Industrial Marketing Management xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Industrial Marketing Management

journal homepage: www.elsevier.com/locate/indmarman

Centralized vs. decentralized supply chains: The importance of decision maker's cognitive ability and resistance to change

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ARTICLE INFO

Keywords:
Behavioral factors
Problem solving ability
Resistance to change
Centralization
Decision-making
Supply chain
Supply chain performance
NK simulation

ABSTRACT

This paper contributes to behavioral supply chain management research, by examining the influence of managers' problem solving ability and resistance to change as regards their choice of the level of centralization to adopt in the management of a supply chain. Since such factors play a critical role in influencing decision maker behavior, they are expected to moderate the relationship between the centralization of decisions and performance. A methodology coming from complexity science is adopted, i.e. NK agent-based model, which is particularly suited to the study of supply chains as complex systems and the modelling of decision-makers as cognitively limited agents. The model proposed reproduces how supply chain managers solve different types of decision-making problems and simulate the resulting supply chain performance in two cases: high and low centralization. The main results show that high levels of problem solving ability and low resistance to change positively moderates the relationship between centralization and supply chain performance. We also find that high centralization should be preferred for complex decision-making problems, especially when the manager is characterized by a high problem solving ability and low resistance to change. In the other cases, low centralization is an option to take into consideration.

1. Introduction

Supply chains consist of interconnected firms that are involved in different processes and activities producing value in the form of products and services, which are delivered to the ultimate consumers. They include raw material suppliers, suppliers of components and work in process products, assemblers, and final product distributors (Christopher, 1992; Harland, Lamming, Zheng, & Johnsen, 2001).

Supply chains can be managed by adopting different levels of centralization. High centralization occurs when decision-making power is concentrated in one party/single decision maker (Aiken & Hage, 1968; Auh & Menguc, 2007; Giannoccaro & Pontrandolfo, 2004). The vendor managed inventory program (VMI) is an example of a centralized supply chain, where the supplier makes the decisions concerning the inventory control both for itself and the buyer (Darwish & Odah, 2010). Conversely, a low level of centralization (decentralized approach) characterizes supply chains where each firm independently manages its own decisions (Christopher, 1992; Stock, Greis, & Kasarda, 2000; Carbonara, Giannoccaro, & Pontrandolfo, 2002; Cousins, Lamming, Lawson, & Squire, 2008; Giannoccaro, 2011). In such a case, there are multiple supply chain managers each making local decisions and pursuing local interests (Giannoccaro & Pontrandolfo, 2004). As an example, in a decentralized inventory control system, the supplier and the retailer independently manage their own inventory (Duan & Liao, 2013; Saharidis, Kouikoglou, & Dallery, 2009).

The choice of the level of centralization to manage the supply chain is a critical issue, because it affects supply chain performance. For example, a high level of centralization of inventory control is beneficial for supply chain performance since improves efficiency and reduces the bullwhip effect (Fu, Ionescu, Aghezzaf, & De Keyser, 2014; Lee, Padmanabhan, & Whang, 1997). High centralization has also proved to be valuable for managing complex problems (Giannoccaro, 2011; Novak & Eppinger, 2001), and in an uncertain environment (Duan & Liao, 2013).

However, in the majority of studies on the topic, an implicit assumption is made: the managers involved in a governance system, whatever the level of centralization may be, are assumed to be completely rational and informed. Full rationality implies that a manager is able to gather all the needed information, has the ability to make the optimal decision by analyzing the information collected, and behaves for the best interest of the system. However, human decision makers behave very differently from these approximations in practice (Simon, 1979). As well described by Simon (1990) with his scissor analogy, they should deal with both their cognitive limitations and environmental complexity. Managers' personal motives and their behavioral attributes profoundly affect the decision-making process (Bendoly, Donohue, &

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https://doi.org/10.1016/j.indmarman.2018.01.034
Received 11 April 2017; Received in revised form 11 December 2017; Accepted 26 January 2018

Schultz, 2006; Mantel, Tatikonda, & Liao, 2006). Furthermore, complex and dynamic decision-making situations force human decision makers to adopt a variety of cognitive heuristics, which add vulnerability to judgment and decision biases (Carter, Kaufmann, & Michel, 2007; Katsikopoulos & Gigerenzer, 2013). Thus, the assumptions above appear to be too simplistic and the need to introduce behavioral factors mandatory.

Our research aim is thus to investigate the influence of manager behavioral factors on the relationship between centralization and supply chain performance. In doing so, we contribute to a new field of study, i.e. Behavioral Supply Chain Management, which concerns the study of the interaction between human behavior and supply chain management (Bendoly et al., 2006; Carter et al., 2007; Croson & Donohue, 2002; Croson, Schultz, Siemsen, & Yeo, 2013; Katsikopoulos & Gigerenzer, 2013; Siemsen, 2009).

In particular, we focus on two behavioral attributes, i.e. problem solving ability and resistance to change. Previous studies have shown that individual problem solving ability influences decision-making in supply chains. Cantor and Macdonald (2009) have analyzed the effect of different individual problem solving approaches (abstract vs. concrete) on supply chain performance. Non-rational decision-making approaches and biases commonly incurred by human decision makers have been also investigated (Gino & Pisano, 2008; Kaufmann, Carter, & Buhrmann, 2010; Kaufmann, Carter, & Buhrmann, 2012). Individual problem solving ability also involves the cognitive ability to conceive alternative solutions to the problem under investigation and the processing power to evaluate the outcomes of the alternatives. These aspects may affect the efficacy of centralization. When a supply chain is centrally managed (for example in the case of a VMI system), both these abilities are required most, because a single individual in the supply chain makes a large number of decisions which also concern the supply chain partners. This poses a challenge to any decision maker whose problem solving ability is not sufficiently developed and performance may therefore suffer. As a result, a centralized approach (VMI system) could become detrimental, compared to a decentralized one. To the best of our knowledge, no study has considered the influence of individual problem-solving ability on the efficacy of centralization. We intend to overcome this gap.

Furthermore, we consider that a supply chain manager is characterized by his/her idiosyncratic level of resistance to change. Resistance is a natural part of the change process (Zaltman & Duncan, 1977) and individuals differ in terms of their ability and willingness to adapt to change (Bovey & Hede, 2001). In particular, we consider that a decision maker might prefer to adopt sub-optimal solutions even though a better one is known, because he/she prefers to maintain status quo for fear of poor outcomes, fear of the unknown, and fear of realization of faults (Dubrin & Ireland, 1993). Resistance to change determines an inability to change, with a consequently negative effect on performance, which may be more pronounced in the case of high centralization, where a single decision maker makes decisions for the supply chain, compared to the case when decisions are distributed among several individuals. We study how the degree of decision makers' resistance to change affects the efficacy of centralization.

Thus, our main contribution to the literature is to show that decision makers' problem solving ability (resistance to change) positively (negatively) moderates the relationship between centralization and supply chain performance. Therefore, supply chain managers responsible for centralized systems should be paid particularly attention to their decision-making behavior so as to fully exploit the expected benefit of centralization.

In addition, such an analysis is performed for different types of decision-making problems, which differ in terms of the structure of interdependencies. Interdependencies cause conflicting aims among supply chain firms and make complex the solution of decision-making problem (Simchi-Levi, Kaminsky, & Simchi-Levi, 2000). The need to resolve the multiple trade-off arising from interdependencies calls for appropriate levels of centralization (Giannoccaro, 2011). This choice however could also depend on managers' problem solving ability and resistance to change. We consider three stylized decision-making problems, differing in degree and pattern of interdependencies: the sequential, modular, and complex ones. These cover a wide range of supply chain problems, characterized by increasing complexity. We analyze how the relationship between centralization and supply chain performance is affected by the decision-making problem and the moderating effect played by the examined behavioral factors.

We use the Kauffman's (1993) NK simulation as research methodology. The field of behavioral operations often relies on laboratory experiments (Bendoly et al., 2006; Croson et al., 2013), as the best methodology to capture the behavioral attributes of decision makers and their influence on performance. However, there is no need to limit behavioral research to this approach (Giannoccaro, 2013). In particular, we believe that NK simulation is particularly valuable for diverse reasons. It is appropriate for studying complex adaptive systems such as supply chains (Choi, Dooley, & Rungtusanatham, 2001; Giannoccaro, 2011; Pathak, Day, Nair, Sawaya, & Kristal, 2007; Surana, Kumara, Greaves, & Raghavan, 2005) and suited to the development of simple theories (Davis, Eisenhardt, & Bingham, 2007) with the aim of enriching our understanding of fundamental processes (Axelrod, 1997). Furthermore, NK simulation has been successfully applied to study multi-firm contexts such as alliances (Aggarwal, Siggelkow, & Singh, 2011) and supply chains (Capaldo & Giannoccaro, 2015a, 2015b; Giannoccaro, 2011). Modelling the decision-making process of organizations and examining the efficacy of different coordination mechanisms is proven to be particularly valuable (Gavetti & Levinthal, 2000; Rivkin & Siggelkow, 2003; Siggelkow & Rivkin, 2006). This method has been used to investigate the effect of centralization on firm performance (Siggelkow & Levinthal, 2003; Siggelkow & Rivkin, 2005). In all these studies, the decision-making process is modelled as an adaptive search performed by agents (decision-makers) with bounded rationality. These also follow the tradition of creating simple yet insightful models containing only the features essential to the problem at hand (Axelrod, 1997; Siggelkow & Rivkin, 2005; Siggelkow & Rivkin, 2006), like the one here. Therefore, this approach is well suited to the explorative aim of this research (Siggelkow, 2011). In particular, we extend the NK simulation approach in order to model decision-making problems in the supply chain context and to include the problem solving ability and resistance to change of the searching agent.

The paper is organized as follows. First, the literature background and theory of the study is presented. Then, the NK model is discussed and the simulation analysis described. Finally, the results are illustrated and managerial implications derived.

2. Literature background

2.1. Centralization in the management of the supply chain

Centralization is a widely established construct in organizational literature. It refers to the concentration of the authority and the decision-making power in one or few parties of a system (Aiken & Hage, 1968). In a supply chain context, centralization is referred as to the extent to which a single firm (i.e. the focal company) makes decisions for the firms belonging to the supply chain (Christopher, 1992; Cousins et al., 2008; Fu et al., 2014; Giannoccaro, 2011; Giannoccaro & Pontrandolfo, 2004; Stock et al., 2000). In the case of full centralization, the supply chain is coordinated by a single decision maker, who has the authority to make the decisions for the supply chain partners so as to optimize the overall performance. For example, in the case of a centralized inventory management process, like the vendor managed inventory program, the supplier makes all the decisions concerning the inventory management activities for both itself and the buyer (Duan & Liao, 2013). In the case of a low level of centralization, independent decision makers exist in the supply chain, who make local decisions