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Establishing the relationship between logistics complexity and supply chain objectives and decision areas in large companies operating in Brazil

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ABSTRACT: This paper reports an attempt to explore the relationships between logistics complexity and supply chain management (SCM) objectives and decision areas in large manufacturing companies operating in Brazil. Literature review is conducted, followed by survey research data (using a sample of 108 large companies operating in Brazil) analysis using cluster analysis, factor analysis and binary logistic regression. Results suggest that the level of logistics complexity of companies is a driver of management choices in supply chain objectives and decision areas, confirming our initial proposition that a contingency approach for supply chain management would be more appropriate than the "best practice" one. At the end of the article some further conclusions are drawn and opportunities for further research are discussed.

Keywords: Supply chain management, contingency approach, objectives, logistics complexity, Brazil

1. INTRODUCTION

The contingency approach to management basically argues that there is no one best way to manage. Central to the contingency approach is the proposition that the structure and process of an organization must fit its context (Drazin and Van de Ven, 1985). This is in contrast with the "best practice" paradigm (Voss, 1995), which is reflected in the proliferation of many management practices such as total quality management, lean production, continuous replenishment, and six sigma, many times fueled by consulting firms, specialized in selling "best " or "world class" practices that are often advocated as being universally applicable regardless of context and conditions. Although there are numerous reports in the literature showing a positive relationship between the adoption of best practice and performance (e.g. Liz, 1999; Vergin and Barr, 1999; Johnson, 1999), there are also numerous studies that show little or no impact of the adoption of best practice on performance and the literature is also rich in describing context-related problems that companies face when trying to implement best practices. According to Sousa and Voss (2008), operations management best practices have now matured and research on practices has begun to shift from the justification of the value of such practices to the understanding of the contextual conditions under which they are effective.

In supply chain management, time seems to be ripe for a similar shift. After years of an emphasis on developing and demonstrating the value of practices such as collaborative forecasting (CF), collaborative planning, forecasting and replenishment (CPFR), efficient consumer response (ECR), vendor managed inventory (VMI) among others, maybe it is time for research to shift to better understanding under what contextual conditions such practices work best. Some research papers found in the literature have already started to indicate that, by contributing to giving supply chain management a stronger theoretical foundation and by adopting a more scientific approach to research. Narasimham and Jayaram (1998), Chen and Paulraj (2004), Miles and Snow (2007), storey, Emberson, Godsell and Harrison (2006) among others have all been paving the road for this shift. This paper is an attempt to further contribute to the contingency approach research in supply chain management by using a scientific approach. We set off to analyze the relationships between logistics contextual conditions and complexity (in particular by analyzing variables such as size of the company, number of facilities in the network, number of stock keeping units, number of customers among others) and the different emphases given by supply chain executives of large companies on different decision areas (trying to reflect "practices") and, the different emphases placed on different supply chain objectives. Our general objective is to investigate whether and how large companies, from the view point of their supply chain executives, believe they should adopt a contingency approach in their supply chain management. The research questions that we use to guide us in achieving our objectives are twofold:

RQ1. Is there a significant relationship between the logistics complexity and the emphasis given by companies to different decision areas of their supply chain management?

RQ2. Is there a significant relationship between logistics complexity and the emphasis given by companies to their supply chain management objectives?

The main contribution of the paper is that it unveils the existence of significant relationships between logistic complexity and supply chain management decision areas and objectives within our sample companies, confirming our initial proposition.

2. CONCEPTUAL BACKGROUND

This section presents a review of the relevant literature about the variables related to our research objectives. We start with a discussion on supply chain management decision areas. The following subsection covers supply chain management objectives. The following subsection is dedicated to the issue of logistics complexity. The contingency approach in supply chain management is also discussed by the end of the section.

2.1. Supply chain management decision areas

The objective of this section is to identify the most current and relevant supply chain decision areas, according to the literature so that we can explore them in our research.

The scope of supply chain management is very broad, complex and encompasses numerous and inter-connected activities spread over and across multiple functions and organizations (Kanda and Deshmukh, 2008). The development of supply chain management has been accompanied by calls for a more specific understanding of its concepts. Defining supply chain management as a framework that integrates logistics and distribution networks, production operations and sourcing activities within and across companies provides a starting point to the understanding of the domain of supply chain management decision areas (Frankel et al., 2008).

Integrated logistics and distribution networks

The distribution network provides the basic physical infrastructure where the downstream side of the supply chain operates (Ballou, 2001).

Supply chain distribution network design

Network design plays a critical role in the competitiveness of supply chains (Melo et al., 2009), not only because it is a relevant area of capital investment, but also because it is essential for business to meet the market demand while providing the appropriate level of service (Dotoli et al., 2005). Typically, the design of distribution networks addresses the following questions (Lashine et al., 2006): What is the number of warehouses to operate with? How are demands allocated to plants? How are retailers allocated to warehouses?

Supply chain integration, visibility and supporting initiatives

An integrated distribution network is a set of consecutive stages (e.g. plants, warehouses, and customers) connected by common objectives, communication and transportation links (Dotoli et al., 2005). Visibility is a critical element to integrate distribution networks (Gaukler et al., 2008). Even though there are several different definitions for the term visibility (Francis, 2008), for the purpose of this research we will consider that it encompasses the real-time capturing, monitoring and sharing of relevant pieces of information - such as demands, replenishment orders, forecasts, and in-transit shipments - within and among companies in the supply chain (Bartlett et. al, 2007). Empirical evidence indicates that, if companies across supply chains have visibility of demand, inventory levels and processes, supply chain performance will improve (Barratt and Oke, 2007). Vendor managed inventory (VMI), collaborative forecasting (CF) and collaborative planning, forecasting and replenishment (CPFR) programs are important supply chain initiatives adopted between buyers and suppliers to enhance network visibility and, therefore, improve performance (Khadar, 2007; Rodriguez et al., 2008). Companies that have embraced these initiatives report higher customer service levels, cost and inventory level reduction, and improved supply chain control (Claassen et al., 2008).

Supply chain business intelligence

Network visibility supported by real-time information sharing has also generated opportunities for real-time business intelligence so as to help in several aspects of supply chain decision-making (Chan, 2006). The concept of business intelligence applied to supply chain management is two-fold. First, it denotes an analytic process that transforms internal and external data into relevant information to support different initiatives, activities, and decisions within the supply chain scope (Sahay and Ranjan, 2008). Second, business intelligence also means IT applications that provide support for quick identification of market trends and patterns and flexible analysis of business data. There is growing evidence that the adoption of business intelligence is a critical component in a company's ability to be more responsive and competitive in the supply chain arena (Gulledge and Chavusholu, 2008).

Dealing with supply chain uncertainty

However, despite the possibility to enhance network visibility via integration and IT adoption, effective demand management is becoming increasingly difficult because of the growth in supply chain uncertainty over the past decade (Bower, 2007). This rise in uncertainty levels is the result of several factors such as increased levels of competitive pressure, global sourcing, lead time variance, never-ending and more frequent new product launches, more stringent governmental regulations, price changes, currency exchange rate instability and promotional activities. These factors potentially amplify the bullwhip effect at each stage of the supply chain (Forrester, 1961; Lee et al., 1997), thus making demand management an activity that is very relevant in the supply chain managers' agenda (Kaipia et al., 2006). The bullwhip effect is an observed phenomenon in supply chains, according to which, demand variations in its downstream stages cause an increasing volatility of the perceived demand in its upstream stages. See Lee (1997) for a more detailed discussion. The management of demand uncertainty should be simultaneously conducted, if possible, at each stage of the supply network (Collin and Lorenzin, 2006) and integrated production and distribution systems offer this opportunity.

Integrated production operations

Historically, many firms have tried to optimize their production and distribution systems separately, but this localized approach limits possible improvements in the overall supply chain performance (Park, 2005).

Push vs. pull approaches for supply chain flow management

Thus, it is becoming increasingly important to analyze these two systems simultaneously (Selcuk et al., 1999), so as to explore opportunities to redesign physical and information flows, thus moving the business model from adopting predominantly push to predominantly pull flow management systems and by doing so, mitigating the bullwhip effect (Miemczyk and Howard, 2008; Wanke et al., 2008).

Postponement

Within the ambit of operations management, time and space postponement represent important opportunities to better the supply chain performance, as the highly successful and acclaimed Dell supply chain model for desktop computer production demonstrates (Farhoomand et al., 2000). Postponement may involve not only the delay of the differentiating final stages of production until a customer order is received (Skipworth and Harrison, 2006), but also direct distribution to customers, instead of echeloned distribution via warehouses (Wanke and Zinn, 2004).

Order management

A change in the business model from push to pull requires different ways of managing orders and sales so as to allow the creation of advantages in terms of supply chain visibility and agility (Dekkers et al., 2006). In a broader sense, effective order management is one of the basic processes that provide visibility and agility to the company (Affonso et al., 2008) while keeping high customer service levels (Kirche et al., 2005). It not only supports integration of departments and processes within the company, but it is also necessary for the integration of the company into the supply chain. Empirical evidence seems to support a positive association between order management performance and customer satisfaction (Bharadwaj and Matsuno, 2006).

Transportation and warehousing

Still, with respect to supply chain agility, transportation and warehousing activities are also critical to outperform competitors on lead times (Faber et al., 2002; Galbreth et al., 2008). The recognition of the impact of traditional logistics functions, such as transportation and warehousing, on supply chain agility is not new (Ng et al., 1997). The novelty is the emergence of related IT applications that have changed the way in which these activities operate (Mason et al., 2003; Stefansson and Lumsden, 2009) and leverage supply chain performance: transportation management systems (TMS) and warehouse management systems (WMS), for instance, are key technologies used to manage the physical flow of goods along the supply chain. Integrated systems that encompass TMS, WMS and global inventory visibility can potentially lead to reduced costs and improved customer service by decreasing shipping and receiving cycle times, increasing shipment accuracy, and decreasing lead time variability (Mason et al., 2003).

Integrated sourcing

The increased dynamic changes in the marketplace also produced a radical shift in the sourcing function within companies (Mehra and Inman, 2004). Cost-based practices of the past are being progressively replaced by a value-added focus in the supply chain (Butter and Linse, 2008)

Global sourcing

Global sourcing creates many new opportunities for both cost reduction and value creation, bringing new opportunities to sourcing management (Welborn, 2008). The challenge of global sourcing is to develop management competencies in sourcing operations that are difficult to imitate by competitors (Chung et al., 2004) thus creating more sustainable competitive advantage. Although global sourcing may increase supply chain uncertainty (Christopher and Peck, 2004), companies are striving to manage these risks in developing global supply networks that are able to operate effectively and reliably in any part of the world.

A summary of the categories (or decision areas) that could help define the scope of current relevant decisions related to supply chain management and that were identified in the literature is presented in Table I. In this research these decision areas will help in the identification of the level of emphases given to each of them by the supply chain managers of the surveyed companies. Citations of the references in the literature that support a given decision area are also provided.

Table I.

Supply chain management-related decision areas that can help define the scope of current supply chain management decision areas

Decision area	**Supporting literature**
1 - Network design	Ballou (2001), Dotoli et al. (2005), Lashine et al. (2006), and Melo et al. (2009)
2 – Network integration and Visibility	Dotoli et al. (2005), Bartlett et al. (2007), Gaukler et al. (2008), and Francis (2008)
3 - Business intelligence processes	Chan (2006), Sahay and Ranjan (2008), and Gulledge and Chavusholu (2008)
4 - Vendor managed inventory	Khadar (2007) and Rodriguez et al. (2008)
5 - Collaborative forecasting	Helms et al. (2000), Holmstrom et al. (2002), Smaros (2007), and Rodriguez et al. (2008)
6 - Demand management	Kaipia et al. (2006) and Collin and Lorenzin (2006)

7 - Inventory optimization	Blankley et al. (2008)
8 - Production and distribution planning	Selcuk et al. (1999) and Park (2005)
9 – Operations management (postponement)	Wanke and Zinn (2004), Skipworth and Harrison (2006), Wanke et al. (2008), and Miemczyk and Howard (2008)
10 - Order management	Kirche et al. (2005), Dekkers et al. (2006), and Affonso et al. (2008)
11 - Sales management	Taylor (2006)
12 - Transportation management	Ng et al. (1997), Faber et al. (2002), and Galbreth et al. (2008)
13 - Warehouse management	Green (2001) and Kadiyala and Kleiner (2001)
14 - Purchasing management	Mehra and Inman (2004), Butter and Linse (2008), and Welborn (2008)
15 - Global sourcing	Chung et al. (2004) and Christopher and Peck (2004)

2.2. Supply chain management objectives

Each company within the chain may have its own internal goals, but all members should share common supply chain objectives (Mentzer et al., 2001). In addition, they should all be aware of the nature of the relationships with other members in the chain (Pohlen and Coleman, 2005).

Customer service-related objectives

One major supply chain objective relates to how well customers are served (Sahay et al., 2006; Sebastião and Golicic, 2008). The accomplishment of this objective can be captured by several performance measures such as on-time delivery indexes, order completeness indexes (Gaudenzi and Borghese, 2006), on time in full (OTIF) indexes and perfect order (OTIF and in perfect condition) indexes.

Cost, financial performance and shareholder value

However, supply chain management objectives and performance measures should also account for the translation of nonfinancial performance into financial performance and shareholder value (Ellram and Liu, 2002), if supply chain management is to be fully integrated into the strategic management of companies. The cash-to-cash cycle (Farris II and Hutchison, 2002) and the cash conversion cycle (Tsai, 2008) are examples of important financial-based measures that bridge across inbound material activities with suppliers, through production operations, to the outbound activities with customers. These measures may be particularly useful to guide companies willing to increase inventory turnover and conversion agility and, reduce financial costs in their supply chains (Pohlen and Coleman, 2005).

With respect to other financial-based measures related to the efficient use of assets and costs, the use third-party logistics (3PL) providers can play an important role in achieving higher levels of asset productivity and cost reductions in the supply chain (Liu et al., 2008). Although the beneficial impact of 3PL use on these measures is not new (Boyson et al., 1999), its importance as a potentially critical supply chain weapon is becoming more evident. This happens in part because 3PLs are continually segmenting the services they provide in order to achieve excellence via specialization, to benefit from higher economies of scale across different companies and even industries and, maybe even more important, to provide better fit with relevant supply chain characteristics, such as the manufacturing process type and the logistics sophistication of the shippers as demonstrated by Wanke et al. (2007).

Adapting to change: supply chain flexibility and agility

Another important supply chain objective is the ability to adapt to changes in demand, also known as reactivity (Gaudenzi and Borghese, 2006) or agility (Lee, 2004). In other words, many authors argue that supply chains should be flexible, agile, and lean enough to cope with the uncertainty of a rapidly changing environment (Chopra and Meindl, 2004; Tang and Tomlin, 2008). The ability to build flexible, agile, and lean supply chains, however, has not developed as rapidly as anticipated, not only because the development of IT to support such concepts is still under way, but also because of ill-defined and vague measures to assess these objectives (Jain et al., 2008). Additionally, many times the measurement and reward systems in place do not provide the necessary levels of incentive alignment between the actors in the supply chain (Narayanan and Raman, 2004) around flexibility and agility as objectives.

Nevertheless, effective IT adoption, collaboration, and process redesign, culminating in enhanced supply chain visibility and integration, seem to be important enablers of the ability to effectively react to demand uncertainty (Kok et al., 2005; Swafford et al., 2008; Wang et al., 2008). The key aspect within the concepts of flexibility, agility, and leanness is how supply chains can benefit from visibility to cope with demand uncertainty and to shorten lead times. For instance, visibility may enable companies to design and operate their logistics network so as to provide rapid response to their markets (Baker, 2008). On the other hand, visibility may allow multi-echelon inventory synchronization to end or mitigate the bullwhip effect and control demand uncertainty (Kok et al., 2005). Wal Mart and its “Retail Link” is a frequently cited example of the effective use of IT-enabled supply chain visibility helping synchronize inventory management and replenishment policies between the retailer and their suppliers (Colla and Dupuis, 2002). Visibility may also favor pull-based supply chains with smaller inventory levels and higher inventory turnover rates (Wang et al., 2008). The AutoGiro system, implemented by General Motors Brazil in the year 2000, to manage their spare parts supply chain, based on increased visibility and integration across the chain and on turning a traditional push system into a pull system helped drastically increase annual inventory turns by a factor of 3 (Corrêa and Nogueira, 2008).

Summarizing, supply chain objectives range from customer-driven to cost-related measures. Many of them are similar to traditional logistics objectives. This should be no surprise, not only because logistics and supply chain management concepts share common origins, but also because logistics is a key supply chain management process (Lambert et al., 1998). A summary of the variables identified in the literature related to supply chain management objectives is presented in Table II. Citations to the references in the literature that support a given variable are also provided.

Table II.

Supply chain management objectives

Variable	**Supporting literature**
1 – Increase inventory turnover	Pohlen and Coleman (2005) and Wang et al. (2008)
2 – Reduce cash cycle	Farris II and Hutchison (2002) and Ellram and Liu (2002)
3 – Benefit from relationships with 3PLs	Boyson et al. (1999) and Wanke et al. (2007)
4 – Reduce logistics costs	Boyson et al. (1999)
5 – Increase asset productivity	Boyson et al. (1999)
6 – Improve order completeness performance	Gaudenzi and Borghese (2006)
7 – Improve perfect order performance	Gaudenzi and Borghese (2006)
8 – Improve on-time delivery performance	Gaudenzi and Borghese (2006)
9 – Synchronize supply chain via visibility	Kok et al. (2005) and Corrêa and Nogueira (2008)
10 – Shorten lead times	Baker (2008)
11 – Change business model from push to pull	Wang et al. (2008)

2.3. Logistics complexity

The perception of logistics systems as being complex is emphasized by several authors (Bowersox and Closs, 1996; Christopher, 1998; Lambert et al., 1998). However, it is not always clear what is meant by logistics complexity (Nilsson, 2006). At the most general level, complexity refers to the quantity, level and type of interactions present in a given system.

More precisely, complexity can be viewed as a deterministic component more related to the numerousness and variety of interacting elements in a system (Milgate, 2001).

Although the issue of complexity has been variously studied in the operations management and supply chain management literature (Wilding, 1998; Vachon and Klassen, 2000; Hoole, 2005; Bozarth et al., 2009), literature focusing specifically on logistics complexity is scarce (Nilsson, 2006). An operational definition of logistics is necessary before developing the concept of logistics complexity. Typical definitions of logistics reflect the need for total movement management from point of material purchasing to location of finished product distribution (Bowersox and Closs, 1996; Christopher, 1998; Lambert et al., 1998). One broadly accepted definition of logistics management is given by the Council of Supply Chain Management Professionals (formerly Council of Logistics Management):

"Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all levels of planning and execution--strategic, operational and tactical. Logistics management is an integrating function, which coordinates and optimizes all logistics activities, as well as integrates logistics activities with other functions including marketing, sales manufacturing, finance, and information technology." (http://cscmp.org/aboutcscmp/definitions.asp, visited 04-22-2009).

Complexity in logistics therefore defined in terms of quantifiable scales and based on the notion of numerous actors or parts that are interconnected (Nilsson, 2006) can be captured by measures such as the gross revenue of a company, its number of suppliers, active clients, employees, employees involved in supply chain management, active stock keeping units (SKUs), distribution centers, orders processed, and product launches per year. Defining scales for logistics complexity is important here because our basic proposition in this research is that logistics complexity may be a driver of the way a company manages and emphasizes the different supply chain objectives and decision areas. We argue for a contingency approach of supply chain management, where different contextual condition drive the way the supply chain choices are made and management activities are performed, as opposed to a best practice approach where there would be some universally applicable principles that would be appropriate regardless of the particular conditions under study.

2.4. The contingency approach

The contingency approach to management is based on the idea that, to be effective, planning, organizing, and controlling must be tailored to the context and particular circumstances faced by an organization (Wren, 1994). According to this notion, there would not be a "one-best way" to manage. This is in contrast with some advocates of the "best practice" approach which would be more universally applicable regardless of context.

The contingency approach applied to supply chain management would assume that there is no universal answer to achieving excellence because contextual factors and situations vary and change over time. The frequency with which firms have changed their supply chain management decisions and practices as well as refocused their objectives indicates that finding or maintaining the best strategy is difficult in today's rapidly-changing business environment. According to Chow et al. (1995), weaknesses of the one-best way approach to supply chain excellence indicate that alternatives such as the contingency theory applied to supply chain management could prove to be more useful foci for research. Bowersox et al., 1999 and Bowersox and LaHowchic, 2008 seem to concur.

Still, the literature is scarce in discussing the contingency approach related to supply chain management. Cigolini at al. (2004) propose an interesting prescriptive framework to support the definition of the choice of supply chain tools and techniques to be used. In their work, supply chain management is considered to be contingent upon three variables: which phase is dominant within the end products' life cycle, the structural complexity of the product itself, and the type of supply chain (whether 'quick', 'efficient' or 'lean'). However they do not empirically validate their prescriptions.

One important and highly visible contribution to the contingency approach to supply chain management comes from Fisher (1997).

2.5. Fisher's (1997) contingency model for supply chain management

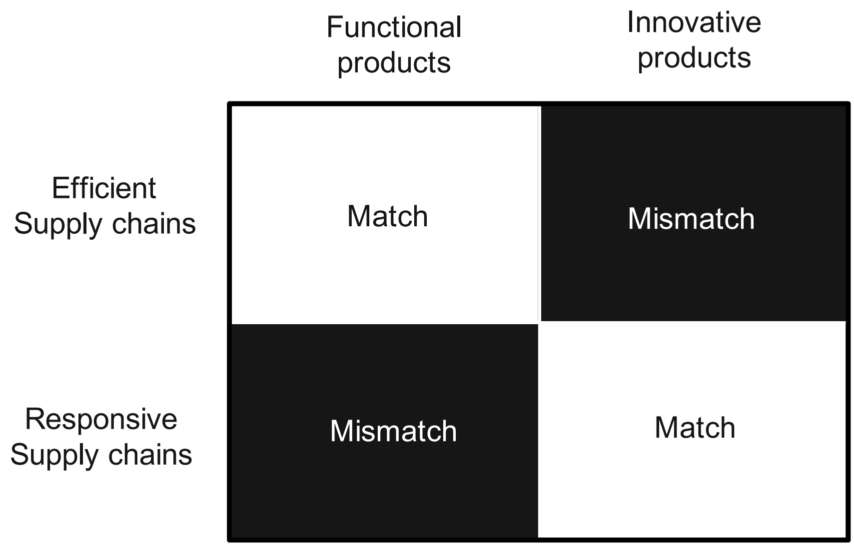
Fisher's model, presented in Figure 1, is also prescriptive in nature and apparently the author has not empirically validated it but it has been highly cited and appeared in a number of popular textbooks on supply chain management such as Wisner et al. (2008) and Simchi-Levy et al. (2003). It has a strong and to a certain extent, intuitive appeal. Fisher argues that the supply chain design and management should be contingent to the type of product being made and delivered by it. According to this notion, products can be categorized as functional or innovative. *Functional products* are staples, commoditized products that normally satisfy basic needs, do not change much over time, have lower profit margins, longer life cycles and more importantly, low forecast uncertainty. Canned soup or washing powder would be examples. *Innovative products* are the opposite: they have frequent product launches and changes, higher profit margins, shorter life cycles and normally less predictable demand. Here fashion and electronics products such as cell phones provide good examples.

Figure 1. Types of products in Fisher's contingency theory on supply chain management

Functional products	Innovative products
Supply demand at the lowest cost	Respond quickly to demand
Maximize performance at a minimum product cost	Create modularity to allow postponement/differentiation
Lower margins because price is a key customer driver	Higher margins
Lower costs through high utilization	Maintain capacity flexibility to meet unexpected demand
Minimize inventory to lower cost	Maintain buffer inventory to meet unexpected demand
Reduce lead time but not at the expense of costs	Aggressively reduce lead times
Select suppliers based on cost and quality	Select suppliers based on speed, flexibility, and quality
Greater reliance on low cost modes of transportation	Greater reliance on responsive modes of transportation

According to Fisher (op. cit.), each category of product - functional or innovative - should require a distinctly different supply chain. Functional products would contingently require more *physically efficient* supply chains where asset utilization and cost control (for e.g. by keeping low inventories by using pull systems and seeking economies of scale in all activities) would play a crucial role. Innovative products on the other hand, would require more *market-responsive supply chain processes* where for e.g. excess buffer stocks of parts and finished products are normally needed and aggressive initiatives to reduce lead times should be pursued (even at the expense of cost efficiencies). These might represent trade-offs in relation to the choices of the physically efficient chain and these trade-offs are at the heart of the rationale behind a supply chain contingency approach. Figure 2 illustrates the idea.

Figure 2 – The relationships between product types and supply chain types in Fisher's contingency theory on supply chain management



Inspired by and with the objective of adding to the discussion about the use of the contingency approach to manage supply chains, we set out to investigate whether not only different *product types* would drive different choices and emphases in supply chain management but whether the more ample concept of *logistics complexity* (that includes but is not restricted to the characteristics of the products being produced and delivered by the chain) would play a role in defining how companies make their supply chain management choices in terms of what objectives and decision areas.

3. RESEARCH QUESTIONS

Our basic proposition is that companies adopt a contingency approach to manage their supply chains. In other words, to be effective, planning, organizing, and controlling must be tailored to the context and particular circumstances faced by an organization (Wren, 1994). In order to investigate the validity of this basic proposition we will analyze the emphasis given by companies' executives in two aspects of their supply chain management: the *decision areas* and the *objectives* (Figure 3) when they face different contexts and circumstances related to logistics complexity. After characterizing the way in which companies manage their supply chains in terms of decision areas and objectives, we then investigate the level of logistics complexity of the researched companies and try to find correlations between the level of logistics complexity and the way companies make their supply chain management choices.

We work with two major research questions (RQ):

RQ1. Is there a significant relationship between the logistics complexity and the emphasis given by companies to different decision areas of their supply chain management?

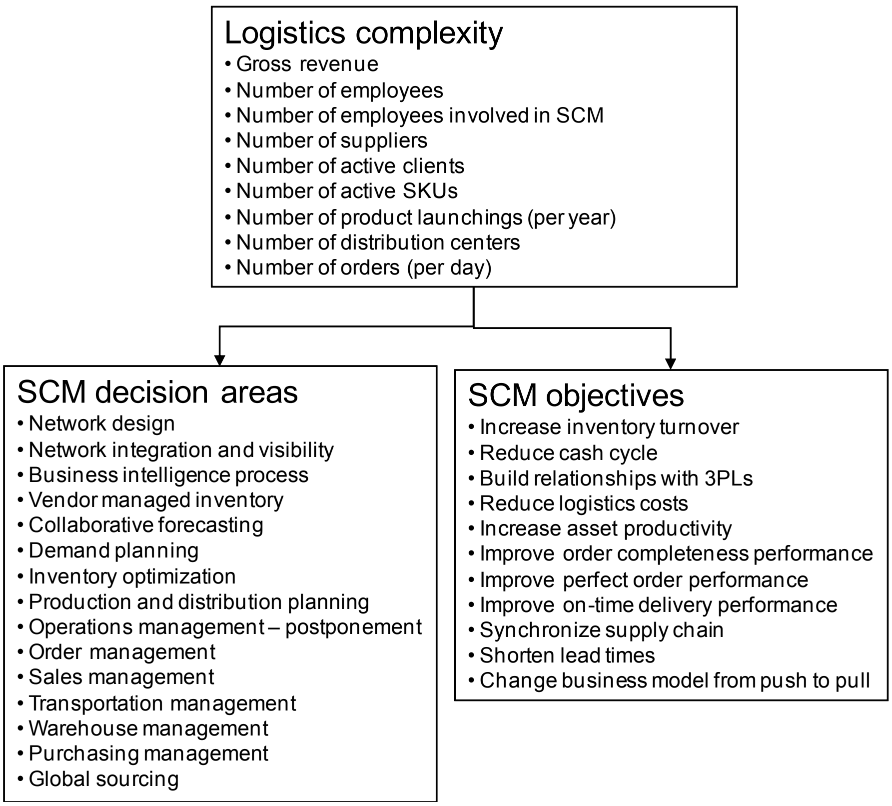
RQ2. Is there a significant relationship between logistics complexity and the emphasis given by companies to their supply chain management objectives?

4. METHODOLOGY

This study is of exploratory nature and intends to achieve a better understanding of supply chain management major features by uncovering possible relationships as stated in the proposed research questions. An empirical study based on data collected in a comprehensive survey was done to try to answer the proposed questions. Respondents of the questionnaire consisted of high ranked managers (directors, vice presidents and senior managers) involved with several aspects of the supply chain decision areas in large companies operating in Brazil. The survey was conducted in the last quarter of 2008.

The survey population consisted of the manufacturing companies included in the *Exame* 500 companies list, a Brazilian annual business magazine listing similar to the Fortune 500. All companies were contacted by telephone so as to verify whether they were willing to participate in the research (and in this case to obtain the name of the highest ranked manager involved with supply chain decision-making to whom the survey instrument would be sent). Questionnaire items were developed based on previous literature review and on results from in-depth interviews conducted with four large Brazilian manufacturing companies' executives and focused on several aspects of supply chain management and logistics complexity. The questionnaire was then pretested with a number of academics and practitioners in order to validate both structure and content. As a result, minor modifications were introduced. A pilot mailing was conducted with four companies to ensure that the research instrument would be well understood by target respondents to guarantee construct validity. Based on observations from these pilot respondents a few questions were removed from the original questionnaire.

Figure 3. A contingency perspective of the impact of logistics complexity on supply chain management choices



The electronic questionnaire was then sent out by e-mail to a mailing list of 273 manufacturing companies that had agreed to participate in the research during the preliminary telephone contacts. The final sample considered in this study consists of the 108 companies that returned usable questionnaires (a response rate of 39.6% of the sent questionnaires, representing 21.6% of the population of companies in the *Exame* 500 listing). The inexistence of non-response bias was verified by cross-tabulation of the frequency distributions of the responses in terms of economic sector in the sample against corresponding data from the population. Three tests to measure the ordinal association between variables were performed: Goodman and Kruskal's Gamma, Kendall's Tau-B and Kendall's Tau-C (Rodrigues et al., 2004). No significant differences between sample and population distributions were determined at $p < 0.05$.

The operationalization of the variables collected and potentially related to logistics complexity and supply chain management (objectives and decision areas) is presented in Table III.

5. RESULTS AND DISCUSSION

An exploratory cluster analysis was performed - with the use of the SPSS 15.0 package - to split the 108 companies in the sample into two different groups using k-means cluster: companies with high logistics complexity and companies with low logistics complexity. Based on literature and because of the exploratory nature of this research, only two groups were selected. The variables considered during the cluster analysis were the company's Gross revenue, Number of employees, Number of employees involved in supply chain management activities, Number of suppliers, Number of active clients, Number of active SKUs, Number of product launchings per year, Number of distribution centers, and Number of orders per day. Table IV presents the final cluster centers and the F tests for differences between clusters. The F tests should be considered only for descriptive purposes, as clusters have been chosen so as to maximize the differences among cases in each cluster. Log transformation on these variables was also tested and did not produce different results.

According to Table IV results, companies located in cluster no. 1 not only present greater revenue, but also greater number of employees, suppliers, SKUs, product launchings, distribution centers, and orders received, thus characterizing high logistics complexity. On the other hand, the reverse is true for cluster no. 2, where companies present lower logistics complexity.

The means of each of the researched variables, related to supply chain management, are presented for each cluster in Table V. The next step now is to analyze whether the executives of the two clusters generated for high/low logistics complexity levels differ in perception, in focus or emphasis on the different aspects of the supply chain management objectives and decision areas. To what extent these differences are statistically significant is addressed by the multivariate analysis detailed next.

5.1. Supply chain decision areas and logistics complexity

With respect to the defined decision areas, an extraction of factors from the 15 variables was conducted by means of exploratory factor analysis with Varimax standardized rotation for data collected within the sample of 108 companies. Results are presented in Table VI. Only factor loads greater than 0.50 and eigenvalues greater than 1.0 deserve to be interpreted, and in these cases the variable is said to represent a good factor measure (Tabachnik and Fidell, 2001). Thus, five main factors represent the scope of supply chain management, interpreted as follows:

1. The scope defined by Network design, Network integration and visibility, Business intelligence, Vendor managed inventory, and Collaborative forecasting makes up factor 1, interpreted as Network intelligence and integration management;

2. The scope defined by Demand planning, Inventory optimization, Production and distribution planning, and Operations management accounts for factor 2, interpreted as Market mediation management;

3. The scope defined by Order management, and sales management structures factor 3, simply interpreted as Customer service management;

4. The scope defined by Transportation management, and Warehousing management makes up factor 4, simply interpreted as Physical logistics efficiency management; and,

5. Identically, the scope defined by Global sourcing and Purchasing management makes up factor 5, simply interpreted as Sourcing management.

The standardized scores of these five factors were used to discriminate the two clusters previously determined for logistics complexity. A binary logistic regression analysis was performed - with the use of SPSS 15.0 - to assess the accurate prediction of membership in one of two categories of outcome (high logistics complexity and low logistics complexity), on the basis of the five factors determined for each of the 108 companies in the sample. There was a good model fit (discrimination between companies with high/low logistics complexity) and the comparison of log-likelihood ratios for models with and without these five factors showed reliable improvement with their addition as predictors: Chi-square $(5, N = 108) = 11.227$, $p < 0.05$. Table VII presents the results of the binary logistic regression. The positive signs of the predictor variables indicate that, the greater the factor, the more complex tends to be the company's logistics. P-values below 0.10 were considered as the cut-off points for significance in this research.

Table III. Surveyed variables potentially related to supply chain management and logistics complexity

Dimension	Research variables	Mean	SD	Scale	Type of scale
Supply chain decision areas *To what extent do you agree that the following SCM decision areas are critical for your company to achieve supply chain excellence in its most important objectives?*	1 - Network design 2 – Network integration and visibility 3 – Business intelligence process 4 – Vendor managed inventory 5 – Collaborative forecasting 6 – Demand planning 7 – Inventory optimization 8 – Production and distribution planning 9 – Operations management – postponement 10 – Order management 11 – Sales management 12 – Transportation management 13 – Warehouse management 14 – Purchasing management 15 – Global sourcing	3.73 3.82 3.65 2.75 2.94 3.81 4.24 4.08 3.46 3.69 2.39 4.24 4.20 3.90 3.41	1.48 1.40 1.39 1.60 1.64 1.49 1.19 1.24 1.46 1.44 1.62 1.24 1.25 1.46 1.60	5 = Strongly agree 3 = Neutral 1 = Strongly disagree	Ordinal
Supply chain objectives *To what extent do you agree that each of the following SCM objectives are critical for your company to meet its most important strategic objectives?*	1 – Increase inventory turnover 2 – Reduce cash cycle 3 – Build relationships with 3PLs 4 – Reduce logistics costs 5 – Increase asset productivity 6 – Improve order completeness performance 7 – Improve perfect order performance 8 – Improve on-time delivery performance 9 – Synchronize supply chain 10 – Shorten lead times 11 – Change business model from push to pull	4.12 4.12 3.97 4.33 4.44 4.10 3.98 4.27 4.02 3.50 3.80	1.14 1.02 0.96 0.80 0.73 0.84 1.05 0.78 0.99 1.28 1.24	5 = Strongly agree 3 = Neutral 1 = Strongly disagree	Ordinal
Logistics complexity *Based on your best judgment, please provide information on the following variables related to your company's logistics complexity:*	1 - Gross revenue 2 - Number of employees 3 - Number of employees involved in SCM 4 - Number of suppliers 5 - Number of active clients 6 - Number of active SKUs 7 - Number of product launchings (per year) 8 - Number of distribution centers 9 - Number of orders (per day)	714883450 3386 137 677 4312 8639 45 4 1112	442491322 6203 308 2016 3193 16847 14 8 4416	Metric	Ratio

Table IV. Final cluster centers

Variables	Cluster no. 1 High logistics complexity (41 companies)	Cluster no. 2 Low logistics complexity (67 companies)	F	Sig.
Gross revenue	1187336167	414231722	242.342	.000
Number of employees	6185	1732	14.237	.000
Number of employees involved in SCM	214	93	3.558	.062
Number of suppliers	1100	459	2.155	.145
Number of active clients	12166	522	3.054	.084
Number of active SKUs	11195	7224	1.298	.257
Number of product launchings (per year)	80	24	3.352	.070
Number of distribution centers	5	3	1.036	.311
Number of orders (per day)	2424	384	4.427	.038

Major products located in cluster no. 1: Heavy machines, automotive, household appliances
Major products located in cluster no. 2: Food, chemicals, pulp and cellulose, furniture

Table V. Supply chain means for each cluster of logistics complexity

Supply chain decision areas	High	Low	Supply chain objectives	High	Low
	Mean			Mean	
Network design	3.95	3.58	Increase inventory turnover	4.00	4.20
Network integration and visibility	4.00	3.71	Reduce cash cycle	4.02	4.18
Business intelligence process	3.68	3.63	Build relationships with 3PLs	3.95	3.99
Vendor managed inventory	3.13	2.51	Reduce logistics costs	4.24	4.39
Collaborative forecasting	3.00	2.91	Increase asset productivity	4.44	4.45
Demand planning	4.10	3.64	Improve order completeness performance	3.95	4.20
Inventory optimization	4.32	4.19	Improve perfect order performance	3.95	4.00
Production and distribution planning	4.34	3.92	Improve on-time delivery performance	4.07	4.39
Operations management - postponement	3.59	3.38	Synchronize supply chain	4.10	3.98
Order management	3.39	3.88	Shorten lead times	3.68	3.39
Sales management	2.22	2.50	Change business model from push to pull	3.95	3.70
Transportation management	4.41	4.14			
Warehouse management	4.54	3.98			
Purchasing management	3.71	4.02			
Global sourcing	3.07	3.63			

Table VI. Results of factor extraction for the supply chain management decision areas

Factor 1 – Network intelligence and integration management	**Factor 2 – Market mediation management**	**Factor 3 – Customer service management**	**Factor 4 – Physical logistics efficiency management**	**Factor 5 – Sourcing management**
Network design (0.81;0.26)	Demand planning (0.60;0.30)	Order management (0.64;0.39)	Transportation management (0.81;0.48)	Global sourcing (0.61;0.44)
Network integration and visibility (0.85;0.27)	Inventory optimization (0.70;0.28)	Sales management (0.76;0.41)	Warehousing management (0.76;0.44)	Purchasing management (0.75;0.54)
Business intelligence (0.85;0.29)	Production and distribution planning (0.63;0.23)			
Vendor managed inventory (0.60;0.19)	Operations management - postponement (0.60;0.26)			
Collaborative forecasting (0.65;0.25)				
Percent of variance explained by factor				
26.93 percent	13.39 percent	8.34 percent	7.18 percent	6.30 percent

KMO = 0.750
Chi-square = 642.927 (Sig. = 0.000)
The first value in brackets represents the load factor
The second value in brackets represents the factor coefficient for the standardized variables

Table VII. Binary logistic regression results: scope of supply chain management decision areas

Factor	B	Wald	Sig.
Network intelligence and integration management	.221	.992	.319
Market mediation management	.470	3.165	**.075**
Customer service management	-.303	1.783	.182
Physical logistics efficiency management	.295	1.650	.199
Sourcing management	-.431	3.640	**.056**
Constant	.504	5.031	**.025**

Criterion variable: High logistics complexity vs. Low logistics complexity
Nagelkerke's R-Square = .15

Results show that two out of the five factors are significant: Market mediation management and Sourcing management.

The factor Market mediation management has a positive sign. It means that the supply chain management decision areas represented by this factor are more likely to be found in companies with higher logistics complexity, that is, with larger number of distribution centers, SKUs, clients, suppliers etc. More precisely, the higher this factor, the more likely that the company will belong to the cluster of high logistics complexity. This finding somewhat confirms proposition by Fisher (1997). According to the author, supply chains that produce innovative products (frequent product launches, short life cycles, and broader product lines – that are characteristics consistent with our definition of higher logistics complexity) should, as we found, place more emphasis on the market mediation function – matching supply and demand – of the supply chain management.

On the other hand, the factor Sourcing management has a negative sign. That is, the company will be more likely to consider decision areas represented by this factor if its logistics complexity is low (smaller revenues, smaller number of employees involved in supply chain management etc). If we consider that sourcing management (purchasing and global sourcing) has predominantly been used to reduce material costs, it should be no surprise that lower logistic complexity companies (more associated with functional products because lower logistics complexity means few product launches, narrow product lines, probable lower margins, etc) emphasize areas that aim at reducing the costs of actually physically producing and delivering products. This finding also seems to be in line with Fisher's propositions.

At last, the factors Network intelligence and integration management, Customer service management, and Physical logistics efficiency management do not present significant differences between both clusters, thus indicating that they may constitute common ground upon which companies differentiate their supply chain management scope based on their logistics complexity. Based on Fisher's model, we would expect that at least the factor Physical logistics efficiency management showed positive correlation with lower levels of logistics complexity. This however was not the case.

5.2. Supply chain objectives factor analysis

Now, with respect to the objectives of the supply chain management, an extraction of factors from its 11 related variables was also conducted by means of exploratory factor analysis with Varimax standardized rotation and its results are presented in Table VIII. Four main factors are adequate to represent the objectives of supply chain management. They are interpreted next.

The objectives Increase inventory turnover and Reduce cash cycle make up factor 1, interpreted as Improve cash efficiency.

The objectives Build relationships with 3PLs, Reduce logistics costs, and Increase asset productivity account for factor 2, simply interpreted as Improve physical logistics efficiency.

The objectives Improve order completeness performance, Improve perfect order performance, and Improve on-time delivery performance structure factor 3, interpreted as Improve service reliability.

At last, the objectives Synchronize supply chain, Shorten lead-times, and Change business model from push to pull make up factor 4, interpreted as Improve service responsiveness.

Table VIII. Results of factor extraction for the supply chain management objectives

Factor 1 – Improve cash efficiency	Factor 2 – Improve physical logistics efficiency	Factor 3 – Improve service reliability	Factor 4 – Improve service responsiveness
Increase inventory turnover (0.82;0.46)	Build relationships with 3PLs (0.65;0.35)	Improve order completeness performance (0.64;0.32)	Synchronize supply chain (0.68;0.49)
Reduce cash cycle (0.77;0.38)	Reduce logistics costs (0.78;0.42)	Improve perfect order performance (0.56;0.28)	Shorten lead-times (0.65;0.38)
	Increase asset productivity (0.82;0.47)	Improve on-time delivery performance (0.64;0.33)	Change business model from push to pull (0.57;0.35)
Percent of variance explained by factor			
31.22 percent	12.59 percent	10.19 percent	7.76 percent

KMO = 0.789
Chi-square = 343.057 (Sig. = 0.000)
The first value in brackets represents the load factor
The second value in brackets represents the factor coefficient for the standardized variables

5.3. Supply chain objectives and logistics complexity

Similarly, a binary logistics regression analysis was performed to assess the accurate prediction of membership in one of the two clusters (high logistics complexity and low logistics complexity), on the basis of the four factors determined for each one of the 108 companies in the sample. There was also a good model fit and the comparison of log-likelihood ratios for models with and without these factors showed reliable improvement: Chi-square (4, N = 108) = 9.389, p = 0.05. Table IX presents the results of the binary logistic regression: coefficients, Wald statistics and significance levels. The positive signs of the predictor variables indicate that, the greater the factor, the more complex tends to be the company's logistics.

Table IX. Binary logistic regression results: objectives of supply chain management

Factor	B	Wald	Sig.
Improve cash efficiency	-.267	1.222	.269
Improve physical logistics efficiency	-.045	0.410	.840
Improve service reliability	-.479	4.444	**.035**
Improve customer responsiveness	.408	3.203	**.074**
Constant	.509	5.544	**.019**

Criterion variable: High logistics complexity vs. Low logistics complexity
Nagelkerke's R-Square = .12

The factors Improve cash efficiency and Improve physical logistics efficiency seem to constitute common objectives adopted by companies located in both clusters, since they do not present significant differences between companies with high and low logistics complexity. Here we would expect more emphasis being placed on these two efficiency-related factors by companies with lower logistics complexity but the data did not show this to be a fact. This may mean that for instance Improve cash efficiency is actually a more universally adopted objective. This should certainly deserve more research, because objectives that are not context dependent would be very important to be identified. However, the positive sign of the factor Improve service responsiveness indicates that the objectives represented by this factor are more typical of companies with higher logistics complexity. On the other hand, companies with lower logistics complexity focus their objectives to Improve service reliability. These two findings are no surprise and to a certain extent also confirm that firms with high levels of logistics complexity (normally more associated with innovative products) focus more on responsiveness (Fisher, 1997) and conversely firms with lower levels of logistics complexity (possibly more associated with functional products) focus more on service reliability. The findings of the study are synthesized in Table X.

Table X. Impact of logistics complexity on supply chain management

		Decision areas	Objectives
Factors driven by the level of logistics complexity	**High**	Market mediation management	Improve service responsiveness
	Low	Sourcing management	Improve service reliability
Factors not-driven by the level of logistics complexity (typical for both clusters of companies)		Network intelligence and integration Customer service management Physical logistics efficiency management	Improve cash efficiency Improve physical logistics efficiency

6. CONCLUSIONS AND IMPLICATIONS

This study contributes to existing contingency research in operations management by unveiling the existence of significant relationships between logistic complexity and supply chain management decision areas and objectives. Sousa and Voss recently emphasized that "contingency research is important both for the development of the operations management field and for practitioners. From a scientific perspective, operations management should provide theories that are useful across a spectrum of contexts" (Sousa and Voss, 2008, p 711). We agree. In this sense, our research tried to find some empirical evidence to support a contingency approach for supply chain management, which is currently one of the most visible and fast developing areas of operations management. The more it becomes clear that different contexts require different approaches as to decision areas and objectives to pursue, the more research can be directed towards providing theories which are better suited to each context.

More precisely, our analysis indicate that the level of logistics complexity of companies is a driver of choices in supply chain objectives and decision areas, confirming our initial proposition that at least from the view point of the companies' executives, a contingency approach for supply chain management would be the preferred choice. Our findings also confirm some of the propositions offered by Fisher (1997) in his contingency model, if we assume that his classification of products in *functional* and *innovative* bare a relation with our classification of logistics complexity. Innovative products would be more associated with higher levels of logistics complexity because of their more frequently launched products and their larger product ranges. Conversely, functional products would be more associated with lower levels of logistics complexity.

We actually found positive relationships between higher levels of logistics complexity and a higher emphasis on decision areas associated with market mediation management (activities geared towards guaranteeing a good match between supply and demand) and the objectives related to improving customer service responsiveness. All these positive correlations were in a way "predicted" by Fisher's prescriptive model. We also found a positive correlation between lower levels of logistics complexity and decision areas associated with Sourcing management and with objectives related to Improving customer service reliability. Some of these relationships are also found (although less directly) in Fisher's model.

Although this research is predominantly exploratory, our results seem to indicate that executives in the large manufacturing companies surveyed see supply chain management as an area where a contingency approach should be the best approach. Maybe they are not any more convinced that the "best practice" approach, many times offered by consulting firms and software companies as universally applicable panaceas. Maybe they already understand what the different options available are and they are now more aware of the importance of the careful analysis of aspects such as under what conditions and context the available options work best. We have not set off to specifically test the contingency model by Fisher (1997) but we found some evidence that (at least some of) its prescriptions are found in the companies we analyzed.

What is needed now is further research to help managers better understand what specifically are the contextual variables that they should look at so that they can better define the decision areas they should emphasize and the objectives they should pursue. Supply chain management is a very complex area and managers certainly could use contingency models that helped them focus on what actually matter. Fisher's prescriptive model is one example. Our empirical investigation is another example. Now maybe it is time to perform more specific research: do contingency approaches vary by industry? By degree of vertical integration? What specific decision areas are not contingent to logistics complexity? Are there some decision areas that are universally applicable for both low and high complexity contexts (as our research preliminarily identified)?

By answering these questions supply chain researchers will be adding to the effort of making supply chain management increasingly effective in making products more affordable and available, companies more sustainable and the economy healthier.

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