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Supply chain integration and operational performance: The contingency effects of production systems

Yongyi Shou[a], Ying Li[b], Youngwon Park[c], Mingu Kang[a,*]

[a] School of Management, Zhejiang University, PR China
[b] School of Management, Shandong University, PR China
[c] Graduate School of Humanities and Social Sciences, Saitama University, Manufacturing Management Research Center, University of Tokyo, Japan

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ABSTRACT

The boundary conditions of supply chain integration (SCI) have been widely studied in order to find out when SCI is applicable and effective. However, prior studies have mainly focused on external contextual factors, such as supply complexity, environmental uncertainty and country-level infrastructure. This study contributes to the SCI literature by examining the contingency effects of internal production systems on the relationship between supplier integration, customer integration and operational performance. Based on organizational information processing theory, we provide evidence to show that the impact of supplier and customer integration on operational performance varies across production systems, such as one-of-a-kind production, batch production and mass production systems. The empirical results also reveal how supplier and customer integration can be matched with different configurations of production systems in order to achieve the desired quality, flexibility, delivery or cost performance.

1. Introduction

Supply chain integration (SCI) indicates strategic collaboration, information-sharing, joint decision-making and system-coupling between the manufacturer and its supply chain partners, especially in the production phase (Alfalla-Luque et al., 2013; Demeter et al., 2016; Flynn et al., 2010; Kauppi et al., 2016). In prior studies, scholars have confirmed the positive effects of SCI on operational performance (OP). Some studies have examined the contextual conditions under which SCI is effective (Sousa and Voss, 2008). For example, Wong et al. (2011) demonstrate that environmental uncertainty moderates the relationship between SCI and OP. Similarly, Gimenez et al. (2012) indicate that SCI improves performance, but only when the buyer-supplier relationship is characterized by high supply complexity. Wiengarten et al. (2014) extend the literature by considering the role of a country's logistics capability in external SCI.

However, most extant studies on the contextual conditions of SCI focus on the effects of external environmental factors. Few studies have considered internal factors. In a conceptual paper, Ellram et al. (2007) suggest taking product and process characteristics into consideration and establishing an appropriate match between product design, process design and supply chain structure. Tsinopoulos and Mena (2015) assert that manufacturers' internal process structure and product newness require different supply chain configurations at different stages of the product life cycle. Using qualitative data from British manufacturers, Tsinopoulos and Mena (2015) conclude that firms tend to implement supplier integration (SI) and customer integration (CI), especially in the case of high customization and low-volume production, whereas external integration is not particularly necessary for production with high standardization and high volume. In short, it is very important to fit external integration decisions with internal organizational characteristics in order to yield better OP. Nevertheless, limited empirical evidence is available in the extant literature to support the in-depth analysis of how external SCI matches with internal process structures in order to determine individual dimensions of OP.

To address this research gap, this paper aims to empirically explore the boundary conditions (Busse et al., 2017) where external SCI (i.e., SI and CI) is effective in terms of quality, flexibility, delivery or cost improvement by analyzing the contingency effects of internal production systems. One-of-a-kind production (OKP), batch production (BP) and mass production (MP) systems are regarded as three main kinds of production system in modern manufacturing practices. Consequently, this study attempts to answer the research question: *How can manufacturing firms utilize external SCI to achieve the desired OP, given their production system configuration?*

In response to the research question, this paper applies the lens of

* Corresponding author.
E-mail address: jiangmq@zju.edu.cn (M. Kang).

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organizational information processing theory (OIPT). OIPT insists that an organization should align its information-processing capability with information-processing requirements under different conditions (Galbraith, 1973). In prior studies, scholars have investigated SCI as an information-processing system to cope with task interdependence and uncertainty based on OIPT (Hult et al., 2004; Srinivasan and Swink, 2015; Wong et al., 2011). SI and CI can improve an organization's information-processing capability through inter-organizational flows and information-sharing mechanisms (Flynn et al., 2016), as well as by establishing lateral and collaborative relationships with supply chain partners (Srinivasan and Swink, 2015). Production systems, including OKP, BP and MP, differ from each other in terms of the number of variants, lot sizes, automation, specificity of the equipment, and control of production (Woodward et al., 1965; Tu and Dean, 2011). We speculate that the operation of different production systems may have distinct information-processing requirements, which should be matched with different configurations of SI and CI in order to achieve superior OP.

This paper contributes to the boundary condition research on SCI. Based on a survey of 791 firms, our findings provide empirical evidence concerning the importance of the fit between SCI and production systems. This study poses both theoretical and managerial implications.

2. Theoretical background and hypotheses development

2.1. The relationship between SCI and operational performance

There is a growing body of research on the theory and practices of SCI. Integration is elaborated as collaboration (which suggests joint goals and collaborative behaviors) and interaction (which indicates formal communication and information exchange). Correspondingly, external SCI is defined as the degree to which a manufacturer strategically collaborates with its suppliers and customers, as well as collaboratively manages cross-firm business processes (Flynn et al., 2010; Wong et al., 2011). In this study, strategic collaboration, information-sharing, joint decision-making and system-coupling are emphasized as key elements of external SCI (Alfalla-Luque et al., 2013; Demeter et al., 2016; Flynn et al., 2010; Kauppi et al., 2016; Wiengarten et al., 2014). Specifically, in an integrative relationship, manufacturers and their supply chain members engage themselves in sharing information about sales forecasts, production plans, order tracking and tracing, delivery status and stock level. Meanwhile, all the supply chain activities are based on risk- or revenue-sharing and long-term agreements. When contingencies happen, they are willing to make decisions jointly and solve problems together in order to maximize benefits for the whole supply chain. In order to achieve the unified control of inter- and intra-firm processes, system-coupling with suppliers and customers, for example, vendor managed inventory (VMI), just-in-time (JIT), kanban and continuous replenishment, is required in the SCI relationship.

According to OIPT, the success of an organization's activities depends on its information-processing capability to deal with uncertain environments (Galbraith, 1973). SI and CI provide the routines and rules with which to coordinate and control the flow of information and to enhance the firm's information-processing capability (Wong et al., 2011) through information-sharing, system-coupling, collaboration and joint decision-making, which can help the firm to perform effectively in terms of cost, quality, delivery and flexibility. In an integrative relationship, supply chain members are willing to exchange and share information about their inventory, production, logistics and sales. Meanwhile, system-coupling among manufacturers, suppliers and customers establishes a platform for the collection and integration of information in the whole supply chain, which in turn improves supply chain transparency and further ensures in-time delivery and supply chain flexibility. In addition, the manufacturer and its suppliers and customers make joint and collaborative decisions on product and process design, quality improvement and cost control when they are involved in an integrative relationship. Information-sharing and system-coupling help the manufacturer to access and integrate information in the supply chain, while joint decision-making enhances manufacturers' capability in processing a wide range of information. Accurate, adequate and timely supply chain information can help reduce inventories, speed up production cycles and improve flexibility (Flynn et al., 2016). Thus, SI and CI contribute to the improvement of OP. Accordingly, we hypothesize that:

H1.. *SI is positively associated with the firm's OP, including (a) quality, (b) flexibility, (c) delivery and (d) cost.*

H2.. *CI is positively associated with the firm's OP, including (a) quality, (b) flexibility, (c) delivery and (d) cost.*

2.2. The contingency effects of production systems

The production system refers to the arrangement of technological elements (e.g., machines and tools) and organizational behavior (e.g., division of labor and information flow). Based on technical complexity and the continuity of manufacturing, Woodward et al. (1965) classify production systems into small batch, mass and continuous process production. Later on, given the increasing market demand for customized or individualized products, an OKP system emerged in manufacturing plants (Wortmann, 1992) due to its high flexibility and efficiency. Continuous process production is not typically found in most manufacturing industries. Hence, OKP, BP and MP are considered as three main systems in modern manufacturing firms' production practices. Table 1 summarizes the characteristics of the three types of production system.

As shown in Table 1, OKP, BP and MP systems differ from each other in terms of flexibility, the number of variants, lot sizes, automation, specificity of the equipment, and control of production (Woodward et al., 1965; Hayes and Wheelwright, 1979; Safizadeh et al., 1996; Tu and Dean, 2011). Therefore, we speculate that different configurations of production system indicate different requirements for information.

Specifically, the manufacturer with an OKP-dominated production system delivers highly customized products (e.g., customized windows and doors, structural steel for construction and special industrial equipment) to individual customers (Tu and Dean, 2011), meaning it needs a large amount of information about product specifications from

Table 1
Characteristics of production systems.

Production system	Product	Lot size	Production conditions	Flexibility
One-of-a-kind production (OKP)	Highly customized products	Small; manufacturing items singly	Relying more on skilled human labor and advanced technology with significant flexibility	High flexibility enables a quick response to customers' individual requirements
Batch production (BP)	Similar products with variants	Middle; manufacturing items by batch	The need to stop and prepare materials, equipment or machines between batches	A certain degree of flexibility should be ensured to produce variants
Mass production (MP)	Highly standard products	Large; manufacturing items by continuous production	Using assembly line techniques and automatic machines to achieve continuous production	A production line with little flexibility is hard to switch, once it is launched