Analysis of Interoperability Attributes for Supplier Selection in Supply Chain Segmentation Strategy

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Abstract. Because of the competitive market, companies have been feeling the need to adjust and rethink their systems, processes and organizational methods in meeting increasingly stringent demands and imposed at speed by the environment in which they are inserted. The delay in processing information in different parts of the company as well as with their suppliers represents a major challenge for supply chains. One way for companies to adjust and rethink their organizational processes, allowing them to assess the characteristics of their relations with partner companies in their productive processes, is through the company's interoperability. This paper performs an integrative literature review checking the necessary attributes for implementing interoperability in companies. The motivation for the paper lies in vetting the necessary requirements for implementing and evaluating interoperability in order to contribute to the selection of suppliers with the ideal configuration of company environments in studying supply chain segmentation.

Keywords: Supply chain · Interoperability · Segmentation
Integrative review of literature

1 Introduction

In the current dynamic business environment, wherein companies are continuously challenged in delivering a range of products and services and with servicing customers in different segments (stores, direct sale, E-commerce), and hundreds of points of sales, a one-size-fits-all supply chain no longer achieves corporate targets and customer and shareholder expectations [1]. According to [2], companies have identified in their respective supply chains, groups of products and markets with different production features and differing commercial strategies in order to suggest a segment-specific solution for the chain that is most appropriate to each of the segments.

One approach in supply chain segmentation focusing on collaboration is proposed by [3]. In his opinion, a strong collaboration must be limited to a small number of customers and suppliers that are crucial to the company business. One of the

Á. Rocha et al. (Eds.): WorldCIST'18 2018, AISC 745, pp. 92–102, 2018.
https://doi.org/10.1007/978-3-319-77703-0_9

segmentation strategies of the supply chain is the segmentation of suppliers, through which companies create groups of suppliers to deal with them in different ways.

Therefore, suppliers and company must be evaluated with regards to the important business characteristics for the segmentation strategy. In this context, companies and suppliers have felt the need to adjust and rethink their systems, processes and organizational methods to the increasingly stricter and fast supply chain imposed by the environment in which they are inserted.

One way for companies to adjust and rethink their organizational processes, enabling the evaluation of the characteristics in the relationships among partner companies in their productive processes is through corporate interoperability. Interoperability is defined as the capacity to two or more systems or components exchange and use information [4]. Organizations that work in competitive and collaborative environments need to be flexible and connected with the links in their relationship chains, sharing their essential competencies, in order to explore the market opportunities. Thus, it is acknowledged that the development of interoperability among companies is a key factor for the success and a good performance of supply chains [5].

The evaluation of both dimensions (interoperability and business characteristics), with defined selection criteria is fundamental for business success. The Kraljic matrix [6] is the tool that will support the evaluation of suppliers in both dimensions in selecting suppliers capable of participating in the supply chain segmentation strategy.

The objective of this paper is to perform an integrative review of the literature, of the attributes required for the implement of interoperability in companies. Through these attributes undertake an evaluation of supplier interoperability in order to select appropriate suppliers for the supply strategy established in the chain segmentation study. The motivation of this paper is in checking requirements needed for the implementation of interoperability in order to contribute to the ideal configuration of the business environment and of the selection of strategic suppliers in the supply chain segmentation study.

2 Supply Chain Segmentation

The authors [1] define six ways of supply chain segmentation based on the products features, on risk mitigation and enhanced chain resiliency, on production technologies and processes, on the needs for different levels of customer service and on market characteristics. For each form of supply chain segmentation, there are specific business strategies. Knowledge of the characteristics of the chain is important in choosing the correct choice. [7] claim that current literature on supply chain segmentation, research proposes demand volume and variability as key criteria of segmentation.

The authors [1] analyzed the characteristics and criteria that influence the segmentation of supply chains. The criteria presented in Table 1 influence in operating costs and contribute to the study of the appropriate supply chain selection. Once segmentation forms, supply chain characteristics and segmentation criteria have been defined, in Table 2, the authors [1] define the segmentation strategies for each group of activities in supply, production, distribution and planning of supply chains.

Table 1. Segmentation criteria. Source: Adapted on 1.

	Segmentation criteria
Product & demand characteristics	Demand volume; Demand volatility; Product lifecycle; Forecasting ability; Product complexity; Product value; Product relevance; Contribution margin
Channel and customer characteristics	Customer type; Customer specifics; Customer priority; Customer requirements; Channel type; Order type
Supply characteristics	Component supply flexibility; Component lead-time (LT); Component supply reliability; Supply process volatility; Supply capacity constrains; Component value

Table 2. Strategic elements. Source: Adapted on 1.

	Strategic element
Supply	Contract type; Ordering (frequency, volume); Replenishment delivery; Supply planning; Single/dual/multiple sourcing
Production	Product design and portfolio; Operational focus (efficient, responsive); Production strategy (MTS, MTF, DTO, MTP, ATO); Production planning; Inventory levels
Distribution	SL; Customer order lead-time; Delivery reliability rates; Frequency of delivery; Distribution network; Transportation modes; Delivery type (direct/indirect); Delivery speed; Order management
Planning & forecasting	Forecasting time horizon; Forecasting level; Forecasting method

The segmentation strategies that consider supply characteristics as criteria require, for example, supplier and factory agility and flexibility in reacting to new products. With the comprehension of the segmentation strategy elements, the supply chain study can be started to drive suggestions of segmentation scenarios.

In order to start this study, having a definition from leadership concerning the chain link to be segment is important. In other words, if the segmentation must focus on the supply chain, logistics, industry, market, etc.

From the definition of the segmentation objective, suppliers and company must be analyzed with respect to the business characteristics important for the segmentation strategy as well as evaluating the interoperability through the necessary interoperability attributes raised in literature for implementing the supply strategy defined in the segmentation study. Given that, the interoperability attribute study becomes vital in establishing the supply chain segmentation.

3 Interoperability Attributes

Organizations that work in competitive and collaborative environments must be flexible and connected to the entities comprising their relationship chain, sharing their essential competences, in order to explore market opportunities.

Based on that, checking interoperability attributes become essential in supplier selection in the supply chain segmentation strategy. Suppliers have to be evaluated considering the interoperability attributes necessary for implementing the strategy defined in the segmentation study.

3.1 Methodology

The article was drafted following an integrative review [8] that summarizes past research to extract general conclusions from numerous studies.

The choice of this kind of review was driven by the fact of displaying the current state of the art, contributing to the theoretical development and to having direct practical applicability [8]. The model used for the review is the one shown in Fig. 1.

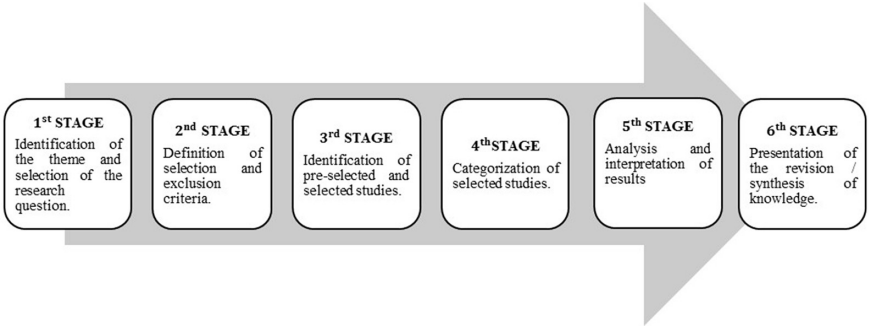

Fig. 1. Stages of integrative review. Source: Adapted on [8].

As shown in Fig. 1, the stages of integrative reviews are: **1st Stage:** Identification of the theme and selection of the research question. The first stage starts with the definition of a problem and the formulation of a research question. The next step is the definition of the key-words, of the research strategy and the database to be used [8]. **2nd Stage:** Definition of the inclusion and exclusion criteria. This stage starts the search in the database in order to identify the studies that will be included in the review. **3rd Stage:** Identification of studies selected. In order to identify the studies, the publications must be read. After that, a table with the pre-selected studies for the integrative review must be produced. **4th Stage:** Categorizing the studies. To analyze the information collected in the scientific articles, the researcher must undertake establish analytical categories that make easier sorting and summarizing each study. **5th Stage:** Analysis and understanding of the results. This stage is about discussing the texts analyzed. **6th Stage:** Presentation of the knowledge review. This last stage consists in the presentation of the main results. For this paper, the expected outcome is to check

the supply chain interoperability attributes in literature, in other words, to define the necessary requirements for the implementation of interoperability in order to contribute to the ideal configuration of a business environment and selection of strategic suppliers in the supply chain segmentation study.

3.2 Definition of Interoperability Attributes

Attributes are defined as qualities or characteristic given to a person, a group, or something. A pertaining abstraction or an entity characteristic [9]. Based on that, interoperability attributes are necessary requirements or competences for companies or supply chains wishing to achieve communication and integration capability among their systems and processes.

After the first stage established the interoperability theme and the research question for mapping attributes in the interoperability assessment, the research inclusion and exclusion criteria were defined in the second stage. The chosen keywords were "interoperability" and "supply chain". The "all fields" field was selected during the research, resulting in 368 articles found.

The database used was ScienceDirect, a platform for accessing approximately 2,500 scientific journals and over 26,000 e-books, and being the largest database of citations and summary of peer-reviewed literature: scientific journals, books and conferences [11].

The third stage identified the pre-selected and the selected studies. With 368 pre-selected articles, the set of quotes was analyzed to enable choosing the most relevant articles. In order to enrich the study, in addition to the most quoted articles, the latest articles, published in the last two years, were also included in the analysis. Thus, 50 articles, out of a total of 368, advanced to the reading stage. The 50 papers were then sorted applying the exclusion criteria with a view to preserving consistency with the previously established research question. Thus, articles unrelated to interoperability and supply chain were excluded and replaced.

In the fourth stage, after reading the 50 articles, the papers were classified according to the 15 interoperability attributes shown in Table 3. The 15 attributes were selected based on their frequency of occurrence in the papers.

Table 4 shows descriptions of the interoperability attributes found in the papers. The authors chosen and shown on Table 4 are based on the definition of the interoperability attributes most appropriate for the supply chain context. Thus, Table 4 presents a sample of the authors descriptions. The complete list of authors is exhibited on Table 3, classifying the papers read.

Table 3. Interoperability attributes

Frequency	**9**	**9**	**5**	**4**	**11**	**5**	**8**	**21**	**9**	**2**	**6**	**3**	**6**	**2**	**8**
Author(s)	Agility	Collaboration	Compatibility	Communication	Know. Sharing	Reliability	Cooperation	Ent. Structure	Integration	Lead Time	Standardization	Process	Human Resources	Responsiveness	ICT
António *et al.* (2016)				x											x
Athena (2005)	x		x					x	x						
Beguria *et al.* (2008); Chalmeta *et* al. (2010)													x		
Bennet *et al.* (2012); Humphrey (2003); Suthikarnnarunai (2008); Vanalle et al. (2011)							x	x							
Blanc (2006)		x			x										
Chalmeta *et al.* (2010); Demeter et al. (2006); Gunasekaran *et* al. (2003); Naude *et* al. (2008)		x						x							
Chen *et al.* (2008)	x				x			x	x	x	x		x		x
Chituc *et al.* (2008);Doumeingts *et* al. (2002); EIF (2010)			x												
Chow *et al.* (2006)						x									
Christopher (2002)	x							x	x					x	
CRAVE *et al.* (2008); Ducq (2007); Konstantas *et* al. (2005)															x
Daclin *et al.* (2006)				x				x							
Espadinha (2012)	x			x				x			x	x			
Grilo *et* al. (2010); Lambert *et* al. (1998); Milan *et* al. (2014)					x										
Guarnieri (2006)								x							x
Guedria (2012)	x												x		
Handfield *et* al. (2002); Taboada *et* al. (2012); Wong *et* al. (2014)								x	x						
Herve Panetto *et al.* (2015)		x		x	x				x						
Liu *et al.* (2000)	x														
M. Mourad *et al.* (2016)						x									x
ÖZTOP *et al.* (2013)					x			x		x			x		
Panetto *et al.* (2011) Veloso *et* al. (2007)							x								
Pires (2004)									x			x		x	
Pollock (2001)									x						
Pries-Heje *et* al. (2010)					x						x		x		
Ramesh *et al.* (2010)	x	x			x	x									
Salum (2013)	x	x	x		x	x	x	x							
Sarraipa *et al.* (2009)		x													
Sideren *et al.* (2011); Whitman *et* al. (2006)											x				
Stewart (1997)											x	x			
Vernadat (2009)					x			x							
Walters (2001)	x							x							x
Yeung *et al.* (2006)						x	x								

Table 4. Description of interoperability attributes

Attributes	Description	Authors
Agility	Chain agility is to deployment of market knowledge to explore profitable opportunities in a volatile environment	Hassan *et* al. (2015)
Collaboration	Collaboration is sharing resources and skills that, together, create value for customers	Hilary *et* al. (2016)
Compatibility	A state in which two things are able to co-exist or occur together without problems or conflict	Oxford Dictionaries
Communication	In communication theory, the semiotic vision defines it as a conveying a message from a sender to a receiver, using a channel	Espadinha (2012)
Knowledge Sharing	Knowledge sharing is defined as an exchange of knowledge and experiences among different groups	Grilo (2010)
Reliability	Reliability is a mutual wish of being vulnerable to the other party, reflecting the expectation of mutual cooperation	Yeung *et* al. (2006)
Cooperation	Cooperation is achieved by dividing work/tasks among participants. However, their objectives must be compatible	Luis *et* al. (2009)
Enterprise Structure	The company's technological and organizational structure enables establishing a common and standard language among the agents in the supply chain	SCOR
Integration	Supply Chain Integration (SCI) can be defined by the level of cooperation existing among a manufacturer and its supply chain partners	Zahra Lotfi *et* al. (2013)
Lead Time	The time to deliver a product or service. This time has to be measured and results have to meet customer necessities	ISO TS 16949 *et* al. (2013)
Standardization	Standardization drives supplier and partner selection and control in order to achieve product and service uniformity, compliance and quality	IS0 9000
Process	A process is a group of work activities with a beginning and end, for which there are clearly identified inputs and outputs	J. Koch *et* al. (2016)
Human Resources	Human Resources define the necessary competence/skills to perform the processes, providing training and checking actions carried out	ISO TS 16949
Responsiveness	A responsive supply chain targets customer base growth and long-term profitability through demand and production planning, with agile logistics	James Roh *et* al. (2014)
ICT	Information and Communication Technology (ICT) contribute to integrating supply chain activities through new communication models	Nor Diana Aziz *et* al. (2016)

4 Results

The fifth stage of the integrative review of literature allowed mapping of the major interoperability attributes. Table 3 illustrates the 15 attributes mapped in order of frequency of appearance in the papers. Attribute "Enterprise Structure" was found to be present 21 times, in other words, in 42% of the papers selected. This is so due to the necessary adjustments to the technological structure, tools and language systems deployed by companies and organizational sectors. These must follow a standard in order to deliver effective communication among connected parties. This was closely followed by the knowledge sharing strategy present in 11 papers, i.e., 22% of the articles selected. The exchange of knowledge, information, competences and experiences is a basic premise in interoperability.

Integration, cooperation and agility had the same frequency mention; being present in 18% of the articles. Integration and Cooperation feature similar characteristics in team work and cooperation among stakeholders involved in processes which require union for solving problems and proposing solutions in order to enhance competitiveness and add value for customers. The agility attribute is a skill that defines the supply chain's capability to react fast to consumer market driven changes.

The attributes of cooperation, ICT, human resources, standardization, compatibility, reliability, process, communication, responsiveness and lead-time are also part of the requirements for implementing interoperability. These reinforce supply chain characteristics and areas that must be explored for an efficient partnering strategy among companies and areas.

In concluding the execution of the six-stage methodology, once interoperability attributes have been defined, in the sixth stage they can be used in evaluating suppliers.

4.1 Supplier Assessment

This section introduces the applicability of interoperability attributes in supplier assessment. The objective is to evaluate supply chain suppliers applying the Kraljic [6] methodology, in order to select the ideal partner(s) for the supply strategy of the segmentation study.

In supply chain segmentation strategies involving different kinds of inventory management approaches (MTS, MTO, MTF, ATO), partner supplier agility, lead time and reliability criteria must be evaluated, given that, in particular make-to-order products, require more speed from the chain, in order to address client requests. Hence the importance of the evaluation of interoperability attributes.

Hypothetically, the objective of the supply chain segmentation strategy is to work with inventory consignment, with able suppliers, with the intention of increasing company competitiveness in a group of components. Inventory consignment is a proven inventory management technique (IM) that demonstrably improves supply chain performance. In this technique, suppliers use buyers' storage facilities to stock their items. Buyers pay sellers when items are drawn down from the inventory in consignation and released to the production line to be transformed into the final product [10].

The authors [10] have verified that analysis results show that, in a cooperative configuration – inventory consignment strategy, final products tend to achieve lower

retail prices, higher stock availability, better service channel supply efficiency and increased earnings for dealers and suppliers through the faster-than-market reaction speed to sales, increasing the service level provided to final customers. This means that consignment is an effective strategy that contributes to immediate stock availability without increasing supply chain costs. Therefore, the intent is to apply Kraljic's Matrix [6] in evaluating suppliers capable of working with the inventory consignment strategy.

Two axes (x and y) and 4 quadrants comprise the matrix. In this paper, axes x and y in the matrix are adapted to the evaluation objective, i.e., the x axis is defined by the assessment of the interoperability attributes present in suppliers, and the y axis established by the evaluation of the supplier with respect to the business characteristics pertinent to the segmentation strategy of working with suppliers capable of inventory consignation.

Table 5. Supplier evaluation through interoperability and business characteristics

	Criterion	Evaluation	Criterion Description	Total
Pivot x	Agility	Yes	Supplier agile in delivering	**1**
	Cooperation	Yes	Supplier shows cooperation characteristics	**1**
	Compatibility	Yes	Supplier presents compatibility of strategy	**1**
Pivot y	Investment	No	Adjustment in system is not necessary by supplier	**1**
	Stock policy	Yes	Safety Stock > BRL 100.000	**1**
	OTIF	Yes	OTIF above 85	**1**
	Financial evaluation	Yes	Able	**1**

The x axis shows the interoperability level by attributing points to the attributes, i.e., attributing a value of 1 when the interoperability attribute is present in the supplier characteristics. Table 5 shows the description of characteristics that suppliers must present to receive a score of 1 for each interoperability attribute.

This hypothetical example enables checking that the supplier presents characteristics of 3 interoperability attributes, therefore, scoring 3 in the evaluation. In order to achieve a complete assessment, all 15 interoperability attributes defined must be evaluated.

The y axis enables checking of business characteristics that are also important for the segmentation strategy, by attributing weighting to each criterion, in other words, attributing a value of 1 when the characteristic is present at the supplier.

Table 5 also presents the description of the criteria that supplier must display in order to receive a score 1. In this case, it is possible to check that the supplier presents characteristics from 4 of the business criteria, and therefore achieving a score of 4.

Figure 2 presents the result of Krajlic Matrix for hypothetical supplier A.

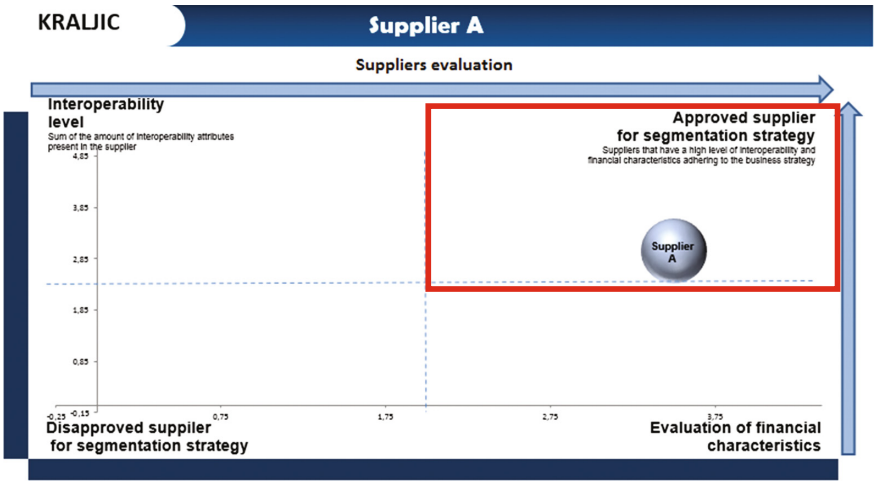

Fig. 2. Results of Kraljic matrix. Source: The author.

The results of the matrix show that supplier A meets both stock consignation demands and is capable of participating in the chain segmentation strategy. This methodology could also be applied to allow for supplier selection in other supply strategies, such as just-in-time.

Evaluating just business characteristics may not be enough for a successful supply strategy, since interoperability attributes like cooperation, IT and process are fundamental in operationalizing the chain segmentation strategy.

5 Conclusions

This paper checked the literature, from an integrative review perspective, for the main attributes required in implementing interoperability in companies, with a view to contributing to the ideal configuration of business environment and selection of strategic suppliers in supply chain segmentation studies. Applying the Kraljic methodology [6] enabled assessing supplier interoperability level and business characteristics related to the inventory consignation segmentation strategy.

The contribution of this paper lies in proposing a supplier assessment methodology for the purpose of selecting suppliers capable of successfully delivering the segmentation strategy chosen, i.e., suppliers displaying characteristics relevant to the success of the business. As well as suppliers compliant with main supply chain interoperability criteria for the inventory consignation strategy.

References

1. Deb, B.: Supply chain segmentation. TOP of Mind Isuues facing. Ernst & Young LLP. Advisory Services, Supply Chain. Ernst & Young LLP (2012)
2. Martin, C., Towill, D.R.: Developing market specific supply chain strategies. Int. J. Logistics Manage. **13**(1), 1–14 (2002)
3. Mark, B.: Understanding the meaning of collaboration in the supply chain. Supply Chain Manage. Int. J. **9**(1), 30–42 (2004)
4. IEEE. Institute of Electrical and Electronics Engineers. Standard computer dictionary: A compilation of IEEE standard computer glossaries (1990)
5. Chalmeta, R., Campos, C., Grangel, R.: References architectures for enterprise integration. J. Syst. Softw. **57** (2010)
6. Kraljic, P.: Purchasing must become supply management. Harvard Bus. Rev. **61**(5), 109–117 (1983)
7. Fichtinger, J., Chan, W.-C., Yates, N.: A joint network design and multiechelon inventory optimisation approach for supply chain segmentation, Int. J. Prod. Econ. (2017)
8. Broome, M.: Integrative literature reviews for the development of concepts. In: Concept Development in Nursing: Foundations, Techniques, and Applications, pp. 231–250 (2000)
9. Vocabulary dictionary
10. Siraj, K.Z., Mohamad, J., Simone, Z.: The consignment stock case for a vendor and a buyer with delay-in-payments. Comput. Ind. Eng. **98**, 333–349 (2016)
11. Elsevier, About Scopus (2017), https://www.elsevier.com/solutions/scopus. Accessed 18 Sept. 2017