



Product variety management and supply chain performance: A capability perspective on their relationships and competitiveness implications

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ABSTRACT

We study 363 manufacturing businesses to investigate the relationships between product variety management and supply chain performance. Applying the dynamic capabilities view of how businesses cope with changing environments, we develop a conceptual model that links product variety management strategies with supply chain responsiveness, and relates supply chain responsiveness to cost and customer service in high- and low-customization environments. We find that a product variety management strategy influences both supply chain cost and customer service performance only when mediated by internal and external responsiveness capabilities. In addition, a product variety management strategy has different impacts on performance depending on the level of product customization. Specifically, in a low-customization environment, both supply chain flexibility and agility acting as dynamic capabilities have a significant influence on cost efficiency while in a high-customization environment, these dynamic capabilities have a significant influence on customer service.

1. Introduction

In recent years, there has been a growing trend for businesses to increase their product and service variety offerings in order to provide more consumer choice and create opportunities to outperform competitors. Most of the extant literature reports an advantageous relationship between an increase in product variety and performance, and suggests that the provision of a high level of product variety positively influences perceived brand quality and repeat business (Berger et al., 2007), customer satisfaction (Lifang, 2007), firm performance (Worren et al., 2002), and market share (Yeh and Chu, 1991). However, Wan et al. (2012) cautioned that “there can be too much of a good thing” as beyond the optimal level of product variety, sales performance would decline. However, a corollary to the general, positive relationship between product variety and performance at the firm level is the notion that as product variety increases, production and delivery performance is expected to suffer as a result of higher direct labour and material costs, higher manufacturing overhead costs (e.g., materials handling, quality control, information systems, and facility utilization), longer delivery lead times, and higher inventory levels (Salvador et al., 2002; Forza and Salvador, 2001). Therefore, there appears to be a trade-off between market performance, and operations and supply chain per-

formance due to the production and market mediation costs, and complexity incurred to the supply chain when product variety is increased (Randall and Ulrich, 2001). Consequently, product variety has significant implications for both production and supply chain processes, so when decisions are made to increase product variety, the response cannot be ad hoc. Rather, not only are the internal operations of the manufacturer required to be supportive and responsive but, equally, supply chain partners have to be in accord and sufficiently responsive to meet changes in customer requirements (Yang and Burns, 2003). Responsiveness is a concept associated with dynamic capabilities which refer to ‘the firm’s ability to reconfigure internal and external competencies’ required to adapt to changing customer needs and technological opportunity (Teece, 1997, 2007). Thus, in this research, we conceptualize responsiveness as comprising two components, namely operating-level responsiveness, which is an internal capability referred to as *supply chain flexibility*, and organizational and inter-organizational responsiveness, which is an external capability referred to as *supply chain agility*. This is in general agreement with Bernardes and Hanna (2009), who, in analyzing the conceptual disparities associated with the usage of the terms responsiveness, flexibility, and agility, concluded that flexibility is an operating characteristic, while agility is more a business-level organizing

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paradigm. Both flexibility and agility are perceived as necessary for achieving variety-related ambitions. In addition, we recognize that supply chains are composed of both internal production activities, and external activities associated with collaboration and coordination of channel partners.

There are many technologies, initiatives, and concepts that manufacturers can employ to help deliver the requisite levels of supply chain flexibility and agility to support their desired levels of product variety. These include product configuration toolkits (Piller, 2004), collaborative networks (Lyons et al., 2013), proximate supply between a production facility and the target market (Lyons et al., 2006; Randall and Ulrich, 2001), scale-efficient production facilities (Randall and Ulrich, 2001), component sharing (ElMaraghy et al., 2013; Abdi and Labib, 2004), postponement (Scavarda et al., 2010; Nair, 2005), product modularity (Aoki et al., 2014; Jacobs et al., 2011; Scavarda et al., 2010), process modularity (Jacobs et al., 2011; Holweg and Pil, 2004), cellular manufacturing (Selim and Muge, 2006; Qiang et al., 2001), and multi-skilling of the workforce (Berry and Cooper, 1999). These various product variety management strategies (PVMSs) have the potential to mitigate the negative impacts of product variety on supply chain performance (Scavarda et al., 2010), and yield improvements in flexibility and/or agility. A number of studies have provided theoretical frameworks for the management of product variety in supply chains (Blecker and Abdelkafi, 2006; Ramdas, 2003; Thonemann and Bradley, 2002; Ulrich et al., 1998), and investigated the impact of a specific strategy such as postponement (Davila and Wouters, 2007; Nair, 2005) on operations and/or supply chain performance. However, such studies and the extant literature have not revealed the effectiveness of a PVMS for mitigating the negative effects of product variety on overall supply chain performance, and have not provided a clear mechanism through which the mitigation effects on supply chain performance occur.

We conduct this study to fill the empirical research gap by investigating the impact of a PVMS on supply chain performance, whilst being mindful of the decision support potential of the research for supply chain practitioners and policy makers. We are motivated by the need to gain a better understanding of how manufacturers can build capabilities to compete and succeed in the face of frequent changes in product variety. Considering product variety management as an organizational capability in this research, we apply the dynamic capabilities view as the theoretical underpinning to address the question of how organizations cope with changing environments by harnessing internal capability in terms of supply chain flexibility and external capability in terms of supply chain agility (Barreto, 2010; Teece et al., 1997). Extending the primarily internally-focused, resource-based view (RBV) of the firm to dynamic markets, dynamic capabilities theory explains how and why firms can gain a competitive advantage in situations of rapid change (Eisenhardt and Martin, 2000). We regard a PVMS, and flexibility and agility as a hierarchy of organizational capabilities that harness and consume firm resources to support the provision of the requisite product variety. We assess organizational supply chain performance in terms of both cost efficiency and customer service (see Khan et al., 2009).

Customization is predicated on the level of customer involvement (Lampel and Mintzberg, 1996), and the performance of a supply chain can be attributed to a match or a mismatch between the type of product and the supply chain design (Fisher, 1997) that relates to the level of customization. For example, functional products that use efficient supply chains typically have low levels of customization and focus more on cost efficiency, while innovative products with responsive supply chain strategies typically have high levels of customization more focused on customer service. Therefore, as a moderating factor, product variety and supply chain performance necessarily require the concept of customer involvement (i.e. customization) to be considered.

This study has two aims. First, we attempt to establish and verify that a PVMS influences supply chain responsiveness in terms of supply

chain flexibility (an internal capability) and supply chain agility (an external capability), and that supply chain flexibility and agility in turn influence cost and customer service performance. This concept of dynamic capability helps explain the structural relationships among the constructs concerned, providing a basis for manufacturers to mitigate the trade-off between product variety and supply chain performance. Second, we attempt to demonstrate the relative, differential impacts that a PVMS has on supply chain performance under different customization regimes. These findings have important managerial implications for the selection and adoption of different dynamic capabilities according to level of customization.

We organize the rest of the paper as follows: In the next section we present a literature review on the strategies to manage product variety and the approaches to enhance supply chain performance. We then present the research model, formulate the hypotheses, and discuss the survey design. In the following section we analyze the data, and discuss the research results and their theoretical and managerial implications. In the final section we conclude the paper, discuss the study limitations, and suggest topics for future research.

2. Conceptual background and literature review

2.1. Product variety management strategy (PVMS)

In this study, a Product Variety Management Strategy (PVMS) is defined as a key organizational strategic capability to mitigate the impact of product variety on supply chain performance. Scavarda et al. (2010) suggested that, in order to mitigate the trade-off between product variety and supply chain performance, PVMSs can be broadly grouped into three classes: modularity (i.e. product-based strategy), operations flexibility and postponement (i.e. process-based strategy). Pil and Holweg (2004) supported these three classes and noted that modularity, flexible manufacturing structure and late configuration are fundamental variety management strategies. In addition, ElMaraghy et al. (2013) investigated strategic firm capabilities to achieve profit from variety and recommended postponement, modularisation and cellular manufacturing. In the following sections we explain the three classes of PVMSs proposed by Scavarda et al. (2010) in detail.

Used to provide a high level of end-item variety while maintaining a low level of component variety and assembly complexity during production (Fisher et al., 1999), modular designs have been found to be central to increasing product variety in new ventures (Patel and Jayaram, 2014). Product modularity eases outsourcing of production to a manufacturer's suppliers, so internal manufacturing operations can be simplified (Kaski and Heikkila, 2002; Salvador et al., 2002; Kim and Chhajed, 2000). Employing the concept of modularity also allows manufacturers to share developmental burdens arising from the increase of product variety with component suppliers (Aoki et al., 2014). In addition the impact of uncertain demand forecasts can also be reduced through modularity (van Hoek et al., 1999).

While a product-based strategy such as the use of product modularity concerns changes to product architectures, a process-based strategy concerns making changes to production and distribution processes (Fisher et al., 1999; Blecker and Abdelkafi, 2006) using processmodularity in order to able to support changing customer needs through enhanced operations flexibility (Erlicher and Massone, 2005). Examples include cellular manufacturing, postponement and production technologies such as adaptive process control and additive manufacturing. McCutcheon et al. (1994) highlighted the use of cellular manufacturing as an approach to process design to address the customization-responsiveness squeeze. Cellular manufacturing systems are broadly employed to manage product variety through the provision of enhanced manufacturing flexibility and process standardization (Yeh and Chu, 1991; Selim and Muge, 2006). da Silveira (1998) observed the variety-enhancing capability of cellular manufacturing. Cellular manufacturing is an inclusive, process-based PVMS as it is often composed

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