CONNECTIVITY IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT: A FRAMEWORK

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Abstract
This paper seeks to investigate the connectivity construct in logistics and supply chain management literature. A review of existing literature is conducted regarding connectivity on a broad basis. The review is based on a general search in the ABI-Inform database for articles containing the twin search phrases of *connectivity* and *logistics*, and *connectivity* and *supply chain management*. An initial analysis of articles found resulted in a total of 195 articles, of which 76 are found to be relevant. These are categorised and analysed with regard to main issues and areas dealt with, and the impact of connectivity on logistics and supply chain management. Moreover, interacting constructs are identified and placed in relation to connectivity. The literature review and analysis are used to position current research and literature, and to identify potential gaps in research and further research needs. As a result, the features which characterise the connectivity construct are identified and a framework is proposed. The framework is valuable as it presents a holistic and comprehensive picture of the connectivity construct within logistics and supply chain management.

Keywords*: Connectivity, Framework, Literature review, Logistics, Supply chain management*

Introduction

The connectivity construct is being increasingly used in a variety of forms and contexts. In logistics and supply chain management (SCM) literature many different connectivity terms are used, e.g. information connectivity (Closs, *et al*. 2005), technology connectivity (Fawcett, *et al*. 2007), organisational connectivity (Clark, *et al*. 2001) and network connectivity (Bhatt and Troutt, 2005). This may result in a general lack of understanding of connectivity and does not facilitate communication among researchers and practitioners. The connectivity construct is also closely linked with other constructs and concepts such as visibility and traceability. This may lead to different perceptions of the constructs and of the differences between them. Thus, there is a need for a holistic view of the connectivity construct.

This paper seeks to investigate the connectivity construct in logistics and SCM literature. A review is conducted to identify features which characterise the connectivity construct. As a result, a framework of connectivity in logistics systems and supply chains is proposed. The review is also used to position current research and literature, and to identify potential research gaps and further research needs.

The structure for this paper will be as follows. In the next section, the methodology for the literature review will be presented, followed by the proposed framework and the findings from the literature review, i.e. insights on the connectivity construct. The subsequent section discusses connectivity research in logistics and supply chain management. Finally, concluding remarks will be presented and suggestions for further research are proposed.

Methodology

A review is conducted of existing literature regarding connectivity on a broad basis. The review is based on a general search in the ABI-Inform database for articles containing the twin search phrases of *connectivity* and *logistics,* and *connectivity* and *supply chain management*. The ABI-Inform database is chosen because of its comprehensive content of business and engineering periodicals. An initial analysis of articles found, eliminated journals, newspapers and magazines which have not been reviewed, as well as articles outside of the scope of this paper. This resulted in a total of 195 unique articles (see Table 1), of which 76 are found to be relevant for thorough analysis.

Search phrases in database	Number of hits in ABI-Inform
Connectivity and *logistics*	116
Connectivity and *supply chain management*	119
Total number of unique articles	195

Table 1 Articles found in the ABI-Inform database search

The 76 articles are thoroughly read and categorised and analysed with regard to main issues and areas dealt with, the impact of connectivity on logistics and SCM, research methods used, and organisational context. Inspired by Pålsson (2007), the authors categorised and structured the articles using an analytical scheme (matrix). The analytical scheme includes fields to fill with text, and fields to mark with a cross. It was developed based on the initial analysis of the articles and then further developed in an iterative manner as essential aspects became apparent in articles analysed. A total of 56 fields are to be considered for each article.

With the help of the analytical scheme a second elimination of irrelevant articles is made. Articles which only mention connectivity or articles which do not even briefly discuss connectivity are eliminated. This resulted in 36 relevant articles. These articles are finally analysed in two steps. First, the material in the analytical scheme is categorised and coded using colour matching. Secondly, mind maps are created based upon the categorised, coded material. Derived from the categorisation and content of the articles, interpretations and discussions are conducted.

Connectivity in logistics and SCM

Findings from the review indicate that there are no widespread definitions of connectivity in logistics and SCM literature. Moreover, the literature on connectivity is heterogeneous and only 6 articles deal primarily with connectivity. In most articles connectivity is used in an informal fashion in the sense of joining/integrating things. However, a common denominator identified in the literature is the situation in which connectivity is used and discussed. The main situations where connectivity is found are in those which discuss information sharing and information technology (IT). Figure 1 illustrates the identified linkages between these areas and connectivity.

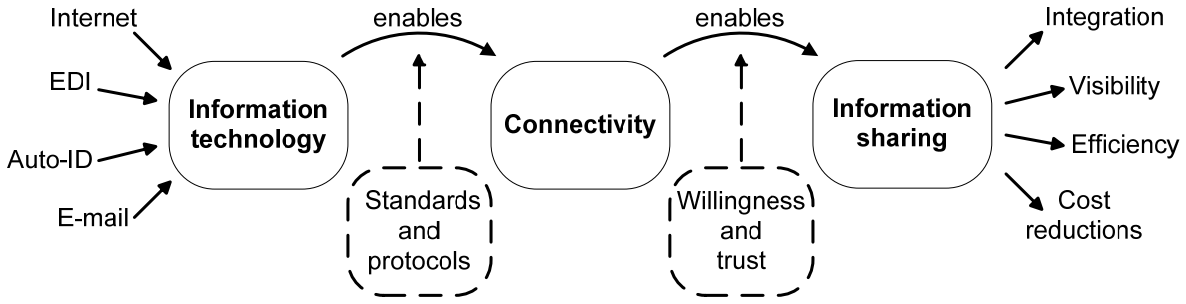

Figure 1 Framework of identified features which characterise the connectivity construct

The representation of the connectivity construct in Figure 1 shares similarities with the research of the Global Logistics Research Team at Michigan State University (1995). They argue that there are three dimensions to the information-focused capabilities of a firm: information technology, information sharing, and connectivity. Connectivity was defined as “the capability to exchange data in a timely, responsive, and usable format” (p. 160). The research findings of Zhao et al (2001) reveal that these information-focused capabilities alone do not represent a distinctive factor directly relating to firm performance, but must be used to facilitate the creation of other capabilities. Moreover, they emphasise that the impact of information technology is not manifested through hardware or a particular application such as Electronic Data Interchange (EDI); rather, information technology must be leveraged through information sharing and connectivity across departments and the supply chain.

Information sharing

In numerous articles, e.g. Fawcett and Cooper (2001), and Rishel et al (2003), connectivity is generally viewed as an enabler for information sharing. Closs et al (2005) have explicitly investigated the role of information connectivity in flexible logistics programmes, i.e. the willingness and capability to respond to unique customer requests. They argue that the information connectivity construct incorporates 1) the ability to share information with customers and suppliers, 2) effective operational information sharing, 3) information systems support 4) information directly obtained from customers and reduced reliance on forecasting, 5) supply chain collaboration, and 6) time-based logistics solutions. Their findings indicate that the role of information connectivity on logistics flexibility is more complicated than previously reported in literature. Results from their study show that information connectivity has only partially a mediation effect on delivery speed, delivery dependability and delivery consistency, while the effect on return on assets, inventory turns and low logistics costs is fully mediated. Moreover, information connectivity has no mediation effect on responsiveness, i.e. the ability to provide customisation of products, orders and delivery. This is supported by Bhatt and Troutt (2005), who also came to the conclusion that communication networks connectivity does not have a significant impact on responsiveness.

The term communications networks connectivity is used by Bhatt and Troutt (2005) and refers to the extent various systems within, and between, firms are connected for the sharing of information. They argue that communications networks connectivity consists of two factors; intrafirm- and interfirm connectivity. Their research findings indicate that intrafirm connectivity has a mediation effect between business process improvement initiatives, and customer responsiveness and product/service innovation, while interfirm connectivity has no significant mediation effect. Bhatt and Troutt (2005) emphasise that communication networks connectivity alone cannot meet the future information needs of firms. There is a need for standards and protocols to co-ordinate information systems (Fabbe-Costes, *et al*. 2006; Dias, *et al*. 2002). Besides this, efficient information sharing requires willingness from supply chain members (Fawcett, *et al*. 2007).

Fawcett et al (2007) have identified two dimensions to information sharing, connectivity and willingness. They argue that many firms recognise the need for connectivity and have invested in the connectivity capability. However, the importance of willingness is often overlooked. With high connectivity and low willingness, information sharing becomes restricted. Even though technology is in place, a lack of trust and fear of opportunistic behaviour prevents information sharing. With low connectivity and high willingness, trust is established but the resources to create adequate technological linkages are not sufficient. There is a risk that the information shared in this case might be inaccurate due to the lack of connectivity.

Clark et al (2001) conduct a study in which they propose a vertically differentiated hierarchy of interorganisational connectivity. The hierarchy consists of seven levels: physical data transfer; technology-supported document transmission; EDI; new information-intensive processes and data sharing; new policies and integrated operations; joint optimisation; and virtual channel integration. Higher levels of interorganisational connectivity enable increased information sharing. This in turn can lead to cost reductions and higher efficiency, i.e. savings in cycle times and reduction in ordering errors (Bowersox, *et al*. 2000). However, all levels of interorganisational connectivity come with both opportunities and risks. At the higher levels senior management needs to put in a lot of time and commitment. There is also a potential risk of a shift of balance in power since information is shared more greatly with increasing connectivity levels.

Information technology

Auto-ID, e-mail, EDI and Internet are the most frequently mentioned information technologies which enable connectivity. According to Kwan (1999), the Internet can be considered as the most promising network infrastructure for supply chain connectivity. By using the Internet, companies can manage their operations across the whole globe (Kwan, 1999). This view is shared by Balakrishnan et al (1999) who examined the capabilities of IT in manufacturing. They found two capabilities related to connectivity; 1) connectivity permits access and involvement in decisions by providing connections between supply chain members, stakeholders and customers; and 2) with connectivity, information can be gathered faster which can enrich decision-making processes.

The primary dimensions of e-commerce are speed and connectivity (Golicic, *et al*. 2002). The connectivity dimension of e-commerce provides new market structures through the access to new

customers. According to Golicic et al (2002) interaction and market access are two components of connectivity. By using IT such as the Internet, firms can interact and be interconnected to their suppliers and customers. Internet connectivity enables companies to access customers they were not possible to reach before the advent of to e-commerce. The interaction component of connectivity in e-commerce has been further investigated by Cullen and Webster (2007). They have developed a taxonomy by which business-to-business e-commerce transactions may be categorised. The model categorises interaction between buyers and sellers by connectivity, e.g. one to one, one to many, many to many, etc. According to Cullen and Webster (2007), this connectivity is referred to as the number of agents taking place in a transaction, where transactions take place using IT, e.g. via the Internet. Ratnasingam et al (2005) provide a similar description of connectivity in e-commerce; a technological mechanism which enables firms to be IT connected in order for them to undertake transaction exchanges.

Interacting constructs

Visibility and traceability are two constructs which are interrelated to connectivity. Surprisingly, not even one article was found which mentioned traceability, while only two articles were found which dealt with visibility. To quote Cassivi et al (2005), "visibility in the supply chain is achieved by making accurate information, such as forecasts, schedules and production capacity, accessible to all members of the chain." According to Golicic et al (2002), information visibility is achieved through connectivity. In their study they found that connectivity together with information visibility, speed, market structure and uncertainty, were emergent themes specific to the nature of conducting e-commerce, where the primary dimensions of e-commerce were found to be speed and connectivity. Responses from interviews conducted in the study indicate that responsiveness to supply chain members increases due to the visibility of real-time data via the Internet. This is in line with Cassivi et al's (2005) findings which indicate that the benefits of e-commerce partially come from visibility in the supply chain.

Discussion

The review revealed that most literature uses connectivity in an informal fashion in the sense of joining/integrating things. However, one may wonder what logistics components are joined, integrated or connected? On what organisational level does the literature discuss connectivity? To illustrate this, a diagram is presented in Figure 2. The foundation of Figure 2 rests in the 36 relevant articles found in the review. These articles are positioned in the diagram based on the authors' interpretation of what the article discusses in relation to connectivity.

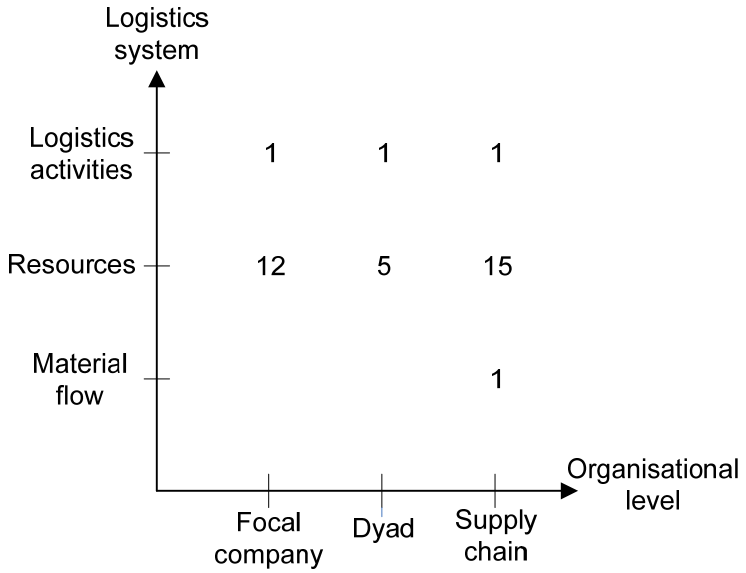

Figure 2. Connectivity in logistics systems and organisation levels

The diagram has two dimensions, i.e. organisational level and logistics system. The organisational level dimension is divided into three organisational scopes, i.e. focal company, dyad and supply chain. The logistics system dimension contains logistics activities, resources and material flow. Stock and Lambert (2001, p.4) state that the logistics system is, "a network of related activities with the purpose of managing the orderly flow of material and personnel within the logistic channel". Thus, material flow

and logistics-related activities are central components of logistics systems. Moreover, the logistics system constitutes, and is dependent on, natural, human, financial and information resources for inputs.

From a logistics systems perspective the majority of the articles focus on connecting information systems, i.e. resources. Connecting information systems is not a means in itself. One intention of connecting information systems is to connect logistics system components. Even though information systems are essential logistics resources, only a very few articles focus on connecting material flow and logistics activities. Thus, connectivity-related research needs to take one step further from focusing on information systems to focusing on logistics activities and material flow. However, it is important to bear in mind that the review is carried out on a broad basis, i.e. 14 relevant articles are published in logistics journals while the remainder are published in IT and management journals. Moreover, articles which focus on connecting information systems may indirectly seek to connect logistics activities and material flow.

From an organisational level perspective, approximately half of the relevant articles deal with connectivity on a supply chain level and the other half deal with connectivity within a single firm. Very few articles are on a dyad level. This may have a reason in the connectivity construct itself. When discussing connectivity researchers tend to either focus on "internal" connectivity within firms or on "external" connectivity in supply chains/network. This means that connectivity research on a dyad level is somewhat overlooked and could represent an area for further research. An aspect which also has to be borne in mind is that of the search phrases used in the literature search, which have an impact on the number of articles found on the different organisational levels.

Concluding remarks

This paper adds to the limited existing literature which explicitly deals with the connectivity construct in logistics and SCM. The scope of this is, by its design, limited. Therefore, it cannot be seen as an examination of the full range of the literature in the area. However, it serves as a basis for understanding the current status of connectivity in logistics and SCM and to identify potential directions for further research.

As a result of this literature review, the features which characterise the connectivity construct are identified and a framework is proposed. The proposed framework presents a holistic and comprehensive picture of the connectivity construct within logistics and SCM. It highlights the fact that connectivity represents a bridge between IT and information sharing, i.e. IT enables connectivity and connectivity enables information sharing. However, standards and protocol are needed in order for IT to enable connectivity. Similarly, willingness and trust are needed in order for connectivity to enable information sharing.

Further research

Connectivity is a relatively new construct in logistics and supply chain management. Thus, there is a need for further research. One direction for further research might be to investigate how connectivity and its identified features impact on logistics systems components. Other questions which could be of interest for the logistics- and SCM community are the following: What role will connectivity play in logistics and SCM in the coming decade? How do firms/organisations manage connectivity? What level of connectivity do firms/organisations aim for? To improve communication among researchers and practitioners within logistics and SCM it would also be worthwhile to develop a general definition of connectivity.

For future research, the purposed framework in this paper needs to be further verified and tested through the widening of the scope of the literature review. Empirical research also needs to be conducted. It would be interesting to focus on finding the level of importance of each of the enabling factors which influence connectivity. Research strategies including case studies, Delphi studies, and surveys can be employed in the further research of connectivity.

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