SUPPLY CHAIN FLEXIBILITY: A REVIEW OF THE ACADEMIC LITERATURE

Although Supply Chain Risk Flexibility (SCF) has become more popular over the last decade, attempts to synthesize research within this field have seldom been conducted. Aiming to fulfill part of this gap, this paper presents a systematic review of the literature on SCF using a content analysis approach. Two important electronic data bases were used in this process (Science Direct - Elsevier and Emerald Insight). In pseudo code, the following phrase was adapted to the search engines in each database: “Supply chain Flexibility” using as reference the title, abstracts and keywords of the papers. Thirty papers published between 1998 and 2013 in 19 peer reviewed international journals have been retrieved. Interest in the subject is growing, as evidenced by the number of papers recently published on different aspects of SCF reaching a pick in 2012. The paper provides a discussion of main definitions available, although there is no universal definition of the concept. The collected papers are classified in the theoretical, empirical and theoretical empirical dimension, allowing a reasonable comprehensive assessment of research approaches taken in the current body of literature on the subject. The results highlight the high number of definitions for SCF, the main topics in SCF research and research applications, identify the key issues addressed in these researches, and emphasise remaining gaps that deserve special attention in future research.

Keywords: flexibility; supply chain, content analysis approach
1 Introduction

Systematic literature reviews are a means of providing an objective theoretical evaluation of a particular topic (Hopayian, 2001) that facilitates the identification, evaluation, and interpretation of studies by examining existing concepts, practices, and theories and ultimately summarising the state of the reproducible research in a specific area (Rowley and Slack, 2004; Seuring and Müller, 2008).

Although Supply Chain Flexibility (SCF) has become more popular over the last decade (Stevenson and Spring, 2007, Stevenson and Spring 2009; Merschmann and Thonemann, 2011), attempts to synthesize research within this field have seldom been conducted. Aiming to fulfill part of this gap, this paper presents a systematic review of the literature on SCF using a content analysis approach. The research is restricted to papers published in academic journals between 1998 and the first quarter of 2013.

This paper is divided into four main sections, the first of which this introduction. Section 2 describes the research method used. Section 3 presents the analysis of results. Finally, the last section offers the authors’ final remarks.

2 Research method

This literature review adopts the content analysis approach to develop, what allows researchers to select, filter, and summarise large volumes of data, thereby facilitating data analysis (Gao, 1996), being a systematic technique that is replicable by other researchers as it is based on explicit rules (Weber, 1990).

The review examines publications found in the Elsevier and Emerald electronic databases, technique that facilitates objective and systematic inference (Holsti, 1969), that were published between 1998 and the first quarter of 2013. The data gathered for this review was exclusively from scientific journals, as academics and professionals generally use such journals to acquire knowledge and disseminate new results (Nord and Nord, 1995; Ngai and Wat, 2002, Ngai et al., 2009).

In accordance with recommendations for initial research synthesis found in the literature, the keywords selected were sufficiently broad to avoid artificially limiting results and still provided limitations to avoid undesirable results. In pseudo code, the following phrase was adapted to the search engines in each database: “Supply Chain Flexibility”, using as reference the title, abstracts and keywords of the papers. The use of this Boolean expression in the selection process, of just two electronic databases and scientific journals may have caused the researchers to omit studies that address this theme using other words or terms or that are available in other databases or dissimilation source (e.g. theses, dissertations and conference papers), however it is believed that the articles reviewed comprise a reasonably representative and comprehensive body of the research work being accomplished in this area. It is not the intention of this paper to be exhaustive.

Thirty papers have been retrieved. All the selected articles were computer managed. For the purposes of this study, a Microsoft Excel database was designed containing the key issues addressed in each paper. A special effort was given to the SCRM definitions to identify a possible lack of a single consistent definition of the concept or a universal accepted definition. The collected papers have been classified in the theoretical and empirical dimension (see scheme developed by Olsen and Ellram (1997), Croom et al. (2000) and Luo et al. (2001), allowing a reasonable comprehensive assessment of research approaches taken in the current body of literature on the subject by highlighting both the basic methodology used and the aim
or focus of studies. Theoretical papers primarily develop models, concepts or conceptual frameworks, while empirical ones generally report practice by means of surveys, case studies, interviews or anecdotal information. Some papers can be classified both theoretical and empirical: these works typically develop a number of hypotheses and test them empirically.

3 Presentation and analysis of results
This section presents and analyses the results obtained from the systematic review on SCF based in two broad categories: study identification, including definitions for SCF, and key issues addressed.

3.1 Study identification and SCRM definitions
Figure 1 presents the 30 papers retrieved for the systematic review analysis. Interest in the subject is growing, as evidenced by the number of papers recently published with a peak in 2012.

![Figure 1: Number of publications on SCRM by year](image)

Main SCRM definitions are depicted in Table 1. The first column displays the considered references, while the second presents the definitions themselves and the third provides the other papers that have adopted the mentioned definition in their work.

Table 1: Main SCF definitions

<table>
<thead>
<tr>
<th>Reference</th>
<th>Definition</th>
<th>Papers that adopted the definition</th>
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<tbody>
<tr>
<td>Vickery et al. (1999)</td>
<td>&quot;... is an amalgamation of product flexibility, volume flexibility, new product flexibility, distribution flexibility and responsiveness flexibility&quot;</td>
<td>Duclos et al. (2003); Gosling and Naim (2010); Malhotra and Mackelprang (2012); Qrunfleh et al. (2012)</td>
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<tr>
<td>Das and Abdel-Malek (2003)</td>
<td>&quot;...is defined as the robustness of the buyer–supplier relationship under changing supply conditions&quot;</td>
<td>Gosling and Naim (2010)</td>
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<tr>
<td>Duclos et al. (2003)</td>
<td>&quot;...include the flexibility dimensions required by all the participants in the supply chain to successfully meet customer demand&quot;</td>
<td>Coronado and Lyons (2007); Candace et al. (2011)</td>
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<tr>
<td>Gosain et al. (2004)</td>
<td>&quot;...refers to the extent to which the supply chain linkages are able to adapt to changing business conditions rather than being forced into adapting to a given environment&quot;</td>
<td>Choy et al. (2008); Gosling and Naim (2010)</td>
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</table>
In the academic literature there is no unanimous definition for SCF. The most adopted definition within literature is proposed in Vickery et al. (1999), being mentioned in five articles. The others definitions are mentioned at most in twice academic papers. Most papers propose definitions that are not used in others articles. However, every proposed definition embraces the ability to respond to demand uncertainties through one systemic supply chain view, since flexibility dimensions is required by all the participants in different perspectives as internal and external dimensions. In order to illustrate the flexibilities dimensions necessary among the supply chain members, Stevenson and Spring (2007) point out the following five elements to provide a comprehensive definition of flexible supply chains:

- Robust network (or rigid) flexibility: The range of events that the existing supply chain structure is able to cope with.
- Re-configuration flexibility: The ease (mobility) with which the supply chain can be re-configured (adaptability). The need to re-configure is largely determined by the range (or resilience) of the existing supply chain structure.
- Active flexibility: The ability to act as a chain either as a response to, or in anticipation of, changes/events (i.e. a reactive or proactive capability).
- Dormant (or potential) flexibility: The flexibility of the supply chain is partially a contingent resource, i.e. it does not have to be a demonstrable capability.
- Network alignment: Entities are focussed on aligning their capabilities (internal flexibility) in order to meet the objectives of the supply chain and compete as a chain (external flexibility).

The different SCF definitions presented in table 1, show the evolution of the concept, which starts focused on internal flexibility and dyadic relationship, and extend, along the time, the
scope of the definition to a supply chain view, where the flexibility dimensions are required by all the involved members in a supply chain. The objective of SCF has also evolved, since the first definitions bring the idea of meet customer demand and the last ones aggregate the idea of performance beyond to respond to demand uncertainties.

3.2 Key issues addressed

The thirty papers address different aspects of SCF, the next subsections presents the main aspects that should be highlighted. Within this presentation, the papers are classified in theoretical, empirical and theoretical-empirical studies and are presented chronologically, as done in Leão et al. (2011).

The result analysis indicates that most of the papers retrieved are theoretical-empirical (43% of the total). The remaining articles are purely empirical (17%) or theoretical (40%). Empirical studies are predominantly focused on two manufacturing sectors and one service sector (logistic service providers). This further emphasises the need for more empirical studies on other industry sectors exposed to demand uncertainties in their supply chains (i.e. oil & gas).

3.2.1 Theoretical studies

The focus of the main theoretical studies is presented in this section. Das and Abdel-Malek (2003) introduce a measure for estimating supply chain flexibility as a function of varying order quantities and varying supply lead-times. Their survey indicates that order quantities and supply lead-times are the two most common changes which occur in supply chains, and are most often the cause of buyer–supplier grievance. Duclos et al. (2003) present an integrated conceptual model of supply chain flexibility. It examine flexibility classification schemes and the commonalities of flexibility typologies published in the literature to create a theoretical foundation for analyzing the components of supply chain flexibility. Chiang and Monahan (2005) present a two-echelon dual-channel inventory model in which stocks are kept in both a manufacturer warehouse (upper echelon) and a retail store (lower echelon), and the product is available in two supply channels: a traditional retail store and an Internet-enabled direct channel. Kumar et al. (2006) develop a conceptual framework for implementing and managing supply chain flexibility in supply chain organizations, concerning three-stage approach: required flexibility identification, implementation and shared responsibility, and feedback and control. Wu et al. (2006) analyze the sources of supply chain enterprise risk and propose measures for risk reduction considering the aspects of risk sharing, information sharing, change of inventory control mode, and supply chain flexibility. Stevenson and Spring (2007) presents a timely review of the available literature on supply chain flexibility and provides a more complete definition of flexibility in the context of supply chains. Reichhart and Holweg (2007) synthesize the existing contributions to manufacturing and supply chain flexibility and responsiveness, and draws on various related bodies of literature that affect a supply chain's responsiveness such as the discussion of product architecture and modularisation. Gong (2008) develops a supply chain flexibility model comprising labor flexibility, machine flexibility, routing flexibility, and information technology, with total system flexibility measured by an economic index. Outputs from the model can assist in making suitable production decisions to produce multiple products under an uncertain environment. Kumar et al. (2008) identify and evaluate the relationships among the flexibility enablers and to prepare a hierarchy of these enablers to know their influences over each other in global supply chain. Chandra and Grabis (2009) promote and disseminate research that investigate the problem of planning and operating flexible supply chains facing demand, supply, and other types of uncertainty. The goal of their paper is to engage in the discussion of many of the above issues impacting flexibility in a supply chain through
elaboration of models of flexibility evaluation, supplemented by methods for application, modification, and solving these models. Keser et al. (2010) present a mode to select the supplier that minimizes the procurement plus lost sales costs from a given set of supply bids and a known expected customer demand behavior. Finally Zapp et al. (2012) present a reference model which outlines measures for the dimensions of strategy, processes, technology, and IT systems to improve collaborative supply chain planning and control.

3.2.2 Empirical studies
The focus of the main empirical studies is presented in this section. Jenkins and Wright (1998) report the use of decision support systems to manage an inflexible supply chain through the examination of the supply chain of a major U.K. retailer of petroleum. Tachizawa and Thomsen (2007) focus on supply flexibility, the aspects of flexibility related to the upstream supply chain. Its purpose is to investigate why and how firms increase supply flexibility. Coronado and Lyons (2007) evaluate the implications of operations flexibility in industrial supply chains and the effect it has on supporting initiatives designed for build-to-order (BTO) manufacturing. Merschmann and Thonemann (2011) contribute to the emerging body of research by addressing the relationship between environmental uncertainty, supply chain flexibility, and firm performance through a survey of German manufacturing companies. The authors use structural equation modeling to analyze the match between environmental uncertainty and supply chain flexibility and competitive advantages. Finally, Yi et al. (2011) illustrate and examine the different flexibility strategies adopted by supply chain participants as a result of different environmental uncertainties.

3.2.3 Theoretical-empirical studies
The focus of the main theoretical-empirical studies is presented in this section. Sánchez and Pérez (2005) explore the relationship between the dimensions of supply chain flexibility and firm performance in a sample of automotive suppliers. Choy et al. (2008) propose an intelligent performance measurement system for measuring the performance of 3PL providers and their upstream and downstream supply chain partners. Swafford et al. (2008) provide insights for firms sharing characteristics through applying empirical analysis techniques to survey data from multiple manufacturing firms in the United States. The authors also present a performance construct, thus addressing the impact of supply chain agility and supply chain flexibility on performance. Stevenson and Spring (2009) present an empirical study of supply chain flexibility, addressing specific inter-firm practices used to achieve increased flexibility in buyer-supplier pairs and in the wider supply chain or network, and how do these practices and effects interact. Hua et al. (2009) aim to advance research in the challenging area of achieving competitiveness through supply chain flexibility and trust development. Chuu (2011) presents a framework for evaluating supply chain flexibility comprising two parts, an evaluation hierarchy with flexibility dimensions and related metrics, and an evaluation scheme that uses a three-stage process to evaluate supply chain flexibility. The author proposes an algorithm for determining the degree of supply chain flexibility using a fuzzy linguistic approach. Koçoğlu et al. (2011) focus on the influence of supply chain integration on information sharing and supply chain performance (SCP) and the role of information sharing in shaping SCP. Hence, the main purpose of this study is to evince the influence of supply chain integration on information sharing and SCP. Moon et al. (2012) adopt a comprehensive and rigorous procedure to develop a multifaceted scale for SCF through an empirical investigation. The authors suggest that SCF can be operationalized as a second-order factor model comprising four dimensions, namely: sourcing flexibility, operating system flexibility, distribution flexibility, and information system flexibility. Malhotra and Mackelprang (2012) examine if simultaneous utilization of both internal and
external flexibilities does in fact create synergies that can improve a firm's delivery performance. Based on a sample of 158 U.S. manufacturing plants, the authors find that the extent to which performance enhancing synergies are generated is primarily dependent upon the type of internal flexibility that is paired with supply chain flexibilities. Chang and Huang (2012) explore trust and shared vision moderate the relationship between the manufacturer's influence strategies and supplier delivery flexibility. The authors contribute to guidelines for management on how to align their suppliers for delivery flexibility to respond quickly to customer demand. Qrunfleh et al. (2012) examine alignment between supplier management practices and information systems strategies and its effects on supply chain integration and supply chain flexibility. Finally, Bai and Sarkis (2013) introduce a flexibility framework for reverse logistics utilizing operations and supply chain management flexibility research as a foundation and introduce a methodology to help organizations evaluate and/or monitor third party reverse logistics providers.

4 Final Remarks
This paper offers a systematic literature review on SCF using the content analysis approach. Although this research is not exhaustive, the thirty selected papers constitute a significant and representative portion on the scientific research carried out on SCF. It serves as a comprehensive base for an understanding of the main definitions, the main topics and research applications, and the key issues addressed in these researches.

The review highlights the lack of a unanimous definition for SCF among researchers; however, they share a similar point of view about SCF definition. Another point noticed was the need of conducting more empirical and theoretical-empirical studies. There are many industries that present many demand uncertainty and events that are not yet covered in the literature, for instance, the oil and gas industry.

The literature lacks an integrated and accepted framework for SCF. Many models need to be tested in real supply chains. Further studies are need about the assessment stage in SCF, with the conduction of more research on how customer uncertainties can be treated and the impact of supply chain flexibility strategies on supply chain performance.

References


