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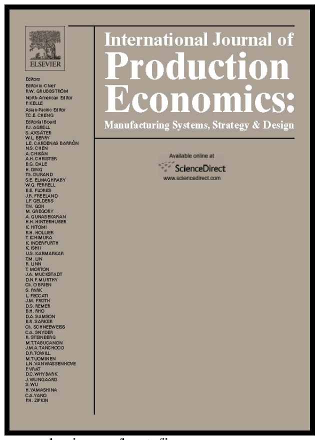

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PRODUCT VARIETY MANAGEMENT AND SUPPLY CHAIN PERFORMANCE: A CAPABILITY PERSPECTIVE ON THEIR RELATIONSHIPS AND COMPETITIVENESS IMPLICATIONS

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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.

Keywords: product variety; supply chain performance; customization; dynamic capabilities; structural equation modelling

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 & Chu, 1991). However, Wan et al. (2012) cautioned that “there can be too much 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 & Salvador, 2001). Therefore, there appears to be a trade-off between market performance, and operations and supply chain performance due to the production and market mediation costs, and complexity incurred to the supply chain when product variety is increased (Randall & 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 & 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 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 & Ulrich, 2001), scale-efficient production facilities (Randall & Ulrich, 2001), component sharing (ElMaraghy et al., 2013; Abdi & 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 & Pil, 2004), cellular manufacturing (Selim & Muge, 2004; Qiang et al., 2001), and multi-skilling of the workforce (Berry & 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 & Abdelkafi, 2006; Ramdas, 2003; Thonemann & Bradley, 2002; Ulrich et al., 1998), and investigated the impact of a specific strategy such as postponement (Davila & 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 & 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 & 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 & Jayaram, 2014). Product modularity eases outsourcing of production to a manufacturer's suppliers, so internal manufacturing operations can be simplified (Kaski & Heikkila, 2002; Salvador et al., 2002; Kim & 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; Feitzinger & Lee, 1997).

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 & 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 standardisation (Yeh & Chu, 1991; Selim & Muge, 2004). da Silveira (1998) observed the variety-enhancing capability of cellular manufacturing. Cellular manufacturing is an inclusive, process-based PVMS as it is often composed of a series of quick changeover manufacturing processes and makes use of advanced production technologies to produce items in single or small lots. Cellular manufacturing is predicated on group technology principles such as production flow analysis (Yasuda & Yin, 2000), and parts classification and coding systems (Warren, 2001), so parts with similar design characteristics and/or processing requirements can be grouped into families. The similarities of the production items within part family groupings enable firms to economically produce small batch sizes through reductions in set-up time and work-in-progress inventory, and using groups of machines (cells) to produce each part family (Abdi & Labib, 2004; Qiang et al., 2001). The result is a series of highly productive manufacturing units where the benefits of a high-volume manufacturing methodology can be employed in a high-variety environment.

Postponement at the point of product differentiation has received considerable attention as one of the most beneficial concepts for reducing the costs and risks of product variety, and improving the performance of supply chains (Davila & Wouters, 2007). Postponement often involves outsourcing and requires extensive reconfiguration of the supply chain (van Hoek, 1999) to delay the point at which product variations assume unique identities (Blecker & Abdelkafi, 2006). This in turn implies that additional external variety can be made available post-factory using the mass production of semi-finished components. Bowersox and Closs (1996) suggested three types of postponement, namely form, time, and place, which refer to the processing stage in the supply chain, the time at which postponement occurs, and the position in the supply chain in which postponement occurs, respectively.

2.2. Supply chain performance and dynamic capability

Studies in supply chain management have employed a multitude of performance measures (Gunasekaran et al., 2001; Arntzen et al., 1995; Lee & Billington, 1993). Developing a performance management framework for supply chain systems, Beamon (1999) identified three types of performance measures as crucial components of a supply chain performance measurement system, namely resource, output, and flexibility. Resource measures provide goals associated with cost efficiency (e.g., total cost of resources, inventory, manufacturing, and distribution incurred in the supply chain). Output measures provide goals associated with customer service, which cover customer satisfaction, customer response times, on-time deliveries, order fill rates, customer complaints, backorders/stock-outs, manufacturing lead times, and shipping errors. Flexibility, the final type of performance measure, is regarded as the functional ability to respond to a changing environment (Beamon, 1999). Based on the performance structure of Beamon (1999), Khan et al. (2009) proposed that supply chain-driven organizational performance is separated into three categories, namely resource performance that reflects value added in terms of achieving efficiency, output performance that reflects value added in terms of a firm's ability to provide high levels of customer service, and flexibility performance that reflects value added in terms of a firm's ability to respond to changes. Most of the previous studies on flexibility have been focused on a range of inter-organizational capabilities for a single manufacturer (Thome et al., 2014) and considered flexibility based on supply, manufacturing and logistic dimensions (see Swafford et al., 2006; Esmaeilikia et al., 2014). We regard supply chain flexibility and agility as distinct concepts in this research. Specifically, supply chain flexibility represents internally-focused manufacturers' capabilities and responsiveness in a firm's internal functions such as purchasing, production and distribution flexibility. On the other hand, agility refers to externally-focused manufacturers' competencies that emphasize speed (i.e., reaction time) at the organizational level, so it is concerned with rapid market responsiveness, delivery reliability, and frequency of product introduction (Swafford et al., 2008).

This differentiation of a firm's internal and external activities conforms to Teece et al.'s (1997) dynamic capabilities theory, which concerns a "firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (p. 516) which allows firms to maintain a competitive advantage. Thus, distinctive performance requires the creation of new products and processes and the implementation of new organizational forms and business models (Teece et al., 2007). Also, improving the mismatch between supply and demand of products with short life-cycles and unpredictable demand continues to attract attention from supply chain managers (Kuthambalayan et al., 2015). Thus, the provision of a dynamic capability such as rapid response in a supply chain has great potential in a dynamic environment, particularly in an environment with a high level of customization. Based on our viewpoint, supply chain agility is regarded as a dynamic capability that is derived from flexibilities in the supply chain processes.

2.3. Customization

A high-variety offering acts as a proxy for customization, but true customization requires customer involvement during product specification. For example, product variety can be defined as the number of different versions of a product presented by a firm at any single point in time (Randall and Ulrich, 2001). However, the product can be differentiated according to the stage in the value chain where customization occurs, i.e., at the point where customer input is injected (Lampel & Mintzberg, 1996). Thus, the degree of customer involvement (i.e., the decoupling point) is pivotal in determining the degree of customization (Duray et al., 2000). A number of researchers delineate customization into various types, or along a standardization/customization continuum (Amaro et al., 1999; da Silveira et al., 2001; Duray et al., 2000; Gilmore & Pine, 1997; Lampel & Mintzberg, 1996; Mintzberg et al., 1988; Poulin et al., 2006). Lampel and Mintzberg (1996) proposed a customization framework that comprises five types, namely pure standardization (PS), segmented standardization (SS), customized standardization (CS), tailored customization (TC), and pure customization (PC). PS concerns products that are produced on a large scale and distributed commonly to all. In SS, products are standardized within a narrow range of features, where customization occurs during distribution (i.e., delivery and packing). In CS, products are made-to-order from standardized components that are mass-produced for an aggregate market, where assembly is customized. In TC, the firm presents a product prototype to a buyer and tailors it to the buyer's wishes or needs during fabrication. PC provides a unique product design on which customer input is taken into account at the beginning of the design process. In this study, we considered the decoupling point position of each customization type.

3. Research framework and hypothesis development

PVMSs may reduce the negative impacts of product variety on supply chain performance by fostering supply chain flexibility and/or agility. Supply chain flexibility and agility can be harnessed to support the achievement of both supply chain cost efficiency and superior customer service. By implication, a PVMS can have a significant impact on cost efficiency and customer service. In order to achieve the dual goals of cost efficiency and superior customer service, flexibility and agility are fostered as an internal function capability and an external response capability, respectively, and can be rationalized by dynamic capabilities theory (Teece et al., 1997). This coalition of cost efficiency, customer service, (internal) flexibility, and (external) agility is in concert with both Beamon's (1999) and Khan et al.'s. (2009) recommended portfolios of supply chain performance measures. Figure 1 presents the conceptual model that guides our research to investigate the relationships between PVMS, supply chain flexibility, agility, cost efficiency, and customer service. The use of PVMSs implies a degree of dynamism in the external environment of the focal firm, an apposite setting for applying the dynamic capabilities perspective (Barreto, 2010) as the theoretical grounding for our study. The proposed links are complex and have not been adequately specified or empirically explored in the extant literature.

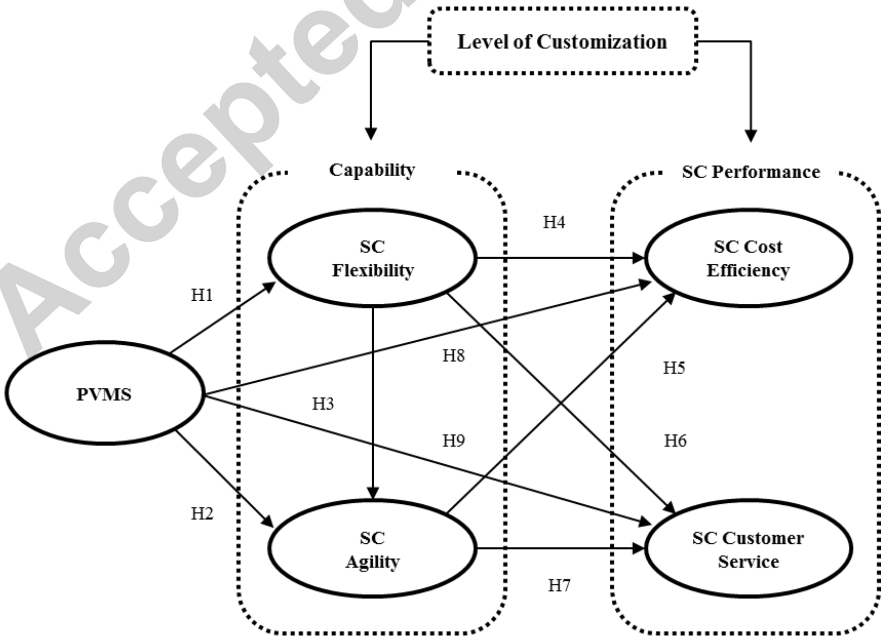

Figure 1. The research model.

The research model provides a means to empirically examine how different classes of PVMS are related to supply chain flexibility and agility, and how, in turn, supply chain flexibility and agility are related to supply chain customer service and cost efficiency. In the model, supply chain flexibility and agility act as intermediate variables that mediate the links between a PVMS and supply chain cost efficiency and customer service.

A PVMS can be product- or process-based. In this study we use prominent strategies to exemplify the two PVMS classes. Product modularity is used to represent the product-based PVMS, cellular manufacturing and postponement are used to represent the process-based PVMS. These three mitigating strategies are regarded as latent variables that can act as potential antecedents to achieve dynamic capability. In particular, the modular concept is used to reduce the complexity and associated cost in product development, sourcing, and manufacturing (Holweg & Pil, 2004; Forza & Salvador, 2002) and supports the process of cellular production and postponement, which can improve dynamic capabilities. Building on these concepts, we propose the following hypotheses about the putative links among the variables of interest in our study:

H1: A PVMS is positively related to a firm's dynamic capability.

H1a: A PVMS is positively related to a firm's supply chain flexibility.

H1b: A PVMS is positively related to a firm's supply chain agility.

The agility concept has experienced increasing attention in supply chain management research (Blome et al., 2013). Based on empirical research, Swafford et al. (2006) found that an organization's supply chain process flexibility is an important precursor of supply chain agility. From the dynamic capabilities perspective, agility relies on various capabilities, i.e., various forms of flexibility (see Swafford et al., 2008), so flexibility is expected to boost supply chain agility. Flexibility is defined as a requisite internal dynamic capability to achieve supply chain agility (Swafford et al,, 2006; Thome et al., 2014; Esmaeilikia et al., 2014). Therefore, we propose:

H2: Supply chain flexibility is positively related to supply chain agility.

Supply chain flexibility measures the chain's internal capability to adapt to changes without incurring high costs (Chan, 2003). It has been suggested that agility can be achieved through synergies of flexibility (Swafford et al., 2008), and facilitates the achievement of resource efficiency, and high levels of customer service and responsiveness, leading to competitiveness improvement in volatile business environments (Hiroshi & David, 1999). Therefore, dynamic capabilities generate competitive advantages for a supply chain in a fast-changing environment (Blome et al., 2013). Cost efficiency in this research is a performance measure concerned with a firm's ability to minimize the costs associated with managing its supply chain operations, while customer service provides goals associated with supply chain output measures such as customer satisfaction, customer response times, on-time deliveries, order fill rates, customer complaints and manufacturing lead times. Based on these notions, firms employ flexibility and agility as internal and external capability levers, respectively, to support their pursuit of both high supply chain cost efficiency and superior supply chain customer service (Vickery et al., 1999). Thus, we postulate:

H3: Dynamic capability is positively related to supply chain performance

H3a: Supply chain flexibility is positively related to cost efficiency.

H3b: Supply chain agility is positively related to cost efficiency.

H3c: Supply chain flexibility is positively related to customer service.

H3d: Supply chain agility is positively related to customer service.

A PVMS concerns the development of competencies to strike a proper trade-off between product variety and supply chain performance. Previous researchers proposed that PVMSs have direct positive relationships with both cost efficiency (see Anderson, 2004; Graves & Tomlin, 2003) and customer service (see Davila & Wouters, 2007). For example, set-up cost, manufacturing cost, manufacturing overhead cost and lead time can be reduced by modularity (Anderson, 2004). Modular architectures also reduce manufacturing and supply chain costs by increasing the number of common components and modules, ensuring a low incremental cost for producing product variations (Worren et al., 2002). Cellular manufacturing promotes cost effective changeovers (Christopher, 2000) and improves equipment utilization and product quality (Bhandwale and Kesavadas, 2008). This is because cellular manufacturing improves flexibility through the creation of cells, which are modified flow shops processing parts with similar designs and/or manufacturing characteristics, thus streamlining changeovers and facilitating small lot sizes. Postponement improves supply chain performance (Davila & Wouters, 2007). For example, postponement position (the customer-order decoupling point) is often close to the market (van Hoek, 2001), which can explain the strong relationship between postponement and customer service. Thus, to ascertain the direct impact of a PVMS on cost efficiency and customer service, and verify the claims made by these studies, we propose the following hypotheses:

H4: A PVMS is positively related to the supply chain performance

H4a: A PVMS is positively related to the cost efficiency performance of a supply chain.

H4b: A PVMS is positively related to the customer service performance of a supply chain.

However, we formulate two final hypotheses to examine the relative performance impacts of a PVMS according to different levels of customization. Stavrulaki and Davis (2010) stressed the alignment between the key aspects of a product and its supply chain processes (from build-to-stock to design-to-order). Therefore, the level of customization can be regarded as a moderating factor on the relationships between a PVMS and supply chain performance.

In addition, the aim of a PVMS differs according to the level of customization. Supply chain flexibility and agility, regarded as internal and external capabilities respectively, are expected to have significant impacts on customer service in a customized environment (see Stavrulaki & Davis, 2010). Similarly, although all PVMSs may not be chosen practices for some organizations in low-customization environments, these practices are expected to support the achievement of cost efficiency through flexibility and agility. For example, an environment with a low level of customization uses standard modules without options or component swapping. However, if the degree of customization increases, modules can be altered or components can be fabricated to provide for the unique requirements of the customer (i.e. component sharing) (Duray et al., 2000). Improved agility conveys the ability to efficiently change operation states in response to changing market conditions (Narashimhan et al., 2006) through reduction in setup time and cost. Consequently, we propose:

H5: In a low-customization environment, both supply chain flexibility and agility have a more significant influence on cost efficiency than customer service.

H6: In a high-customization environment, both supply chain flexibility and agility have a more significant influence on customer service than cost efficiency.

Table 1 summarizes the study constructs, measurement items, and related references for the research model.

Table 1. Constructs, measurement items, and related references.

Construct	Measurement item	Related literature
Modularity	Use of product modularity	(Aoki et al., 2014 ; Patel & Jayaram, 2014; Jacobs et al., 2011; Scavarda et al., 2010; Blecker & Abdelkafi, 2006; Salvador et al., 2002; Ulrich & Tung, 1991)
Cellular manufacturing	Groups parts with similar design and process	(Scavarda et al., 2010; Blecker & Abdelkafi, 2006; Abdi & Labib, 2004; Ko & Egbelu, 2003; Yeh & Chu, 1991)
Postponement	Delay of the process that transforms the form and function of products until customer orders have been received	(Aoki et al., 2014 ; Scavarda et al., 2010; Nair, 2005; van Hoek *et al.*, 2001; Whang & Lee, 1998)
Supply chain flexibility	Changes in quantity of orders to suppliers	(Esmaeilikia et al., 2014; Swafford *et al.*, 2008; Narasimhan & Das, 1999)
	Changes in times of orders placed with suppliers	(Swafford *et al.*, 2008; Narasimhan & Das, 1999)
	Changes in production volume	(Esmaeilikia et al., 2014; Swafford *et al.*, 2008; Sethi & Sethi, 1990; Gerwin, 1987)
	Changes in production mix	(Esmaeilikia et al., 2014; Swafford et al., 2008; Duclos et al., 2003; Sethi & Sethi, 1990)
	Implement engineering change orders in production	(Esmaeilikia et al., 2014; Swafford et al., 2008; Gerwin, 1993)
	Alter delivery schedules to meet changing customer requirements	(Esmaeilikia et al., 2014; Swafford et al., 2008 ; Duclos et al., 2003; Slack, 1983)
Supply chain agility	Rapidly reduce product development cycle time	(Blome et al., 2013 ; Hallgren & Olhager, 2009; Swafford et al., 2008; Agarwal et al., 2006; Goldman et al., 1995)
	Rapidly reduce total lead time	(Swafford et al., 2008; Agarwal et al., 2006; Sharifi & Zhang, 1999)
	Rapidly increase the level of product customization	(Blome et al., 2013 ; Hallgren & Olhager, 2009; Swafford et al., 2008; van Hoek et al., 2001)
	Rapidly increase level of customer service	(Swafford et al., 2008; Sharifi & Zhang, 1999; Goldman et al., 1995)
	Rapidly improve delivery reliability	(Swafford et al., 2008; Sharifi & Zhang, 1999)
	Rapidly improve responsiveness to changing market needs	(Blome et al., 2013 ; Swafford et al., 2008; Goldman et al., 1995)
	Rapidly reduce delivery lead time	(Swafford et al., 2008; Goldman et al., 1995)
Cost efficiency	Ability to minimize total cost of resources used	(Sezen, 2008; Beamon, 1999)
	Ability to minimize total cost of distribution (including transportation and handling costs)	(Sezen, 2008; Beamon, 1999)
	Ability to minimize total cost of manufacturing (including labour, maintenance, and re-work costs)	(Aoki et al., 2014 ; Zelbst et al., 2009 ; Sezen, 2008; Beamon, 1999)
	Ability to minimize total inventory holding cost	(Aoki et al., 2014 ; Sezen, 2008; Ramdas & Spekman, 2000; Beamon, 1999)
Customer service	Order fill rate	(Blome et al., 2013 ; Sezen, 2008; Beamon, 1999)
	On-time delivery	(Blome et al., 2013 ; Sezen, 2008; Kim, 2006; Beamon, 1999)
	Customer response time	(Sezen, 2008; Vickery et al., 2003; Beamon, 1999)

Product quality	(Blome et al., 2013 ; Sezen, 2008; Beamon, 1999)
Order lead time	(Sezen, 2008; Beamon, 1999)
Customer complaints reduction	(Sezen, 2008; Kim, 2006; Ramdas & Spekman, 2000; Beamon, 1999)
Customer satisfaction	(Ramdas & Spekman, 2000; Beamon, 1999)
Stock-out reduction	(Beamon, 1999)

4. Methodology

4.1. Sample and data collection

We employed a survey to collect data for this study. After conducting a pilot test based on interviews with five manufacturing firms, we sent the final questionnaire to 1,950 manufacturing firms by postal mail and by telephone in the UK and South Korea. We selected manufacturers based on their standard industrial classification (SIC) codes. We included a covering letter in the questionnaire to explain the purposes and significance of the study. As suggested by Weisberg et al. (1996), we made follow-up phone calls (or e-mail) to the non-respondents to increase the response rate. At the end of the survey period, we received completed questionnaires from 363 firms (211 from the UK and 152 from South Korea), representing an 18.6% response rate. This is an acceptable number of respondents (> 271) with which to investigate relationships, including marginal effects, with a 0.8 statistical power and a 0.05 significance level (Forza, 2002). We surveyed the opinions of CEOs (21.2%), directors (26.4%), and managers (33%). While 59.1% of the firms are small and medium-sized enterprises (SMEs), 40.9% are large enterprises (LEs) in terms of the number of full-time employees ($N > 250$). Table 2 categorizes the respondent firms by their product sectors.

Table 2. Survey respondents.

Manufacturing industry type	Total	Valid %
Food, beverage, tobacco	26	7.2
Wood and furniture	32	8.8

Chemical materials and products	28	7.7
Non-metal mineral products	15	4.1
Fabricated metal products	33	9.1
Computer and communication products	26	7.2
Electric parts and components	41	11.3
Electric machinery and equipment	39	10.7
Transport equipment	38	10.5
Textiles and leather	8	2.2
Paper products	11	3.0
Machinery and equipment	32	8.8
Basic metal products	8	2.2
Clothing and footwear	11	3.0
Other	15	4.1
Total	363	100%

To estimate the likelihood of late response bias, we follow the procedure suggested by Armstrong and Overton (1977). The results of *t*-tests suggest no difference at the 0.05 level between early and late respondents, indicating an absence of response bias. To test for common method bias, we use Harman's one-factor test. We conducted a principal component factor analysis on all the items in the study, resulting in five factors with eigenvalues above 1 (accounting for 66.7% of the total variance, with the largest accounting for 16.1%). Since no single factor is apparent in the un-rotated factor structure, the common method variance problem is not an issue in this study.

Since samples are collected from two countries, a measurement invariance test was applied by using two separated samples. The aim of the test is to confirm that the basic structure of the model is cross-culturally stable and individuals in two countries use its scale in a similar manner (Malham and Saucier, 2014). Therefore, as suggested by Chen (2007), we conducted multi-group CFA estimation and the indices for the baseline model (i.e. the same items load on the same factor) show an acceptable fit to the data ($\chi 2/df = 2.04$, RMSEA = 0.054, SRMR = 0.606, CIF = 0.903) whereas the indices for the constrained model (i.e. factor loading) are $\chi 2/df = 2.01$, RMSEA = 0.053, SRMR = 0.609, CIF = 0.903, suggesting that measurement invariance is supported across the two countries. Also, the chi-square difference test ($\Delta\chi^2$) was not significant and there was no substantial difference in fit, which means that the data from the two countries do not suggest the presence of measurement bias (Milfont and Fischer, 2010).

4.2. Measurement

PVMSs represent the policies and activities that a firm employs to support the provision of product variety. We focus on three prominent PVMSs, namely, modularity, cellular manufacturing and postponement. We invited respondents to indicate their firms' levels of agreement to a series of questions pertinent to various PVMSs on a five-point Likert scale (1 = strongly disagree and 5 = strongly agree). For example, we asked respondents to respond to the statement "We delay the process that transforms the form and function of products until customer orders have been received" to indicate the extents of their firms' engagement in postponement. Also, we measure the elements of supply chain performance and capability on a five-point Likert scale (1 = poor and 5 = excellent). Based on the framework of Lampel and Mintzberg (1996), we invited respondents to report on the customization type of their firms' core product families. Using cluster analysis, we segregate the data on customization into two levels, namely low customization (mean centre = 2.15, n = 207) and high customization (mean centre = 4.43, n = 156).

4.3. Measurement validation

We conducted confirmatory factor analysis (CFA) to determine measurement reliability in terms of composite (CR), convergent, and discriminant validity. Table 3 shows the results with a supporting caption presenting the fit indices. We use CFA instead of exploratory factor analysis (EFA) because we form an *a priori* theory on the links between the item measures and their structures. This suits the use of structural equation modelling (SEM) as an approach to test both the model and hypotheses. SEM facilitates the examination of not only the bivariate relationships between single interacting variables but also the overall causal fit of a holistic model (Worren et al., 2002). Shah and Goldstein (2006) provided a detailed and discipline-relevant description of SEM.

We deleted six items from the list of dependent and independent variables because their loadings are lower than 0.7, namely two items from flexibility, one item from cost efficiency, and three items from customer service performance. Removing these item measures with insignificant factor loadings from the scale reduces the number of construct indicators without sacrificing content validity, while enabling a leaner, more parsimonious analysis. Despite the deletion of FL2 and FL5, the supply chain flexibility construct includes item variables related to purchasing, manufacturing, and distribution. Similarly, the cost efficiency construct concerns the ability to minimize costs in terms of purchasing, manufacturing, and distribution (without CE4; see Table 3). Pertaining to customer service, CUS5 is related to CUS3, CUS6 to CUS7, and CUS8 to CUS1 (see Table 3). Therefore, using the results from the purified constructs does not affect content validity.

Table 3. Confirmatory factor analysis.

Structure	Code	Abbreviated item statement	Factor loading	CR	AVE
PVMS	PVMS1	Level of modularity in product	0.736	0.782	0.544
	PVMS2	Level of cellular production that groups parts with similar design and process	0.789		
	PVMS3	Level of process delay that transforms the form and function of products until customer orders have been received	0.724		
Supply chain flexibility (FL)	FL1	Ability to change the quantity of orders to suppliers	0.696	0.870	0.627
	FL2	Ability to change the timing of orders placed with suppliers	D		
	FL3	Ability to change production volume	0.819		
	FL4	Ability to accommodate changes in production mix	0.797		
	FL5	Ability to implement engineering change orders in production	D		
	FL6	Ability to alter schedules to meet changing customer requirements	0.722		
Supply chain	AG1	Ability to rapidly reduce product development cycle time	0.709	0.906	0.579

agility (AG)	AG2	Ability to rapidly reduce lead time	0.775		
	AG3	Ability to rapidly increase the level of product customization	0.727		
	AG4	Ability to rapidly improve level of customer service	0.704		
	AG5	Ability to rapidly improve delivery reliability	0.748		
	AG6	Ability to rapidly improve responsiveness to changing market needs	0.754		
	AG7	Ability to rapidly reduce delivery lead time	0.765		
Cost efficiency (CE)	CE1	Ability to minimize total cost of resources used	0.768	0.851	0.656
	CE2	Ability to minimize total cost of distribution (including transportation and handling costs)	0.730		
	CE3	Ability to minimize total cost of manufacturing (including labour, maintenance, and re-work costs)	0.704		
	CE4	Ability to minimize total inventory holding costs	D		
Customer service (CUS)	CUS1	Order fill rate	0.743	0.914	0.682
	CUS2	On-time delivery	0.810		
	CUS3	Customer response time	0.782		
	CUS4	Product quality	0.697		
	CUS5	Order lead time	D		
	CUS6	Customer complaints reduction	D		
	CUS7	Customer satisfaction	0.719		
	CUS8	Stock-out reduction	D		

Composite Reliability (CR) = $(\sum \text{standardized loading})^2 / \{(\sum \text{standardized loading})^2 + \sum \varepsilon_i\}$
Average variance extracted (AVE) = $\sum(\text{standardized loading})^2 / (\sum(\text{standardized loading})^2 + \sum \varepsilon_i)$
Note: Fit indices: χ^2/df (chi square) = 421.326 /199 = 2.11, GFI (goodness of fit index) = 0.907, SRMR (standardized root mean square residual) = 0.042, RMSEA (root mean squared error of approximation) = 0.055, CFI (comparative fit index) = 0.942 (D = deleted item)

After deleting the redundant items, we re-tested the model using CFA. The measurement model offers an acceptable fit to the data (χ^2/df = 421.326/199 = 2.11, GFI = 0.907, SRMR = 0.042, RMSEA = 0.055, CFI = 0.942). CR shows acceptable internal consistency (CRs > 0.782). Convergent validity is assured since all the loadings are greater than 0.7, with acceptable average variance extracted values (AVE > 0.544). Table 3 reports the factor loadings, CR, and AVE, with the fit indices. There is no case where the square of the correlation between a pair of constructs is greater than the AVE of the constructs. Thus, we confirm discriminant validity using the procedures suggested by Fornell and Larcker (1981) (see Table 4). We conducted multi-group SEM to compare the different relationships in the model and coefficients of both the low-customization and high-customization models. The imposition of the equality constraint deteriorates the model fit significantly ($p < 0.05$).

The results indicate that the path coefficients across the groups differ significantly (Byrne, 2001). Thus, the models across the groups are comparable.

Table 4. Inter-construct correlation estimates and related AVEs.

	PVMS	FL	AG	CE	CUS
PVMS	0.544 +				
FL	0.501**	0.627 +			
AG	0.504**	0.701**	0.579 +		
CE	0.217**	0.436**	0.451**	0.656 +	
CUS	0.264**	0.524**	0.514**	0.466**	0.682 +
Mean	3.26	3.49	3.24	3.39	3.81
SD	0.872	0.708	0.731	0.640	0.591

+ =Average variance extracted, * represents significant at the 0.05 level and ** 0.01 level.

5. Results

5.1. SEM analysis

We performed a SEM analysis in order to examine the impact of a PVMS on each of the constructs relating to supply chain performance. The model paths have high *t*-values (≥ 2.65) and acceptable *p*-values (< 0.05) with the exceptions of the direct links between a PVMS and cost efficiency and customer service. The fit indices of GFI (0.904), CFI (0.939), RMSEA (0.057), and SRMR (0.053) indicate an acceptable fit with the model.

Thus, the results presented in Table 5 support hypotheses H1, H2 and H3. However, H4a (i.e., the relationship between a PVMS and cost efficiency), and H4b (i.e., the relationship between a PMVS and customer service) are rejected. Figure 2 depicts the SEM diagram with the path coefficients and levels of significance.

A PVMS exhibits significant direct impacts on supply chain flexibility ($p < 0.001$) and agility ($p < 0.01$). Supply chain flexibility impacts agility significantly ($p < 0.001$). In addition, a PVMS ($p < 0.01$) has a positive and significant impact on both cost efficiency and customer service via supply chain flexibility and agility.

Table 5. Structural equation model results.

Construct (Combined sample)	Path coefficient	*t*-value	Significance
PVMS – Flexibility	0.502***	7.30	0.000
PVMS – Agility	0.204**	3.30	0.001
Flexibility – Agility	0.599***	8.18	0.000
Flexibility – Cost efficiency	0.2**	2.65	0.005
Flexibility – Customer service	0.350***	3.89	0.000
Agility – Cost efficiency	0.306**	3.60	0.001
Agility – Customer Service	0.312***	3.21	0.000
PVMS – Cost Efficiency	-0.079	-1.02	0.310
PVMS – Customer Service	-0.072	-1.04	0.298

(Ch-sq / df = 436.122 / 200 = 2.18, GFI = 0.904, SRMR = 0.053, RMSEA = 0.057, CFI = 0.939)
* represents significant at 0.05 level,
** 0.01 level,
*** 0.001 level

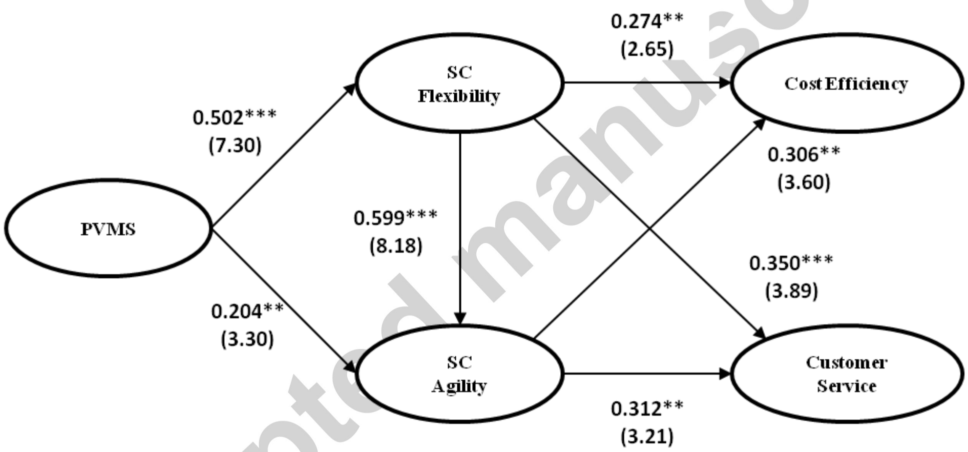

Figure 2. Structural equation model.

5.2. Low-customization model

The fit of the SEM was examined using multiple fit indices (Ch-sq/df = 349.202/200 = 1.75; SRMR = 0.055; RMSEA = 0.060; CFI = 0.933). All paths in Table 6 showed significant impacts with the exception of the relationship between SC agility and customer service, between PVMS and cost efficiency, and between PVMS and customer service. Comparing the significant direct and indirect impacts of both flexibility and agility on cost efficiency and customer service, H5 is supported, so dynamic capabilities have a more significant impact on cost efficiency than customer service in a low-customization environment. It is a revealing point that supply chain flexibility (i.e. internal capability) in the low-customization environment has a positive impact on customer service. Figure 3 shows the SEM models, together with their path coefficients and significance levels.

Table 6. Structural equation model for a low-customization environment.

Construct (Low Customization Environment)	Path coefficient	*t*-value	Significance
PVMS – Flexibility	0477***	5.36	0.000
PVMS – Agility	0.214**	2.82	0.005
Flexibility – Agility	0.638***	6.70	0.000
Flexibility – Cost efficiency	0.299*	2.20	0.028
Flexibility – Customer service	0.369**	2.91	0.004
Agility – Cost efficiency	0.332*	2.46	0.014
Agility – Customer Service	0.226	1.81	0.070
PVMS – Cost Efficiency	-0.075	-0.755	0.450
PVMS – Customer Service	-0.001	-0.015	0.988

Ch-sq / df = 349.202/ 200= 1.75, SRMR = 0.055, RMSEA = 0.060, CFI = 0.933)
* represents significant at 0.05 level,
** 0.01 level,
*** 0.001 level

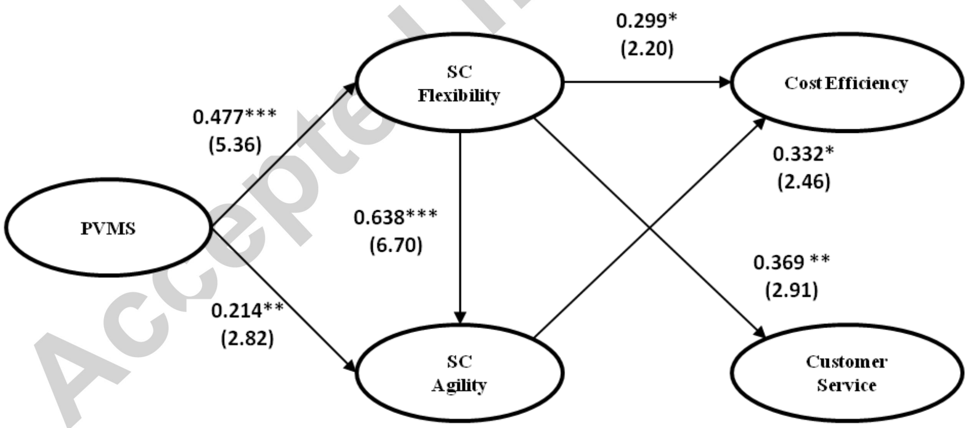

Figure 3. Structural equation models for a low-customization environment.

5.3. High-customization model

Fit for the SEM was confirmed through multiple fit indices (Ch-sq/df = 336.373/200 = 1.68; SRMR = 0.069; RMSEA = 0.068; CFI = 0.911). All paths in Table 7 except those between PVMS and SC agility (p>0.1), SC flexibility and cost efficiency (p>0.1), PVMS and cost efficiency (p>0.1), and PVMS and customer service (p>0.1) demonstrated a significant influence. This suggests supply chain flexibility mediates the impact of a PVMS on supply chain agility in a high-customization context. In addition, there is no link between supply chain flexibility and cost efficiency ($p > 0.1$). The results suggest that supply chain agility plays an important role in a high-customization environment. Furthermore, agility in the high-customization environment has a higher coefficient (i.e. 0.388>0.338) for customer service than cost efficiency. Comparing the significant impacts of both flexibility and agility on cost efficiency and customer service, H6 is supported, so dynamic capabilities have a more significant impact on customer service than cost efficiency in the high-customization environment. Supply chain agility (i.e. external capability) in a high-customization environment has a positive impact on cost efficiency. Figure 4 depicts the SEM models, together with their path coefficients and significance levels.

Table 7. Structural equation model for a high-customization environment.

Construct (High-Customization Environment)	Path coefficient	*t*-value	Significance
PVMS – Flexibility	0.449***	3.80	0.000
PVMS – Agility	0.204	1.74	0.082
Flexibility – Agility	0.518***	4.54	0.000
Flexibility – Cost Efficiency	0.160	1.25	0.213
Flexibility – Customer Service	0.338**	2.76	0.006
Agility – Cost Efficiency	0.279*	2.18	0.029
Agility – Customer Service	0.388**	3.22	0.001
PVMS – Cost Efficiency	0.086	0.69	0.488
PVMS – Customer Service	-0.132	-.1.23	0.219

(Ch-sq / df = 336.373/ 200= 1.68, SRMR = 0.069, RMSEA = 0.068, CFI = 0.911)
* represents significant at 0.05 level,
** 0.01 level,
*** 0.001 level

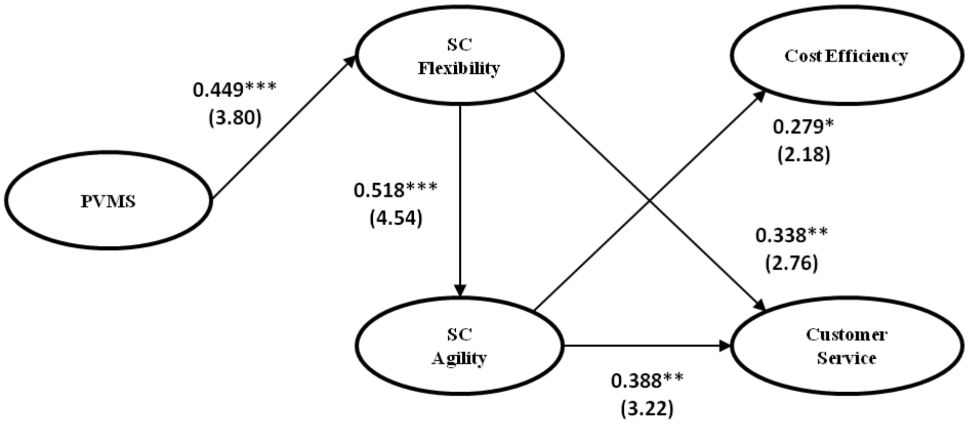

Figure 4. Structural equation models for a high-customization environment.

6. Discussion

The SEM results verify the relationship hierarchy of the conceptual model illustrating that a PVMS leads to achievements in cost efficiency and superior customer service (i.e., supply chain performance) through increased supply chain flexibility and agility (i.e., internal and external dynamic capabilities). Comparing the path values amongst the three constructs (i.e., from PVMS to flexibility/agility and from flexibility to agility), supply chain flexibility tends to mediate the impacts of a PVMS on supply chain agility. The results also support the notion that synergy between process flexibility in the internal supply chain of a firm affects the firm's supply chain agility, and the firm's supply chain flexibility is an important antecedent to its supply chain agility, as suggested by Agarwal et al. (2006) and Swafford et al. (2006). Flexibility and agility are often conjugated with flexibility acting as an antecedent to agility.

In addition, supply chain flexibility and agility influence both cost efficiency and customer service. Thus, a PVMS achieves supply chain flexibility and agility, and supports the management of the trade-off between product variety and supply chain performance. Supply chain flexibility and agility are multi-item constructs used to represent internal, operating-level responsiveness capability and external, organizational and inter-organizational responsiveness capability, respectively. These dynamic capabilities can lead to competitive advantages (Blome et al., 2013). Exploring item-level linkages implies, for example, that the relationship between flexibility and agility is partially a consequence of the relationship between the ability to change the quantities of suppliers' orders and the ability to accommodate changes in production mix and their effects on the ability to reduce product development cycle time, which, in turn, supports customer service items such as order fill rate and cost efficiency items such as the ability to minimize manufacturing cost. Thus, a capability-driven strategy, composed of supply chain flexibility and agility competencies acting as dynamic capabilities, provides a viable approach to product variety management, producing cost efficiency and high customer service outcomes. Modularity, cellular manufacturing, and postponement PVMSs in a supply chain are competencies that form the basis of the value-creating strategy (Eisenhardt & Martin, 2000; Aoki et al., 2014), which helps satisfy the distinct product variety management requirements of different markets, and realizes the potential of creating a competitive edge. These competencies, and the flexibility and agility dynamic capabilities from which they are derived, are not the sole preserve of any manufacturer but are recognized best practices and, although not often implemented at the same level of efficacy, with suitable knowledge and investment, they can be imitated by competitors. However, they will still differ in operational details, yet it can be the operational details that yield the marginal gain. Differences in operational details are less likely with the postponement strategy, where opportunities for idiosyncratic choices of the postponement position may not be axiomatic but are relatively limited, whereas they are more likely with product modularity and cellular manufacturing where engineering knowledge, specifics of product differentiation, and investment affordability increase idiosyncratic choices. This is exemplified by common PVMSs in both the high- and low-customization environments in which the same competencies yield contrasting results. In addition, a PVMS improves cost efficiency and customer service through its dynamic capabilities (see Christopher, 2000 and

Anderson, 2004). This result reveals the importance of dynamic capabilities as a mediating mechanism.

In a low-customization environment, agility does not guarantee better customer service. Rather, both supply chain flexibility and agility (i.e. dynamic capabilities) impacted cost efficiency (i.e., the expected order winner), the target strategy in a low-customization environment such as PS, SS and CS. (It should be noted that even in a PS environment, product variety is still present.). The reason for this can be found within the characteristics of the low-customization environment. Such an environment is associated with a stable industry structure, and firms operating in this environment focus on low price and high product availability by employing the make-to-stock or assemble-to-order system to achieve market competiveness through cost leadership. The PS, SS, and CS environments can be regarded as moderately dynamic markets (Eisenhardt & Martin, 2000). In these environments, we contend that dynamic capabilities in terms of supply chain agility and flexibility require competencies in product variety management to achieve low cost and desirable outcomes.

In a high-customization environment, flexibility does not necessarily guarantee cost efficiency directly, but both supply chain flexibility and agility through an improved PVMS positively influence customer service (i.e., the expected market winner). The link between supply chain agility and customer service yields the highest coefficient (0.388), highlighting the importance of supply chain agility in enhancing customer service in a high-customization environment. The reason for this can be found in the customization characteristics. Firms operating in a high-customization environment employ upstream decoupling points, and the make-to-order or design-to-order system to enhance customer service capability through product differentiation. High product variety due to diverse customer requirements, competition with high-demand uncertainty, unstable industry structures, short product lifecycles, and the need to assimilate new knowledge quickly also strengthen supply chain agility capabilities in a high-customization environment. A high-customization environment can be regarded as having a high-velocity market (Eisenhardt & Martin, 2000), in which volume can be low but changes occur rapidly, so effective product variety management in such an environment demands high adaptability to requests for new, customized products.

The results from the SEM analyses also reveal the effectiveness of a PVMS for improving dynamic capabilities. Considering the beta coefficients between a PVMS and dynamic capabilities, we see that a PVMS has a significant and direct positive impact on both flexibility and agility. However, to be agile in a supply chain in a high-customization environment, we find that a PVMS is the necessary strategy to achieve internal flexibility ($p>0.001$), then internal flexibility (i.e. an internal capability) leads to improved supply chain agility (i.e. external capability) as suggested by Swafford et al. (2006) and Thome et al. (2014). Supply chain flexibility and agility are derived from modularity, cellular manufacturing, and postponement. We find that the three PVMSs can dampen the potential negative effects of increased product variety, whilst enhancing cost efficiency and raising customer service in the supply chain.

It is necessary to investigate the degree of impact a PVMS has on cost efficiency and customer service through dynamic capabilities. We find that a PVMS is most effective for improving cost efficiency through supply chain agility (beta = 0.306), followed by supply chain flexibility (beta = 0.274). This is because agility represents an externally-focused competence focusing more on speed and fast reconfiguration (Swafford et al., 2008) which explains the strong relationship between supply chain agility and the ability to minimize cost in the supply chain. Although cost is a market qualifier in an agile supply chain (Hallgren and Olhager, 2009), supply chain agility improves the ability to minimize the costs in a supply chain when product variety increases. On the other hand, a PVMS is most effective to improve customer service through supply chain flexibility (beta = 0.350), followed by supply chain agility (beta = 0.312). This relative impact differential is revealing. Both flexibility and agility support their pursuit of both high supply chain cost efficiency and superior supply chain customer service (Vickery et al., 1999; Hiroshi & David, 1999), which leads to competitiveness improvement in volatile business environments (Hiroshi & David, 1999). Whilst a PVMS addresses internal flexibility, this dynamic capability provides an effective means to improve customer service and react to customer requests, providing a high level of customer service, but at the expense of cost efficiency. Therefore, supply chain flexibility functions as an internal capability to adapt to changes without incurring high costs (Chan, 2003). This role can be supported by supply chain agility.

When subject to a highly-customized environment, external capability in the form of supply chain agility was found to play a crucial role in improving both cost efficiency and customer service (i.e., the perceived order winner), while agility in a low-customization environment helps achieve cost efficiency (i.e., the perceived market winner) rather than customer service (see Stavrulaki and Davis, 2010). Instead, flexibility was found to play a key role to achieve customer service in a low-customization environment. It is notable that agility as an external dynamic capability in a high-customization environment can also have the ability to address the cost burden when product variety increases. Instead, flexibility as an internal dynamic capability in a low-customization environment has better potential to improve customer service, and the environment does not necessarily require an agile capability to improve customer-oriented performance.

7. Conclusions

Motivated by the need to better understand how manufacturers can build capabilities to compete and succeed in the face of capricious markets and severe competition, which lead to frequent changes in product variety, and in an attempt to ground more supply chain management research in prominent theories, we study the relationships among five constructs, namely product variety management strategy (i.e., modularity, cellular manufacturing, and postponement), supply chain flexibility, supply chain agility, cost efficiency, and customer service, via the construction of a conceptual model, and testing the model using structural equation modelling according to different levels of customization as a moderating factor. A distinctive feature of our work is its empiricism. The empirical findings verify the integrity of the proposed model, support the general, intuitive relationships between a PVMS and supply chain performance, and verify the relationship hierarchy of the constructs. The results show that a PVMS improves cost efficiency and customer service through increased supply chain flexibility and agility. We find that supply chain flexibility and agility acting as dynamic capabilities mediate the impacts of PVMSs on cost efficiency and customer service. The impact of dynamic capabilities is influenced by market dynamism (Eisenhardt & Martin, 2000). For example, we find that supply chain agility plays a crucial role in improving both cost efficiency and customer service in a high-customization environment. The competencies of modularity, cellular manufacturing and postponement are determinants of supply chain flexibility and agility, and supply chain flexibility and agility in turn are determinants of supply chain cost efficiency and customer service. However, a PVMS does not impact the four supply chain constructs in the same manner. A PVMS has both a first-order positive relationship with flexibility and agility, and a second-order relationship with cost efficiency and customer service. A PVMS is most effective for improving cost efficiency through supply chain agility, while a PVMS is most effective to improve customer service through supply chain flexibility. The findings have both theoretical and managerial implications. They contribute to the extant literature on product variety management and product variety management capability formation. They provide empirical evidence that confirms and augments our understanding of the causal relationships between product variety management and supply chain performance within an operationalized dynamic capabilities framework. They support decision and policy-making for manufacturers and their supply chain partners by revealing the relative effectiveness of representative examples of the product and process-based strategies for variety management.

8. Limitations and future research

We focus exclusively on manufacturing industries in the UK and Korea, limiting generalisation to other populations. This is a pertinent point, even when measurement invariance is supported, there are potential competitive, environmental, and cultural differences that exist among different countries and regions (Hughes & Morgan, 2008). In addition, modularity, cellular manufacturing, and postponement, although prominent examples and observed variables of the product- and process-based strategies for product variety management, respectively, could be explained as second-order constructs. Therefore, extrapolation of the conclusions from the examples studied to the two different classes requires further investigation. Also, we do not consider all the permutations of PVMSs in combination with different levels of customization. For example, we do not consider that, in certain industries, product modularity facilitates manufacturing postponement. Future research should investigate the complementarity and determine the synergistic impacts of different strategies to product variety management considering a cross-industry analysis. We encourage researchers to consider dynamic capabilities as a theoretical lens to explain and better understand how superior supply chain performance emerges in markets subject to different rates and forms of change.

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