A COMPARATIVE ANALYSIS OF SUPPLY NETWORK RISK MANAGEMENT TECHNIQUES BASED ON SYSTEMATIC LITERATURE REVIEW

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RESUMO

Redes globais de suprimentos requerem a coordenação precisa dos fluxos de matérias-primas, produtos acabados, recursos financeiros e informações. Operações globais buscam maximizar o lucro da rede através da melhor utilização dos ativos (insumos, recursos produtivos, pessoas e infraestrutura) e da utilização de condições favoráveis da economia e política globais. A natureza dinâmica nas relações entre os diversos agentes numa rede de suprimentos evidencia a necessidade de uma abordagem adequada para gestão de riscos. Nesse contexto, o conhecimento e a correta aplicação de técnicas de gestão de riscos em redes de abastecimento pode tornar-se vantagem competitiva num ambiente globalizado. O objetivo deste trabalho é apresentar uma revisão das abordagens de gestão de riscos existentes na literatura e avaliar suas aplicabilidades em operações de redes de suprimentos. A metodologia utilizada foi a revisão sistemática com meta-síntese, no intuito de identificar lacunas e oportunidades nesta recente área de pesquisa.

ABSTRACT

Global supply networks require a precise coordination of flows of raw materials, finished goods, information and financial resources. Global operations seek to maximize profits in the supply chain through the best use of productive assets (inputs, production resources, labor and infrastructure) and favorable economic and political global conditions. The dynamic nature of relationships between the various links in the supply chain increases its variability to disturbances. Thereby, there is a need for an appropriate approach to risk management. The knowledge of key techniques of supply network risk management and its correct application is an advantage to enhance the competitiveness of global supply network operations. The aim of this paper is to present a review of technical approaches to risk management and evaluate their applicability in supply network operations. In order to identify the gaps and the research opportunities was used the systematic literature review with meta-synthesis.

1. INTRODUCTION

Global supply networks require a precise coordination of flows of raw materials, finished goods, information and financial resources. Global operations seek to maximize profits in the chain through the best use of productive assets (inputs, production resources, labor and infrastructure) and favorable economic and political global conditions (Manuj and Mentzer, 2008b).

The implementation of innovative management strategies adds a competitive edge in global operations. There are lots of challenges to management complex supply chain processes: the coordination of transportation planning for dealing with the long lead times, the outsourcing of products and services, the reduction of inventory levels through just in time (JIT), collaboration with suppliers located on several continents, network re-design, ability to quick response changes in demand or supply, etc.. All of these points become the organizations and supply network partners more vulnerable to events or situations not covered in the planning stages (Christopher et al., 2011).

Events like natural disasters, closure borders between countries for political-economic or public-health reasons, suppliers' delivery failures of raw materials and components, and so on, have shown the vulnerability of supply networks in a global environment. To address this risk exposure it becomes necessary to use adequate approaches for risk management in global supply networks. Especially for transportation operations as responsible to integrate all the links in the global networks (Hallikas *et al.*, 2004).

Global supply network risk management consists of the identification and evaluation of risks and consequent losses in a global environment, and the implementation of appropriate strategies, through a coordinated approach between network partners, to mitigating these losses and to ensure the supply network outcomes (Manuj and Mentzer, 2008a).

The main discussions in the literature address two issues: first, the vulnerability in the supply network processes (supply, demand, product, information and transportation management) increased by competitive pressure and the market globalization; second, the impact from natural disasters in global supply networks (Wagner and Bode, 2008).

These issues motivated publications presenting frameworks that aim to identify, classify and manage risks in global supply networks. This paper proposes to analyze these works using the systematic literature review method and presents the gaps and the research's opportunities for this new research field. Section 2 presents the methodology adopted and defines the main points of this work. Section 3 shows the results from the literature review analysis. Finally, in section 4, the conclusions and opportunities for future research will be presented.

2. METHODOLOGY

The methodology used in this work was the systematic literature review with meta-synthesis. This approach suggests a procedure for carrying out the literature review covering six steps (Kodali and Soni, 2011):

Step 1: Define the research question, giving the drivers for the literature review. It must be clear and concise;

Step 2: Set the search's strategy - define the databases and search period;

Step 3: Define the criteria for inclusion or exclusion – choose the appropriate keywords for the selection of the papers;

Step 4: Search the articles – select the first group of papers according to the strategy (Step 2) and based on criteria of inclusion/exclusion (Step 3);
Step 5: Analyze the papers – a deep review of the papers selected in the Step 4, considering only the works that are related with the research question (Step 1) and classified in accordance to the following categories:

a) *Structure* – layer or level of planning (strategic, tactical or operational) that encompasses the risk management technique applied;

b) *Flows* – which type of flows (information, material or resources) were considered into the technique used;

c) *Finality* – classification under the type of risk considered: internal or external (Olson and Wu, 2010);
   - Internal:
     - Available capacity: capacity cost, financial capacity/insurance, ability to increase production, structural capacity, supplier bankruptcy;
     - Internal operation: forecast inaccuracy, safety (worker accidents), bullwhip effect, agility/flexibility, holding cost/order fulfillment tradeoff, on-time delivery , quality;
     - Information system: breakdowns, distorted information, integration, viruses/bugs/hackers.
   - External:
     - Nature: natural disaster(flood, earthquake, tsunami, volcano eruption), plant fire, diseases, epidemics;
     - Political system: war, terrorism, labor disputes, customs and regulations;
     - Competitor and market: price fluctuation, economic downturn, exchange rate risk, consumer demand volatility, customer payment, new technology, changes in competitive advantage, obsolescence, substitution alternatives.

d) *Degree of relationship* – considers the scope of the network's links analysis: internal (inside organization), immediate (until first tier) and expanded (until second tier);

e) *Technical approach* – what kind of technical approach used: qualitative or quantitative.

Step 6: Present the results – the final results of the analysis, highlighting the journals and authors whom most contribute with the research topic, presenting gaps and future research opportunities.

Figure 1 details the definitions for all the steps according with the described methodology.

In the next section will be presented the final results from the critically examination of the papers in order to show the major findings, regarding the authors and the journals, and the gaps identified.

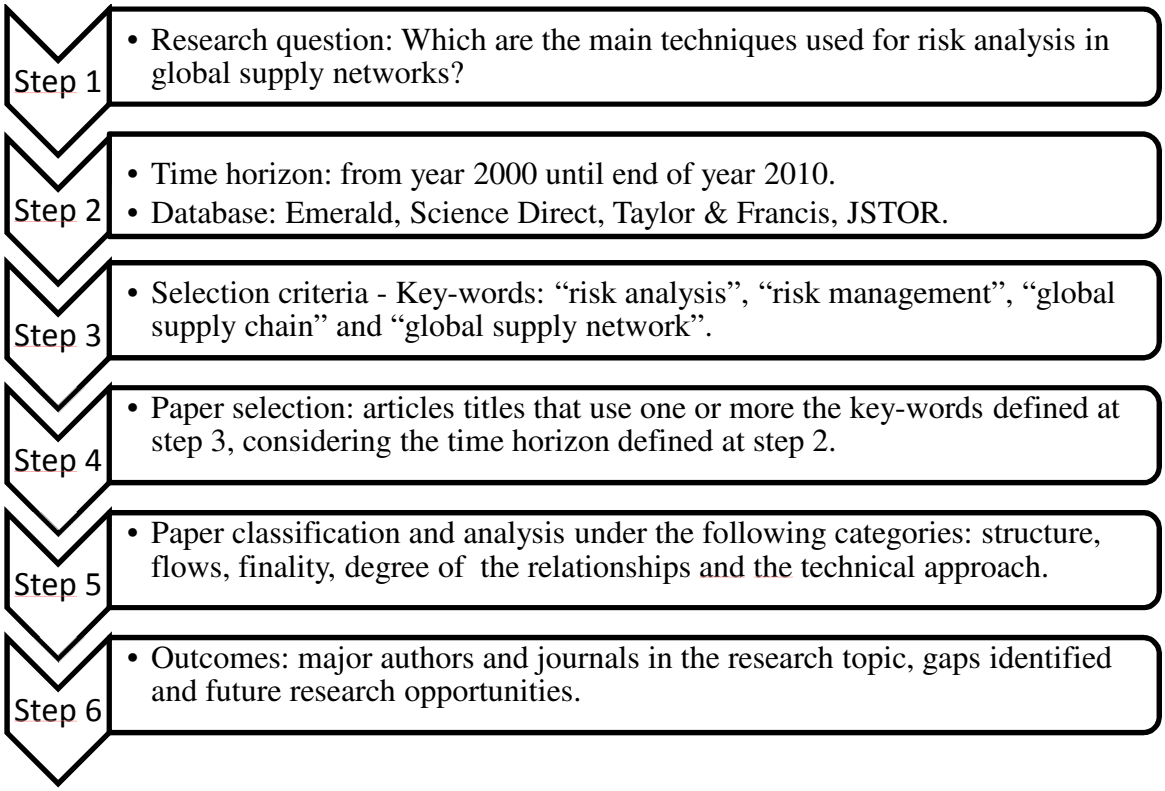

Figure 1: Methodology approach for the systematic literature review (adapted from Kodali and Soni, 2011).

3. RESULTS

As a result applying the methodology, were selected 63 works at step 4. At step 5, during the deep analysis, were defined 5 categories (as detailed in Section 2) to identify the most appropriate works that address the research question (step 1). Finally, 31 papers related were achieved and all of them were analyzed. Table 1 shows the journals' publications per year.

In the last five years were published approximately 75% of the papers concerning technical aspects of network / supply chain risk management. Certainly, this evidence shows the importance of this new research field. Moreover, at least three special issues about risk management were edited by important journals: POM - Production and Operations Management (2005), JSTOR - The Journal of the Operational Research Society (2007) and PPC - Production Planning & Control (2009).

Table 2 shows the representative authors and the analysis of network risk management techniques among the selected papers, according with the five categories (structure, flows, finality, degree of the relationships and technical approach).

Table 1: Papers published per journals per year.

	Journal	Papers per year											Total
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	31
1	Business Process Management Journal	0	0	0	0	0	0	0	0	0	1	0	1
2	Computers in Industry	0	0	0	0	0	0	1	0	0	0	0	1
3	Interfaces	0	0	0	0	0	0	0	0	1	0	0	1
4	International Journal of Operations & Production Management	0	0	0	0	0	0	0	1	0	1	0	2
5	International Journal of Physical Distribution & Logistics Management	0	0	0	0	1	0	0	0	1	0	0	2
6	International Journal of Production Economics	0	0	1	0	1	0	1	0	0	0	0	3
7	International Journal of Risk Assessment & Management	0	0	0	0	0	0	0	0	1	0	0	1
8	Journal of Manufacturing Technology Management	0	0	0	0	0	0	1	0	0	0	0	1
9	Journal of Operations Management	0	0	0	0	0	0	0	0	0	3	0	3
10	Management Research News	0	0	0	0	0	0	0	0	1	0	0	1
11	Production and Operations Management	0	0	0	0	0	3	0	0	0	0	0	3
12	Production Planning & Control	0	0	0	0	0	0	0	0	0	4	0	4
13	Strategic Outsourcing: An International Journal	0	0	0	0	0	0	0	0	1	0	0	1
14	Supply Chain Management: An International Journal	1	0	0	0	0	0	0	0	1	1	0	3
15	The Journal of the Operational Research Society	0	0	0	0	0	0	0	4	0	0	0	4

For the structure category, the most of risk management technics were considered, at least, in two levels of planning simultaneously (strategic-tactical-operational: 29%; tactical-operational: 26% and strategic-tactical: 13%). Around 30% of the papers treated only with the tactical level and 3% only with strategic level. None of the works looked upon operational level alone.

Concerning the flows category, almost all the papers dealt with two kinds of flow (material-information-financial: 68% and material-information: 29%). About the finality category, the majority of the works considered the impacts of internal and external risks (70%). In terms of the relationship's degree, the most of the technics applied looked until to the first tier inside the supply chain (71%). Nearby 29% treated until the second tier of entire supply network. At last, regarding the technical approach category, 58% corresponded to qualitative approach, 22% to quantitative and 20% used both approaches (qualitative and quantitative).

Thereby, from the results presented, some important gaps were identified. First, few approaches considered simultaneously the three planning levels. To achieve the best practices, these three layers must have to be considered in an integrated way. This is an important issue to succeed a reliable management for the entire supply network.

Second, concerning the relationships in global supply networks, the risk management process should be able to deals with all agents or partners in the network. Thus, the main risks could be mapped, measured and managed. In particular, in transportation processes, some aspects like the selection of the mode of transport (maritime, rail, road, air, etc.) should impact the level of risk management decisions.

The last gap recognized was regarding the lots of qualitative techniques used. The qualitative approaches should be useful to identify, map and classify the risks within a global supply network. However, should be necessary to analyze some scenarios to define the trade-off between management decision variables (e.g. stock levels through the network) and the risks taking assumptions. Therefore, combining the qualitative and quantitative techniques would generate the best approach for risk management in global environments.

Table 2: Relevant authors and the analysis of network risk management technics among the selected papers (based on the five categories)

	Author(s)	Technical Approach	Structure	Flows	Finality	Degree of Relationships
1	Zsidision et al., 2000	Qualitative	Tactical	Materials and Information	Internal and External Risks	Immediate
2	Hallikas et al., 2002	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal Risks	Expanded
3	Norrman and Jansson, 2004	Qualitative	Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Expanded
4	Hallikas et al., 2004	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Expanded
5	Gan et al., 2005	Qualitative	Tactical	Materials, Informations and Financial	Internal Risks	Immediate
6	Kleindorfer and Saad, 2005	Qualitative	Tactical	Materials, Informations and Financial	Internal and External Risks	Expanded
7	Sodhi, 2005	Quantitative	Tactical	Materials and Information	Internal and External Risks	Immediate
8	Wu et al., 2006	Quantitative and Qualitative	Tactical	Materials and Information	Internal and External Risks	Immediate
9	Cucchiella and Gastaldi, 2006	Quantitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
10	Tang, 2006	Quantitative and Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Expanded
11	Ritchie and Brindley, 2007a	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Expanded
12	Ritchie and Brindley, 2007b	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
13	Haksöz and Seshadri, 2007	Quantitative	Tactical	Materials, Informations and Financial	Internal Risks	Immediate
14	Tapiero and Kogan, 2007	Quantitative	Strategic	Materials, Informations and Financial	Internal Risks	Immediate
15	Datta et al., 2007	Quantitative	Tactical and Operational	Materials and Information	Internal Risks	Expanded
16	Nagali et al., 2008	Quantitative	Tactical	Materials, Informations and Financial	Internal Risks	Immediate
17	Li and Barnes, 2008	Qualitative	Tactical	Materials and Information	Internal and External Risks	Immediate
18	Micheli et al., 2008	Qualitative	Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
19	Ellegaard, 2008	Qualitative	Strategic and Tactical	Materials, Informations and Financial	Internal and External Risks	Immediate
20	Kara and Kayis, 2008	Quantitative and Qualitative	Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
21	Manuj and Mentzer, 2008	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
22	Matook et al., 2009	Qualitative	Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
23	Pujawan and Geraldin, 2009	Quantitative and Qualitative	Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
24	Blos et al., 2009	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Immediate
25	Braunscheidel and Suresh, 2009	Quantitative and Qualitative	Strategic and Tactical	Materials and Information	Internal and External Risks	Immediate
26	Knemeyer et al., 2009	Qualitative	Strategic and Tactical	Materials and Information	Internal and External Risks	Immediate
27	Neiger et al., 2009	Qualitative	Strategic and Tactical	Materials, Informations and Financial	Internal Risks	Immediate
28	Xiea et al., 2009	Quantitative and Qualitative	Tactical and Operational	Materials and Information	Internal Risks	Immediate
29	Yang et al., 2009	Quantitative	Tactical and Operational	Materials and Information	Internal Risks	Expanded
30	Oehmen et al., 2009	Qualitative	Strategic, Tactical and Operational	Materials, Informations and Financial	Internal and External Risks	Expanded
31	Wu and Olson, 2009	Qualitative	Tactical	Information	Internal Risks	Immediate

4. CONCLUSIONS

During the last ten years many researches regarding risk analyses for supply networks were developed. In an effort to consolidate this knowledge, this paper examined a representative sample of works executed to risk management in supply networks, using a systematic review with meta-syntheses methodology.

As a recent research's field some gaps were identified and some opportunities could be addressed as for future researches. In this way, some suggestions will be highlighted:

- Consolidate the best approaches for risk analysis for global supply networks;
- Develop an comprehensive conceptual approach for risk management in global supply network, considering the integration of the three planning levels and all the relationships among the members of the supply network;
- Develop simulations models, integrated with the holistic conceptual approach that could be applied for risk analysis considering internal and external risks and the dynamic variables of the global environment;
- Identify the interfaces and the specific risks between transportation operation and the others process in a global supply network;
- Investigate the influence of intangible aspects in supply network risk management (e.g. the organizations' brand impacts, environmental impacts, etc.) and how they could be quantified and applied to the simulation scenario analysis.

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