Chapter 16
Future Research Directions in Supply Chain Configuration Problem

16.1 Introduction

As in the case of any open and adaptive system, the structure of supply chain has evolved progressively over time from a sequential supply chain, to a global supply chain, a supply network, and alliance networks, respectively. This evolution has reflected the change in business environment from static to dynamic. In Chaps. 1 and 2, we discuss such supply chain configuration phenomenon and shed light on its sources and causes. It was also observed that various components of supply chain have a significant impact on its structure. So what does the future hold for the supply chain configuration problem? To answer this question, we review the anatomy of a supply chain from the perspective of trends and opportunities and their impact on its structure. Then, we propose an agenda for future research in supply chain configuration, which takes into account the confluence of interdisciplinary research and the increasing use of emerging technologies.

16.2 Trends and Opportunities in Supply Chain Configuration

To prognosticate trends and opportunities in the area of supply chain configuration, one only has to review some of the vital issues driving the development of manufacturing and logistics in the twenty-first century (Lasi et al. 2014; NRC 1998):

- Increasing consumer expectations for customized products has led to demand segmentation and fragmentation.
- Next wave of globalization has changed traditional regional division of labor in international supply chains.

C. Chandra, J. Grabis, *Supply Chain Configuration*,
DOI 10.1007/978-1-4939-3557-4_16

- Environmental issues are addressed in a more holistic manner rather than just focusing on individual aspects such as carbon emissions. That has increased importance of supply chain traceability and accountability.
- Resilience to withstand random disturbances in the inter-connected world has come to the forefront of supply chain management implying that efficiency without flexibility is not sufficient.
- Products as well as supply chain processes are increasingly digitized, thus blurring boundaries between the physical and digital products and operations.
- Information technologies, such as cloud computing provides ample computational power for solving complex configuration problems and sharing data. Internet of Things allows for capturing data at their origination and mobile technologies enable easy communication (Tien 2015).

Mass customization enabled production of customized products efficiently. However, nowadays customers often become a part of product development, manufacturing, and delivery activities (Wu et al. 2013). For instance, additive manufacturing allows customers to print spare parts. Demand is also increasingly fragmented because new groups of customers are appearing and products are consumed in increasingly specific contextual situations.

Traditional patterns of supply chains have witnessed various forms of transformation. For instance, South-East Asia has long been a region supplying components and performing contract manufacturing in the electronics industry for supply chains serving customers in the USA and Europe. Nowadays, customers are scattered around the world and Asian companies increasingly develop and market their own products. Companies assume different roles in supply chains and products flow in different directions. At the same time, customers require greater transparency in supply chains which is more difficult to attain in networked supply chains. Governmental regulatory requirements are often superseded by a variety of informal guidelines of ethical behavior (Yusuf et al. 2014).

Strong emphasis on cost reduction and lean practices has been challenged by a string of exceptional events ranging from natural disaster to man-made calamities. Supply chain evaluation according to multiple-criteria and risk management emerges as one of the critical supply chain management areas (Heckmann et al. 2015).

Development of information technologies affects supply chains in different ways. The physical products are packaged together with digital products and services, and costs for opening warehouses are replaced by costs associated with establishing digital distribution avenues involving channel development, marketing; including social marketing and establishing integrated business models. Contractual issues are becoming particularly important for the combined physical–digital products since revenues and liabilities are often attained indirectly and over prolonged periods of time. On the other hand, information technologies play a major role in increasing supply chain flexibility by reducing communication cost, transforming delivery channels, and providing instantaneous access to data about supply chain process, products, and customers.

16.3 Future Research Agenda

The aforementioned trends motivate future supply chain configuration research agenda. The increasing customer expectations and the digital–physical blur can be addressed by focusing on solution supply chain rather than product-oriented supply chains. Networked and efficient logistics clusters capture opportunities provided by globalization and clusters act as multipurpose units in global supply chains. New business models are needed in the solution supply chains and environmentally and socially conscious supply chains. Big data as the basis for big modeling contributes to development of resilient supply chains.

The increasing role of information technologies and digital products in supply chains has the potential of creating unique capabilities for improving supply chain management. Therefore, it is befitting to recognize that it will have a prominent role in defining the agenda for future research in supply chain configuration. As described in previous chapters, information sharing and information integration are two of the key problems in supply chain management. As the size of the supply chain network grows, there is an exponential increase in the amount of data—and, therefore, information and eventually knowledge—that needs to be acquired, stored, managed, processed, and serviced for various decision-making needs, while managing the supply chain. This problem needs efficient solution both from an operational perspective (forecasting and inventory management), as well as development of efficient information processing methodologies and techniques. *Cyberinfrastructure* offers that venue for supply chain configuration research.

More specifically, the key dimensions to be considered for future research in supply chain configuration area are as follows:

Design of Problems. As we have elaborated in previous chapters, supply chain configuration can have potentially a complex web of problems, which may have to be dealt at different decision-making levels. These problems need to be coordinated to design efficient problem-solving solutions. Therefore, the design of new supply chain solutions must account for appropriate relationships among these problems. For instance, product design and environmental issues are well embedded in the current supply chain configuration models while collaborative business models underlying the supply chain partnership is a future research area.

Design of Solutions. The development of solutions for modification to supply chain information systems, and the integration of advanced decision-making components by adopting modern software engineering techniques, offers opportunities for better supply chain management. Big data increasingly finds application in managerial decision-making. Big modeling (i.e., large-scale integration of decision-making models) is the next step in design of solutions (Tolk 2014). It would enable evaluation and comparison of large number of supply chain evolution scenarios from multiple perspectives.

A System-of-Systems Approach is needed to design complex supply chain networks. This is especially true as supply chains assume global proportions, whereby the number of entities and their relationships multiply disproportionately. It also recognizes the concept-to-fruition notion of product and service delivery, which in the case of a supply chain may sometime span several heterogeneous and independent systems, and must be integrated together to be effective in delivering the product. The systems approach could emerge as one of key techniques for dealing with globalization and resilience related challenges.

Standardization and Interconnectedness. Adopting standards facilitates meta-modeling and implementation of complex networks, thereby saving on development time for a system. The Supply Chain Operations Reference (SCOR) model is an example of successfully applying industry process standards to conceptual modeling of supply chain networks (Stewart 1997). Similarly, web technologies have contributed to achieving Interconnectedness. Data driven and decision-enabled supply chain processes (Deokar and El-Gayar 2011) require further integration especially concerning exchange and joint utilization of decision-making data.

Design-Time and Run-Time Reconfigurability of Supply Chain. Design-time reconfiguralibility is required to deal with customer demand fragmentation, short life-cycle products, small series production and resilience issues. A new or revised existing customer requirement for a product specification may spawn modifications and/or enhancements, with potential impact on the physical and logical systems enabling the realization of the product. The ramifications of such changes should be considered during the conceptualization phase in product design. Changes in product specification typically affect the essential ingredients for competitiveness—namely, minimal cost, lead time, and optimal product variety. The complexity of changes in such a system is magnified when the design, manufacture, and logistics of the product is accomplished in a distributed environment. The contextual information plays an important role under these circumstances. Context aware supply chains capable of changing their behavior in run-time in response to changing context are one of the future solutions to attain reconfigurability.

Solution supply chains. The cloud chain concept introduced in Chap. 12 demonstrates integration between physical and digital units in supply chains. Similarly, supply chains increasingly serve their customers by providing solutions (Cavalieri and Pezzotta 2012) combining physical and digital products as well as services. This kind of supply chains can be referred to as solution supply chains and the main focus of their configuration is development of the right product–service mix and establishing mutually beneficial relationships in the network of solution providers. Solution supply chains are likely to be supported by cyberphysical supply chain processes similarly as in the case of Industry 4.0 (Pisching et al. 2015).

The agenda for future research in supply chain configuration must recognize the urgent need for providing solutions that particularly satisfy public policy applications. A generic example of this is the design of supply chain configuration for the *unknown*, which may be any of the following applications:

- Geopolitical issues and cross-country relationships.
- Community issues affecting local (i.e., region, city), state, country, and global levels.
- Mega-disasters, including man-made and natural disasters.

- Cybersecurity.
- Disease prevention and control.
- Management of environmental issues.
- Public finance issues.
- Energy consumption and preservation issues.

These issues are tightly related with reverse logistics, green supply chains, long-term sustainability, and supply chain transparency. Concerning sustainability, a major concern is balancing the typical 2–10 years planning horizon with environmental and social sustainability targets having substantially longer planning horizons. Supply chain configuration tools could be a decision-making tool not only for commercial enterprises, but for governmental institutions to investigate potential impact of particular regulatory requirements.

Other future areas of research are improving computational capabilities of supply chain configuration models and techniques. In this regard, an important area is elaboration of methods for integration of models in decision modeling, and models in information systems design, to offer integrative decision-modeling capabilities. These could certainly be tied to research in cyberinfrastructure to recognize an inter-operable environment offered by the Internet.

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