike the authors of the previously mentioned articles, focused on global supply chains, indicated a process to manage and mitigate risks with this scope composed of five steps: risk identification (classified as supply, operations, demand and security); risk analysis and evaluation (analysis of decisions, case studies and support in perception); selection of appropriate risks to manage (i.e., the proposed strategy: avoid, postpone, speculate, limit, control, share/transfer and insure); implementation of strategies (having as facilitators management of complexity, organizational learning, information technology and performance indicators);

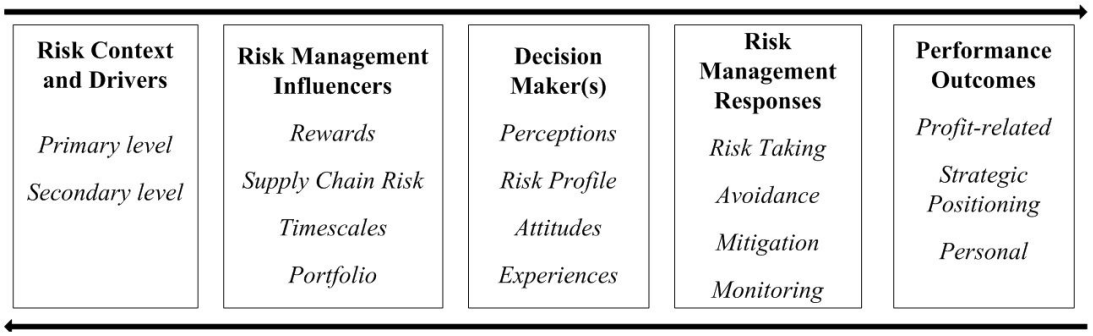

Figure 13. SCRM structure. Source: Ritchie & Brindley (2007).

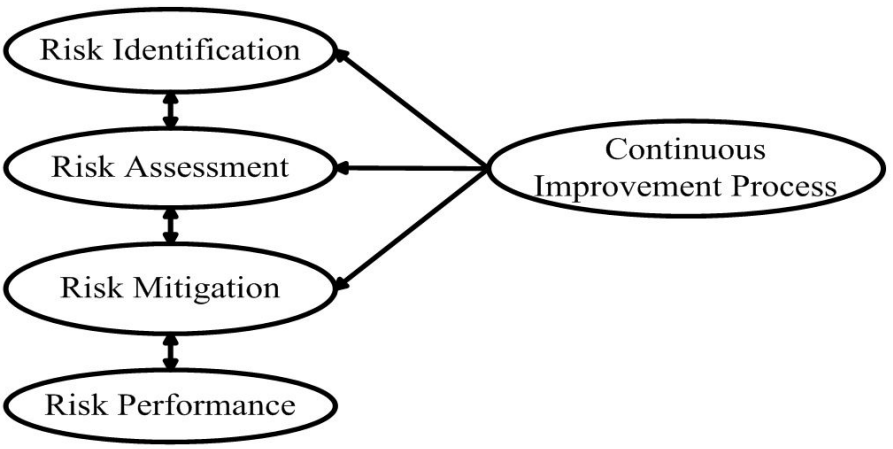

Figure 14. SCRM conceptual model. Source: Kern et al. (2012).

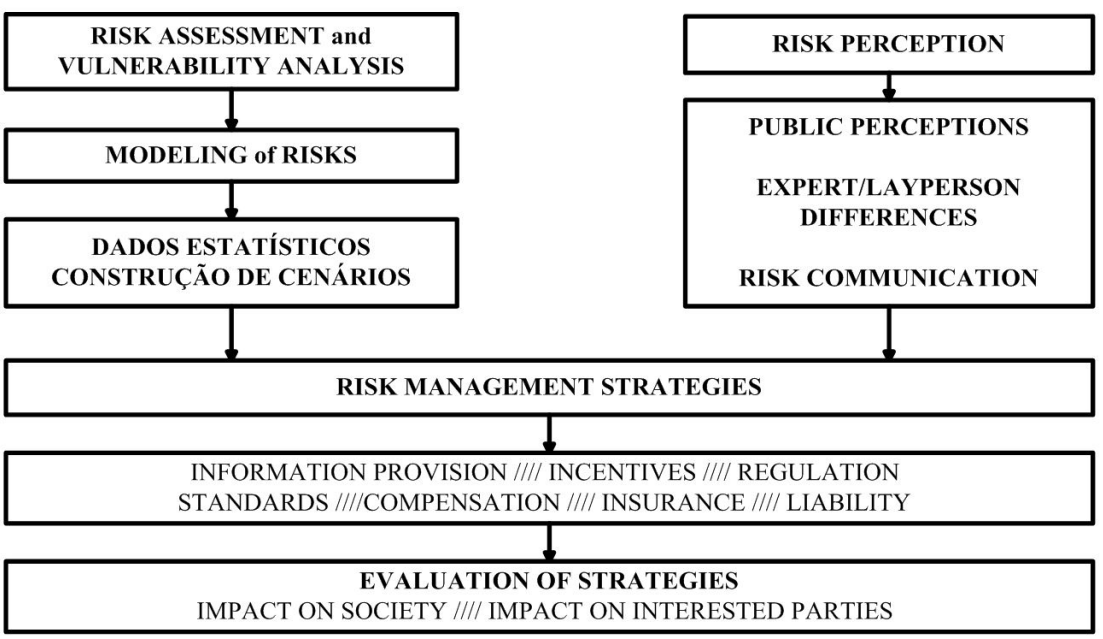

Figure 15. Conceptual structure for risk analysis. Source: Adapted from Cohen & Kunreuther (2007).

and risk mitigation (preparing for unforeseen events), as indicated in Figures 16 and 17.

4.3 Findings on the process of conducting SCRM and its steps

Analysis of the literature on SCRM indicated that the majority of researchers on the theme advocate that knowledge emerges as an important process in SCM, with the main objective of identifying the potential sources of risks and suggesting suitable measures to mitigate them.

Nevertheless, we also noted a lack of consensus among these same researchers regarding the steps that should be developed in SCRM, both the number and their actions. For example, Wu et al. (2006), Khan & Burnes (2007), Oehmen et al. (2009) and Singhal et al. (2011) all argue that SCRM should involve at least three steps, which differ in their procedures depending on the authors.

Other authors, like Hallikas et al. (2004), Kleindorfer & Saad (2005), Manuj & Mentzer (2008a) and Tummala & Schoenherr (2011), advocate different

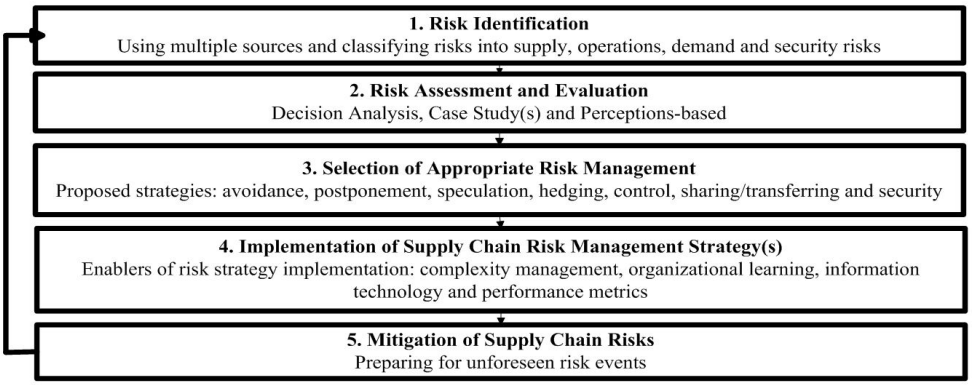

Figure 16. A five-step SCRM process. Source: Manuj & Mentzer (2008b).

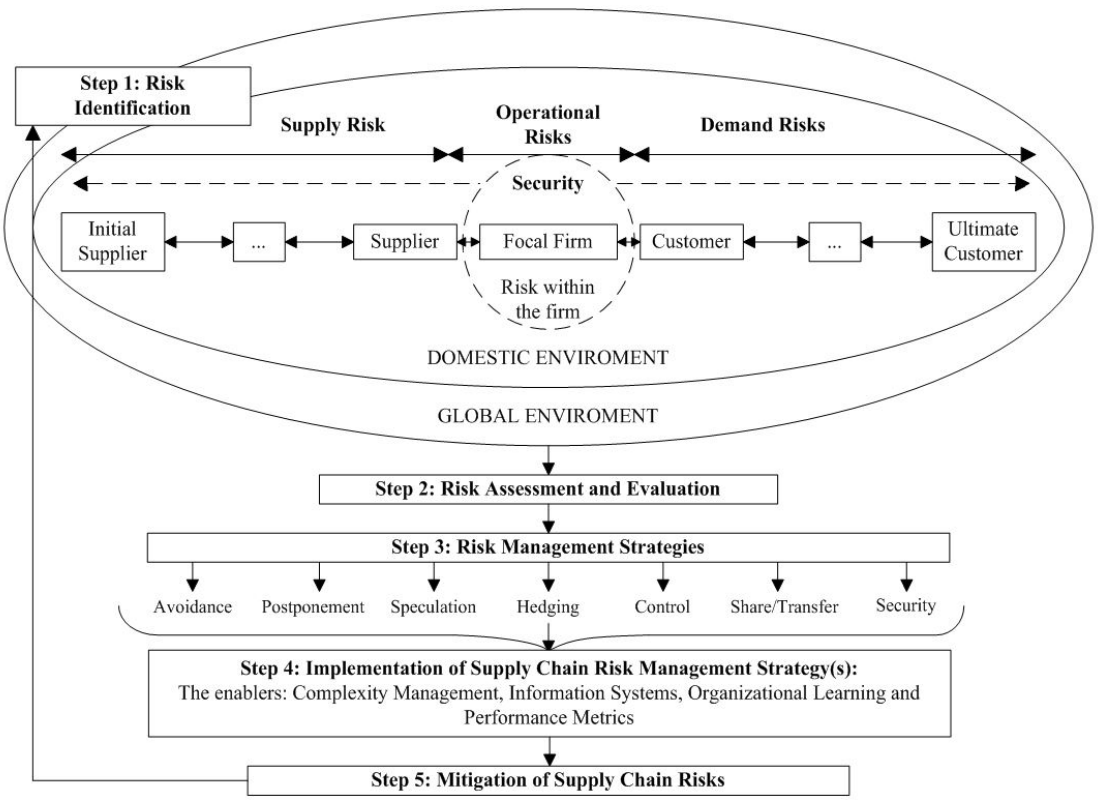

Figure 17. SCRM structure. Source: Manuj & Mentzer (2008b).

procedures, with more than three steps. In this respect, Ritchie & Brindley (2007) urge the use of seven steps for supply chain risk management. Chart 1 presents a summary of these findings, based on the works of 23 groups of authors who have addressed the steps of SCRM.

As is intuitive, the problems in supply chains do not always present the same demands, and hence the same solution methods. Nevertheless, analysis of Chart 1 shows that:

- 86.96% of the works mention the "Identification of Risks" as a step;
- 82.61% mention "Assessment of Risks" as a step;
- 60.87% mention "Proposal of Strategies" as a step; and
- 56.52% mention "Mitigation of Risks" as a step.

In light of this, the question arises: Why is "Control of Risks" not judged more relevant for SCRM? This question is justified because only 30.43% of the articles analyzed mention this step.

Although our focus is not on analyzing the intrinsic definition of each of the steps indicated in Chart 1, we assume that some of these steps are only variants with

Chart 1. Steps suggested for SCRM by various authors who have studied the theme.

Chronological Order	Researchers on SCRM	List of the steps for SCRM												
		Identification of the risks	Assessment of the risks	Proposal of strategies	Mitigation of risks	Monitoring of risks	Control of risks	Measurement of the consequences of risks	Identification of the sources of risks	Measurement of the results	Identification of the risk factors	Measurement of the risks	Process of ongoing improvement	Mapping of indicators
1	Jüttner et al. (2003)		X		X	X			X					
2	Harland et al. (2003)	X	X	X				X						X
3	Hallikas et al. (2004)	X	X		X	X	X							
4	Norrman & Jansson (2004)	X	X	X		X								
5	Kleindorfer & Saad (2005)		X	X	X				X					
6	Zsidisin et al. (2005)	X	X	X			X							
7	Wu et al. (2006)	X			X							X		
8	Faisal et al. (2006)	X	X		X	X								
9	Khan & Burnes (2007)	X		X				X						
10	Ritchie & Brindley (2007)	X		X		X	X		X	X	X			
11	Gaonkar & Viswanadham (2007)		X	X				X	X		X			
12	Cohen & Kunreuther (2007)	X	X	X	X			X		X				
13	Manuj & Mentzer (2008a)	X	X	X	X			X						
14	Matook et al. (2009)	X		X			X			X				
15	Oehmen et al. (2009)	X	X		X									
16	Tuncel & Alpan (2010)	X	X	X		X								
17	Giannakis & Louis (2011)	X	X	X	X		X							
18	Tummala & Schoenherr (2011)	X	X		X	X	X					X		
19	Blome & Schoenherr (2011)	X	X		X		X							
20	Guo (2011)	X	X	X		X								
21	Singhal et al. (2011)	X	X		X									
22	Kern et al. (2012)	X	X		X					X			X	
23	Rangel et al. (2015)	X	X	X		X								
TOTAL BY STEP		20	19	14	13	09	07	06	04	04	02	02	01	01

Source: authors.

the same basic meaning, such as "Monitoring of Risks" and "Control of Risks". That analysis is no more than a supposition, because of the 23 studies, three do not agree with this observation, by considering these steps as being complementary (Hallikas et al., 2004; Ritchie & Brindley, 2007; Tummala & Schoenherr, 2011). Therefore, further research is necessary on this question.

Another important aspect is "how" to carry out each step of SCRM, i.e., what "tools", "techniques", "approaches" and "procedures" should be used, for example, to "identify", "assess", "mitigate" and "monitor" the risks to supply chains. The majority of the 248 articles analyzed in this study do not "teach" readers, be they business executives or other researchers, "how" to conduct SCRM.

4.4 Recommendations for future research into SCRM

In this step, we used the 248 articles surveyed to note the suggestions for future research made by the authors, as shown in Table 12. The purpose of this table is to guide potential researchers about topics that have yet to be analyzed (gaps) in the relevant literature, but that have been mentioned as important in the respective articles.

To delimit the results presented in Table 12, we mention that we did not investigate whether any of the recommendations became themes of other studies, so it is likely that some of these suggestions have been examined by other researchers.

Table 12. Recommendations for future research into SCRM, in chronological order.

Article	Recommendations
Norrman & Jansson (2004)	Study the relationship between supply chain risk management and the principles of supply chain logistics management.
Wu et al. (2006)	Explore the method in more companies, using historical data.
Faisal et al. (2006)	Evaluate the proposed model from a statistical standpoint.
Goh et al. (2007)	Apply the model in a large-scale supply chain.
Ritchie & Brindley (2007)	Concentrate less on the components of the proposed framework and more on the dynamics of interaction between them.
Autry & Bobbitt (2008)	Continue studies about SCSO (supply chain security orientation).
Manuj & Mentzer (2008a)	Refine and test the proposed model with quantitative and qualitative data about different industries.
Manuj & Mentzer (2008b)	Identify how the model proposed in the article is related to the performance of supply chains.
Williams et al. (2008)	Develop the research suggested in the article about risk management strategies.
Ojha & Gokhale (2009)	Assess the financial and operational impact of the model proposed in the article.
Manuj et al. (2009)	Use other simulation tools and other approaches to the proposed study.
Trkman & McCormack (2009)	Prepare an article with multiple case studies involving not only suppliers of a local firm, but also the suppliers of those suppliers.
Sodhi & Tang (2009)	Use Monte Carlo analysis as another approach for the model in the article.
Pujawan & Geraldin (2009)	Take into consideration the interdependency of the variables used in the study.
Moeinzadeh & Hajfathaliha (2009)	Reproduce the study using other methods and techniques; explore more cases and conduct more empirical studies using the proposed model.
Jüttner & Maklan (2011)	Utilize more case studies; approach the theme from other perspectives.
Olson & Wu (2011)	Utilize real data from a specific organization to test the model in practice.
Tummala & Schoenherr (2011)	Investigate how the information on the internal system of firms can be used to feed the model proposed in the article.
Giannakis & Louis (2011)	Perform simulations to assess the performance of the proposed framework.
Sawik (2011a)	Utilize different approaches for the proposed model.
Thun & Hoenig (2011)	Utilize the same method in companies in other sectors, including an international study.
Blome & Schoenherr (2011)	Replicate the study in other industries in other countries; conduct a large-scale international study.
Sawik (2011b)	Increase the size of the sample and the number of variables used to apply the model.
Tse et al. (2011)	Test the model proposed in the article empirically.
Sodhi et al. (2012)	Carry out the same study in other companies in different contexts.
Lockamy & Mccormack (2012)	Examine supply risk profiles and supply networks by the Bayesian network method.

Source: authors.

Table 12. Continued...

Article	Recommendations
Kern et al. (2012)	Replicate the study on a global scale, gathering information on the participating companies from various sources.
Khan et al. (2012)	Conduct similar case studies to compare the level of alignment of the supply chain, analyzing this information from the perspective of risk management.
Wieland & Wallenburg (2012)	Test the proposal of the study empirically; analyze industries in other countries.
Schmitt & Snyder (2012)	Perform a case study comparing two suppliers: one using the method proposed by the article and the other using a different method.
Schmitt & Singh (2012)	Apply the proposed method to other types of industries.
Tang et al. (2012)	Investigate the pricing policy of a company and its influence in a system containing two substitute products.
Kumar & Harrison (2012)	Apply the proposed model more deeply and help firms that want to invest in strategies for a rupture contingency plan.
Vilko & Hallikas (2012)	Collect more data on companies and include more geographic locations; analyze qualitative and financial factors of risks and their effects in the context of supply chains.
Wever et al. (2012)	Take into consideration the structure of the supply chain.
Liew & Lee (2012)	Include other raw materials in the analysis proposed by the article; study the efficiency of risk management in mitigating the risk of price fluctuations of raw materials.
Aloini et al. (2012)	Conduct case studies to support the discoveries from analysis of the literature in question.
Son & Orchard (2013)	Conduct comparative studies where only some firms are exposed to the proposed mode and others not.
Ghadge et al. (2013)	Apply the model in multiple companies instead of just one.
Ekwall & Lantz (2013)	Utilize other data sources and develop a multidisciplinary approach.
Golgeci & Ponomarov (2013)	Perform new studies on the relationship of the concept of innovation with risk management.
Ruiz-Torres et al. (2013)	Analyze more complex supply chains and consider other variables in the analysis of suppliers.
Wu et al. (2013)	Expand the scope of the study and include more variables in the analysis.
Chen & Wu (2013)	Give more attention to the supplier selection criteria used by firms; utilize other methods to learn whether they generate similar results to those of the article.
Urciuoli et al. (2014)	Develop new risk management tools; utilize simulations and mathematical approaches besides case studies.
Vilko et al. (2014)	Empirically test the arguments presented in the article and perform qualitative studies to explore the various types of processes related to reaching decisions faced with different levels of uncertainty.
Liu et al. (2014)	Consider other types of vehicles in the analysis; study the same topic using different methods; perform a study using real data.
Cantor et al. (2014b)	Evaluate the proposed model from a statistical perspective and expand the research regarding the number of companies studied.
Peng et al. (2014)	Collect the opinions of specialists on logistics planning through questionnaires.
Benedek et al. (2014)	Continue the study covering other points of view in different companies.
Hofmann et al. (2014)	Focus studies on companies that have had success in managing their risks relate to the concept of sustainability.
Manuj et al. (2014)	Develop complementary methods outside the simulated environment; increase the number of variables considered.
Cantor et al. (2014a)	Consider other variables, to deepen the study presented in the article.
Chan et al. (2015)	Test the proposed method in other supply chains.
Marija et al. (2015)	Utilize the same method in other firms to compare with the results presented in the article.
Davarzani et al. (2015)	Conduct empirical studies to test the proposal of the article.
Nooraie & Parast (2015)	Increase the number of contextual and organizational variables considered.
Mizgier et al. (2015)	Apply the model presented in a real case; consider a larger number of variables.

Source: authors.

Table 12. Continued...

Article	Recommendations
Li et al. (2015)	Investigate other practices to identify risks; use other theories in the same context as that of the article.
Chae (2015)	Increase the number of keywords used in the study; increase the number of studies relating supply chains with social networks.
Rajesh & Ravi (2015)	Increase the number of case studies to validate the study; use computer programs to help build models.
Yu et al. (2015)	Apply empirical tests of the theory presented.
Kilubi & Haasis (2015)	Carry out more studies relating risk management with the performance of supply chains.

Source: authors.

5 Conclusions

This survey analyzed 248 articles published about SCRM obtained from five databases (Scopus, Web of Science, Science Direct, Emerald Insight and Ingenta Connect), employing the research profiling technique, applied with the VantagePoint® software. The study covered only articles in English-language periodicals, published from 2004 until the end of 2015. The data were gathered in March 2016, and of the 543 works initially obtained (see Table 1), 295 were dropped because of overlap between two or more of the databases.

By responding to the questions (i) Who are the most productive authors? (ii) What periodicals publish the most articles in the area studied? (iii) What institutions are most productive? (iv) What countries are most representative in the production in the area? (v) Who are the most referenced authors? (vi) What are the most referenced periodicals? (vii) What years have seen the largest number of citations? (viii) When were the largest volume of articles in the area published? and (ix) What keywords are most used?, this study achieved its main objective, of mapping the field of research in the area of SCRM.

We hope that the results presented here will save time and contribute to advances in research and learning about SCRM, for example:

- By knowing that the institution that is most active in publication on this subject is the University of North Texas, people interested in the theme can seek to develop research projects with members of this university;
- By knowing that the leading authors in terms of number of publications are Backhurst (six articles), Samvedi (five articles) and Wagner, Ekwall, Khan, Manuj and Olson (four articles each), students/researchers of the theme can seek guidance from and/or partnerships with these authors;
- By knowing that the most used key expressions on the theme are "Supply Chain Risk Management", "Risk Management" and "Supply Chain Management", researchers into SCRM can use these in their searches of databases;
- By knowing that the periodicals that have published the most articles are *International Journal of Production Economics*, *International Journal of Production Research* and *Supply Chain Management: An International Journal*, companies that are interested in knowing more about SCRM can start their searchers in these periodicals;
- By knowing that the most cited authors are, in this order, Christopher, Tang, Chopra and Zsidisin, researchers interested in SCRM can give priority to analyzing studies by these authors; and
- By knowing that of the 248 articles found in five databases, that 95% are in Scopus or Web of Science, those interested in the subject can concentrate their research in these bases.

Besides these results, we observed that: (i) 75% of the publications about SCRM are concentrated in the last five years of the period analyzed (2011-2015); (ii) the authors most often cited are not those who have published the most articles on the subject; (iii) the three most-cited periodicals are together responsible for nearly a third of all the citations (of the 20 most cited); and (iv) the countries with the most publications are the United States, with 69 publications, and China, with 37 (these two countries together account for more than 40% of the publications on SCRM).

Another relevant contribution is the development of Table 12, in which we summarize the authors' recommendations for future research. Although this step of the survey is a bibliographical review instead of research profiling, we believe it is pertinent to

present it, since our intention here is to contribute to the development of research into SCRM. We believe Table 12 can help researchers interested in studying the theme to choose new avenues for analysis.

This study makes a particular contribution to the conduction of future research on SCRM. In this context, we performed an analysis of how the authors on the subject have proposed to carry out SCRM. During the bibliographic review, we found a lack of consensus among the 23 authors who have addressed the steps of SCRM in their articles. Some researchers have described three steps for SCRM while others have urged up to seven steps. Because of this lack of standardization, Chart 1 points to 13 "different" steps to carry out SCRM. We assume, however that after more thorough studies about the content of these authors' articles, considering how each article defined each proposed step, it will be possible to harmonize these 13 steps into a smaller number. To corroborate or refute this assumption, we recommend this be a topic for future research into SCRM.

Finally, based on the analysis of the 248 articles surveyed, it is expected that future SCRM studies focused on risk management better practices, with work processes well defined, clearly explained and detailed for managerial application purposes.

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