Improving supply chain flexibility and agility through variety management

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Abstract

Purpose – A trade-off exists between product variety and supply chain (SC) performance. To help mitigate the impact on SC of increased product variety, this paper examines how variety-management activities including variety management strategy, supplier partnerships and close customer relationships affect SC flexibility and agility at different levels of customisation.

Design/methodology/approach – A survey-research methodology is employed using data from 363 manufacturing firms from the UK and South Korea. In particular, cluster analysis and structural equation modelling were used to evaluate the proposed model according to the level of customisation.

Findings – The results suggest that internal variety-management strategy and external SC integration have a positive influence on SC flexibility and agility. Customer relationships and variety-management strategies influence SC flexibility more than partnerships with suppliers whereas variety-management strategies and partnerships with suppliers influence SC agility more than customer relationships. In fact, for external integration in particular, customer relationships influence SC flexibility (i.e., reaction capability) rather than agility (i.e., reaction time) whereas partnerships with suppliers influence SC agility rather than flexibility. In a high-customisation context, close customer relationships are the most effective way to increase SC flexibility, whereas partnerships with suppliers are the most effective way to increase SC agility. In a low-customisation context, a variety management strategy and customer relationships are the most effective way to increase both SC flexibility and agility.

Originality/Value – This paper suggests key variety management activities to aid managers to better manage product-variety ambitions in SC under varying customisation profiles through internal and external approaches.

1. Introduction

Today's supply chain (SC) managers recognise that their roles are becoming more complex, mainly as a result of rapid changes, globalisation and especially uncertain business environments. Lack of understanding of the complexity of drivers and poorly designed and executed strategies to address this complexity make SC decisions much more difficult, often leading to undesirable outcomes (Manuj and Sahin, 2009). In an ideal world, SC should be designed from the 'customer backwards' rather than by the conventional approach that has a tendency to be from the 'factory outwards'. The temptation is to create SC that is more focused on the goal of 'efficiency' rather than that of 'effectiveness' (Christopher *et al.*, 2006). For products with highly customised options, product variety can be an especially challenging driver of complexity, which can disrupt the SC (see van Donk and van Dam 1996; Faber *et al.*, 2002). Most manufacturers recognise that a trade-off exists between product variety and SC performance (Thonemann and Bradley, 2002). High product variety leads to an increase in sales and market share, but it can also add complexity to demand forecasting and create difficulties in aligning supply with demand in the SC (Whang and Lee, 1998; Randall and Ulrich, 2001). Although the initial impact of product variety on sales is positive, beyond a certain level, increased product variety may gradually lead to lower sales (Wan *et al.*, 2012). Therefore, companies that need to increase product variety should consider the potentially negative impacts on SC performance such as complexity in design, manufacturing and scheduling as well as cost of production and market mediation.

To optimise the trade-off between product variety and SC performance, manufacturers manage product variety by limiting it through focused manufacturing or increased flexibility (Kekre and Srinivasan, 1990; Yeh and Chu, 1991; Gerwin, 1993; De Groote, 1994; Silveira, 1998). However, when considering long term profits and competition for market share as demand uncertainty increases, continuous improvement in flexibility and agility offers a more

competitive method of responding to customer needs. Organisations may focus on either SC flexibility or SC agility to achieve the appropriate response capability, and this is often better than considering both aspects. Also, organisations' SC agility can be impacted by the synergy between the flexibilities in the SC process (Swafford *et al.*, 2006). To manage increased product variety and customisation, SC should be immediately responsive to a constantly changing market (Yang and Burns, 2003). Flexibility and agility have repeatedly been shown to enhance an organisation's ability to effectively react to disruptions in the SC (Skipper and Hanna, 2009). Supply chain flexibility and agility also have a positive influence on both resource efficiency and customer service (Narasimhan and Jayaram, 1998; Hiroshi and David, 1999; Tummala *et al.*, 2006). Supply chain performance includes these cost-efficiency and customer-service indicators (Tummala *et al.*, 2006) whereas, in this research, SC flexibility and agility are defined in terms of SC responsiveness in managing product variety.

Given that maintaining SC flexibility and agility remains crucial for managing variety-related issues, what are the most effective variety management activities to optimise the trade-off between product variety and SC performance? What are the most effective variety management activities to improve SC flexibility and agility, respectively? First, adopting internal variety management strategies (VMSs) such as modularity (i.e., a product-based strategy), cellular manufacturing (i.e., a process-based strategy) and postponement (i.e., a structure-based strategy) has proven essential to achieving SC flexibility and agility (Qiang *et al.*, 2001; Nair 2005; Scavarda *et al.*, 2010; Jacobs *et al.*, 2011; Patel and Jayaram, 2014). However, are internal variety strategies sufficient to mitigate the trade-off between product variety and SC performance? Firms can often best appropriate the benefits of innovation by opening their technology to an outside network of cooperating partners because the development of a modular concept and systems can lead to vertical and horizontal disintegration (Langlois and Robertson, 1992). Therefore, a second, external integration of

supplier and customer is another crucial driver in managing variety issues and promoting the modular concept. External integration emphasises collaboration with the upstream and downstream partners. To respond to customer needs, an increasing number of organisations are attempting to develop partnerships with suppliers and customers (Slack and Chambers, 2007), suggesting that SC integration that focuses on both demand and supply is required to handle the increased complexity and uncertainty caused by product variety (Fisher, 1997; Mendelson and Pillai, 1999; Heikkilä, 2002). According to Vickery *et al.* (2003), two fundamental practices that accomplish integration across a SC are supplier partnering and the establishment of closer customer relationships. Partnership with suppliers to ensure high product quality and low cost entails earlier supplier involvement in product design, or acquiring access to suppliers with superior technological capabilities (Narasimhan and Das, 1999). Close customer relationships enable firms to seek information about customer preferences and needs, which enables firms to become more responsive. Insights gained by establishing strong relationships with customers can also be used to enhance operational effectiveness and cost efficiency (Vickery *et al.*, 2003). Integration of the SC through supplier partnerships and close customer relationships can be crucial, especially for management of product variety and new product development (NPD). Also, external integration has been demonstrated to be positive to cost, delivery, quality and flexibility (Mackelprang *et al.*, 2014).

However, variety-related issues require considering customer involvement (i.e., customisation). Products can be differentiated according to the stage in the value chain where customisation occurs; this is the point at which customer input is injected (Lampel and Mintzberg, 1996). For example, the success of Dell as a mass customiser is due to the late differentiation point and postponement strategy employing make-to-order operation. Postponing customisation by employing various decoupling points allows a SC to react more readily to changes in customer demands (Mason-Jones and Towill, 1999). However, the

strategic focus such as lean or agile in SC functions differs according to the degree of customisation (Agarwal *et al.*, 2006; Stavrulaki and Davis, 2010). Also product customisation determines the amount of flexibility required of a SC (Sengupta *et al.*, 2006). Therefore, the level of customisation can be determined by companies' strategies to support the required variety management, which can affect the level of SC flexibility and/or agility to different degrees.

To identify a process to optimise the trade-off between product variety and SC performance, the present study examines how internal variety management strategies and external SC integration separately influence SC flexibility and agility and explores the implications for SC management with different levels of customisation. Compared with previous empirical researches (e.g., Ramdas and Randall, 2008; Thonemann and Bradley, 2002; Fisher *et al.*, 1999; Fisher *et al.*, 1995), this study makes several critical contributions to practices. First, two distinct performance approaches are required to manage variety issues: SC flexibility and agility, which are frequently employed interchangeably without clear definitions in academics and in practice. Second, the overall variety management activities are designed by considering both internal and external aspects: internal VMS in operations (i.e., modularity, cellular manufacturing and postponement) and external integration (i.e., partnerships with suppliers and close customer relationships). These two approaches provide extensive guidelines for increasing product variety. Finally, the study assesses how the moderating factor embodied by different degrees of customisation affects the relationships between variety management activities and SC flexibility or agility. This approach provides suggestions for a company's strategic focus based on its level of customisation. In addition, this study suggests insights for SC managers by providing the empirical evidence they require to support their companies' decision-making developments regarding product variety.

A number of studies have investigated theoretical approaches to managing the complexity in the SC that results from product variety (Blecker and Abdelkafi, 2006; Ramdas and Ulrich, 1999; Yeh and Chu, 1991), whereas others have empirically investigated the impact of product variety on particular dimensions such as time and cost (Thonemann and Bradley, 2002) or have focused on restricted sectors such as the automotive industry (Fisher, Ramdas and Ulrich, 1999; Fisher *et al.*, 1995) or on a specific strategy such as modularity (Ramdas and Randall 2008; Yadav et al. 2011). However, no attempt appears in the literature to demonstrate discrete procedures for handling variety issues through the consideration of diverse approaches, such as internal and external drivers with distinct levels of SC flexibility and agility in various manufacturing industries. This approach can provide a theoretical foundation to explain how to handle variety-related issues and their impact on the SC. In addition, the impact of potential moderating factors such as customisation on managing the increase in variety has not been determined empirically. In reality, companies with differing levels of customisation require different approaches and strategies for the SC because of their differing product characteristics and levels of product variety (see Lampel and Mintzberg, 1996; Agarwal *et al.*, 2006; Stavrulaki and Davis, 2010).

2. Conceptual model and development of hypotheses

2.1 Supply chain flexibility and agility

Although flexibility and agility can be both dimensions of SC performance (Beamon 1999; Swafford *et al.*, 2006), it is important to distinguish between them. A firm attains SC agility by tapping various synergies in different forms of SC flexibility (Agarwal *et al.*, 2006). In this paper, SC flexibility is concerned with the internally focused capability and adaptability of a firm's internal SC functions including purchasing, engineering, manufacturing and distribution at the operations level, while SC agility represents an externally focused competency concerned

with speed at the business level, such as rapid market responsiveness, lead time reduction, delivery reliability and frequency of product introduction (Christopher and Towill, 2001; Swafford *et al*., 2008). While these measures may resemble performance metrics, they are conceptually different in that SC agility represents how rapidly outcomes can be changed (i.e., responsiveness capability), and not the level of functional attainment of these outcomes (i.e., performance or reaction capability). Swafford *et al*. (2006) employed SC agility item measures that capture the concept of the speed with which a firm's SC can respond. For example, SC agility measures imply how quickly a firm can reduce manufacturing lead times or increase customer service levels but does not imply the level of lead time performance or customer service performance (see Swafford *et al*. 2006).

Bernardes and Hanna (2009) also clarified conceptual disparities between the terms flexibility, agility and responsiveness, which are used inconsistently and ambiguously in operations management. Supply chain flexibility is a separate and antecedent capability required for SC agility (Agarwal *et al*., 2006; Bernardes and Hanna, 2009). Both SC flexibility and agility have a positive influence on SC performance indicators, such as cost efficiency and customer service (Hiroshi and David, 1999; Tummala *et al*., 2006). In addition, SC flexibility and agility are essential capabilities required to mitigate the trade-off between product variety and SC performance (Scavarda *et al*., 2010). Some researchers included SC flexibility as a dimension of SC performance (e.g., Beamon, 1999; Khan *et al*., 2009). However, in the present research, SC flexibility and agility were used as performance indicators for SC reaction and responsiveness in managing variety issues.

Items identified as dependent variables including SC flexibility and agility are taken from the conceptual framework of Swafford *et al*. (2006, 2008), which divides SC flexibility attributes into three processes: procurement or sourcing, manufacturing and distribution or logistics. Based on this framework, Swafford *et al*. (2006) identified six items for SC flexibility and

seven for SC agility. Thus, SC flexibility can involve: (1) production volume, production mix and engineering change flexibility in manufacturing (i.e., items 3, 4 and 5); (2) flexibility in procurement to change material orders (quantity and time; i.e., items 1 and 2); and (3) delivery flexibility in distribution (i.e., item 6). However, SC agility relates mainly to the speed of manufacturing and distribution activities in the SC. Improving SC agility requires: (1) reducing the product development cycle time and the manufacturing and delivery lead time (i.e., items 1, 2 and 7); (2) increasing the level of product customisation in manufacturing (i.e., item 3); and (3) improving customer service (i.e., item 4), delivery reliability (i.e., item 5) and responsiveness to market needs (i.e., item 6).

2.2 Internal variety management strategy

The study defines three activities as fundamental in explaining the structure of internal variety management strategies to mitigate the negative impact of product variety on the SC. Scavarda *et al*. (2010) also suggested three types of operational strategy that can optimise the trade-off between product variety and SC performance. First, changes in product architecture (i.e., use of product modularity) reduce complexity and costs associated with product development, sourcing and manufacturing. Second, flexible manufacturing operations such as cellular manufacturing lead to cost-efficient production. Finally, postponement of product configuration decisions reduces the impact of demand uncertainty resulting from product variety (Scanvarda *et al*., 2010; Patel and Jayaram, 2013). For example, positioning the inventories in centralised distribution operations decreases the cost of market mediation. Similarly, Blecker and Abdelkafi (2006) divided VMSs into product levels such as product modularity, process levels such as component families (i.e., process modularity) and delayed differentiation. All three strategies are supported by modular product design and promoted by the paradigm of a 'decoupling point', which decides the level of customisation. Patel and

Jayaram (2013) supported the concept that product modularity and process modularity improve operational performance, including labour, material handling, mix and modification flexibility. Thus, the present research considers three representative strategies: modularity, cellular manufacturing (i.e., component family) and postponement as product, process and structural approaches, respectively. First, the latent variable VMS refers herein to an internal activity to mitigate the trade-off between product variety and SC performance by enhancing SC flexibility and agility. Next, VMS is identified and represented by three available management strategies (i.e., modularity, cellular manufacturing and postponement strategy) as observed variables based on the measures derived from a literature review (see Table 1).

In an early study, Fisher et al. (1999) suggested process- and product-based strategies to accommodate increased product variety. First, process-based strategies provide production and distribution with sufficient flexibility to handle high variety at a reasonable cost. For example, when using group technology principles in cellular manufacturing, parts with similar design characteristics and processing requirements are grouped into families that lead to operational flexibility (Abdi and Labib, 2004). Second, product-based strategies such as modularity enable product designs that allow high variety while maintaining low component variety in production and distribution (Fisher et al., 1999). Cost increase in SC due to variety increase can be arrested to some extent by modularisation (Syam and Bahatnagar, 2015). Shared components increase economies of scale, simplify production and scheduling processes and lower inventory costs (Patel and Jayaram, 2013). The implications of product modularity stretch beyond the boundaries of a firm's value chain because they allow the firm to reconfigure supply, manufacturing and distribution networks (Salvador et al., 2004). Lastly, an obvious relationship exists between configuration of a SC and postponement (Van Hoek, 1999): as a structure-based strategy, postponement can reduce the impact of demand uncertainty and support more product variety (e.g., Dell's mass customisation). This approach has recently

received considerable attention as a way to reduce the costs and risks of product variety while improving SC flexibility (Davila and Wouters, 2007; Scanvarda *et al*., 2010; Patel and Jayaram, 2013). Therefore, the research proposes the following hypothesis:

H1a. An internal VMS correlates positively with SC flexibility.

Supply chain agility can be achieved by cellular production based on the Pareto Law (see Christopher and Towill, 2001) Cellular production is supported by modular-designed products or parts, resulting in greater agility. Agrawal and Hurriyet (2004) also pointed out that cellular production, whereby similar parts are grouped into families based on shapes or production processes, reduces the complexity created by large-scale production and facilitates the production of a variety of products. In particular, cellular manufacturing reduces lead time and thus accelerates agile production and distribution in the SC. Regarding product-based strategies, Jacobs *et al*. (2011) argued that product modularity facilitates process modularity, engenders agility and improves market growth. Product modularity also supports delayed differentiation (Salvador *et al*., 2004). Postponement as a structure-based strategy enables manufacturers to improve inventory turnaround, asset productivity and SC flexibility and facilitates fast delivery, resulting in improved customer service (Nair, 2005; Davila and Wouters, 2007). To achieve the agile paradigms in the SC, Christopher and Towill (2001) suggested the 'decoupling-point' approach, which can be supported by modular production and postponement strategies. Therefore:

H1b. An internal VMS correlates positively with SC agility.

2.3 External supply chain integration

Partnership with suppliers

External integration boosts SC flexibility. Benefits of external collaboration through integration often emerge when partners are willing to work together by sharing information and resources to achieve collective goals (Stank *et al*., 2001). Various competencies are required to integrate a firm's internal capabilities with those of its external partner (Whipple *et al*., 2015). Sharing sensitive financial, design and research information strengthens trust in a partnership and enables a quick response to customer needs. Thus, by integrating a cross-functional team with suppliers, manufacturers enhance not only communication flows but also product development (Ngai *et al*., 2004; Tummala *et al*., 2006). Joint problem solving and performance evaluations with suppliers are critical during product development (Tummala *et al*., 2006). A full partnership requires sharing risks and benefits, and a SC's long-term focus should not revolve solely around price. Trust between manufacturers and suppliers should encourage extensive knowledge sharing and build deeper relationships (Liao *et al*., 2011), which in turn can reduce uncertainty. Sharing sensitive information such as cost (Ngai *et al*., 2004) and creating close partnerships, especially during product development, are crucial (Cousins *et al*., 2011). Das *et al*. (2006) also stressed the importance of supplier integration, which involves elements such as joint problem solving, mutual trust, joint investment and sharing financial information. These types of partnership with suppliers lead to SC flexibility through enhanced synchronisation of purchasing and production functions. Especially close relationships have a positive influence on volume, mix and new-product flexibility (Suarez *et al*., 1996), which can result in SC flexibility by leading to enhanced mutual commitment and improved communication. Therefore, as an external integration activity:

H2a. Supplier partnerships correlate positively with SC flexibility.

Supplier partnerships relate positively with product-development success (Groves and Valsamakis, 1998; Tan and Kannan, 1998). Tan and Kannan (1998) found that supplier

knowledge and skills play a significant role in reducing production costs. The early formation of close relationships with suppliers is critical for a company during product innovation and development (Power *et al*., 2001; Carr and Kaynak, 2007; Cousins *et al.,* 2011). Supplier involvement also influences turnover (Faems *et al*., 2005), product innovation (Nieto and Santamaria, 2007) and other performance criteria, such as product cost, quality and time to market (Clark and Fujimoto, 1991; Ragatz *et al*., 1997). Supplier alliance in particular can promote greater coordination and faster response of the SC to market changes (Zsidisin and Ellram, 2001). For example, with the advent of business-to-business (B2B) electronic commerce, firms are exploring alternative long-term relationships with their suppliers to improve SC agility (Handfield and Nicholas, 2002). Therefore, partnerships with suppliers as an external integration activity can lead to SC agility, leading to the following hypothesis:

H2b. Supplier partnerships correlate positively with SC agility.

Close customer relationship

Many factors determine product variety including customer requirements, market competition and customisation (Silveira, 1998), so it is vital that each SC participant adds value by providing the best product or service from the perspective of customers in an SC (Jeong and Hong, 2007). Not only the product, but also the entire SC from procurement of raw material to the final point of consumption, should be effectively and efficiently managed to meet the end-consumer's requirement for product and service value (Zokaei and Hines, 2007). Fisher *et al*. (1995) argue that companies need a market strategy to minimise unwanted product variety and propose two strategies: (a) closer relationships with customers to ensure current products reflect customer needs, and (b) eliminating products that are no longer beneficial. Child *et al*. (1991) suggest that companies must assess the variety that customers find attractive, avoiding confusion from information overload that results in withdrawal from purchasing decisions. To

build stronger customer relationships, gathering customer feedback from a SC is required to help identify changing customer specifications (Tummala *et al.*, 2006). Following up on customer feedback and evaluating customer complaints are crucial to building close customer relationships (Tan *et al.*, 1999; Ranganathan *et al.*, 2004; Wang and Feng, 2012). Monitoring customer service and responding to customers' evolving needs are also essential to building close customer relationships (Power *et al.*, 2001; Zokaei and Hines, 2007; Wang and Feng, 2012). Understanding customer needs through close customer relationships can lead to SC flexibility in the form of, for example, product, volume and delivery flexibility. In comparison with supplier management, customer management is highly demand-focused. An accurate understanding of customer requirements and demand is an increasingly important component in enhancing the flexibility of a SC (Tracey and Tan, 2001). Therefore, SC flexibility can be enhanced by external integration activities that lead to closer customer relationships:

H3a. Closer customer relationships correlate positively with SC flexibility.

Supply-chain agility aims for responsiveness to customers and customer service. This is exemplified by co-creation, which has become popular in recent years (Lusch *et al.*, 2007; Michel *et al.*, 2008). User involvement is especially useful for capturing consumers' latent needs, the knowledge of which is crucial to successful new-product development (Kristensson *et al.*, 2008). Co-creation by customer involvement can be one of the most effective methods of managing product variety, and close customer relationship management (CRM) achieves this aim. CRM is the management of technology, processes, information and people to maximise customer contact (Galbreath and Rogers, 1999). CRM can result in high customer satisfaction, which is achieved through customisation, personal relationships and after-sales support (Galbreath and Rogers, 1999).

Heikkilä (2002) points out the need to shift from the supply side to the demand side of SC management. Improved access to demand information throughout the SC permits rapid and efficient delivery, coordinated planning and better logistics communication (Treville *et al*., 2004), resulting in SC agility. Handfield and Bechtel (2002) also support the notion that a relationship of trust between buyer and supplier can improve SC responsiveness. SC agility requires firms to closely manage the legally separate but operationally interdependent parties, including suppliers, manufacturers, distributors and customers, to maintain a close and coordinating relationship (Ngai *et al*., 2011). Therefore, as an external integration activity, closer and coordinated relationships with customers can lead to greater SC agility in response to market needs:

H3b. Closer customer relationships correlate positively with SC agility.

Table 1 presents the independent variables, including internal VMS and external SC interrelation with supplier and customer and related literature sources.

Table 1 Variety Management Activities and Related Literature

2.4 Customisation

Products are distinguished according to the stage in the SC at which customisation occurs (Lampel and Mintzberg, 1996). Identifying the point of initial customer involvement, which is called the decoupling point, is critical in determining the degree of customisation (Duray *et al*., 2000). The customer-order decoupling point (CODP) is receiving increasing attention as an important input to the design of SCs (Olhager, 2010). Early research by Lampel and Mintzberg (1996) showed that development of a customisation framework comprises five strategies: pure standardisation, segmented standardisation, customised standardisation, tailored customisation

and pure customisation. With pure standardisation, the customer has no direct influence on any stage of the value chain. With segmented standardisation, the customer has no direct control over design or production (i.e., distribution customisation). In customised standardisation, products are made to order at the assembly stage from standardised components. Tailored customisation occurs during fabrication to adapt to customer needs and, finally, pure customisation provides products that are specifically designed to customer specifications and are thus unique. Squire *et al*. (2004) associate various forms of customisation with four manufacturing functions: distribution, assembly, fabrication and design customisation. Poulin *et al*. (2006) provide a comprehensive view of the degrees of customisation offered, the framework of which is divided into eight categories: popularising, varietising, accessorising, parameterising, tailoring, adjusting, monitoring and collaborating.

The level of customisation is a moderating factor in this study. The customer-order decoupling point is defined as the point in the value chain of a product at which the product is linked to a specific customer order (Olhager, 2010). This point can determine the level of customisation. Therefore, different manufacturing scenarios such as make-to-stock (MTS), assemble to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO) relate to different levels of customisation. Regarding the relationship between customisation and the SC, a connection between qualifiers or winners and lean or agile is essential (Christopher and Towill, 2001; Aitken *et al*., 2002; Agarwal *et al*., 2006). The lean paradigm, which typically employs low customisation, is most powerful when the winning criterion is cost (i.e., cost leadership). However, when service and customer-value enhancement (i.e., differentiation) are prime requirements of market-winning criteria, a flexible and agile paradigm that typically employs high customisation is critical (Mason and Towill 1999). Drawing from three related literature reviews (Lampel and Mintzberg, 1996; Agarwal *et al*., 2006; Stavrulaki and Davis, 2010), Table 2 summarises the characteristics of the types of customisation. Stavrulaki and

Davis (2010) emphasised alignment as a key aspect of a product (e.g., functional and innovative products) and its SC processes according to four SC strategic foci (e.g., from build-to-stock to design-to-order). They highlight the importance of links between SC processes (e.g., production and logistics) and SC strategies (e.g., lean, legal and agile). For example, a flexible or agile organisation with a high level of customisation would be more effective than a lean organisation within an environment of unstable demand, because flexible or agile operations and SCs can quickly be reconfigured to reflect such demand conditions (Doran, 2005). Thus, a company's strategic focus and capabilities (i.e., a resource-based view) differ according to the level of customisation which can affect the relations between variety management activities and SC performance. Due to the nature of differences in product type, manufacturing, logistic and market focus among different levels of customisation (see Table 2), the present research uses level of customisation as a moderating factor that can have varying impacts on the relationship between product-management activities and SC flexibility and agility. For example, compared with the low-customisation context, in a high-customisation context with a large number of customer segments, customer relations can be vital to improve flexibility (i.e., reaction capability). Figure 1 shows the research model, which supports management of product variety in an SC; the level of customisation is used as a moderating factor. Therefore, the research proposes the following two hypotheses:

> H4a. Variety management activities have different relationships with SC flexibility across levels of customisation.
>
> H4b. Variety management activities have different relationships with SC agility across levels of customisation.

Table 2 General Characteristics of Customisation Types.

Figure 1. Research model.

3. Methodology

3.1 Data collection and sampling process

Data were obtained from manufacturers in both the UK and South Korea. The aim was to investigate interdependencies between partnerships with suppliers, customer relationships, internal variety management strategy and SC flexibility and agility. The two countries apply similar technological advances in the manufacturing sector, whereas potential differences in economic development and income distribution affecting the level of product variety can be reduced by investigating companies from both countries. Following the guidelines of Craig and Douglas (1999), the original version of the questionnaire was translated into Korean by a professional translator, then translated back into English by another expert and finally scrutinised by two more translators. Manufacturing companies were randomly selected based on the standard industrial classification (SIC) code in the FAME database, and individual contacts were also made with various manufacturers in both countries. The questionnaire was put to chief executive officers, directors, managers and staff of SC, purchasing, production, logistics and sales departments. Of the 1950 questionnaires sent to manufacturing companies, 363 companies (211 UK and 152 South Korea) completed them by post, e-mail or face-to-face interviews from February to June 2012; a response rate of 19%. In terms of number of employees, 59.1% of the firms were small or medium sized (SMEs) and 40.9% were large (LEs) (i.e., over 250 employees). Of all the respondents, 87% were in senior management positions. To investigate disparities with the model according to customisation, the data were divided by K-mean cluster analysis into two levels of customisation: low (mean centre = 2.15; $n = 207$) and high (mean centre = 4.43; $n = 156$). Table 3 shows the types of industry in relation

to customisation levels; equivalence between the two levels of customisation was ensured in terms of industry characteristics (Floyd and Widaman, 1995).

To assess the possibility of non-response and late-response bias, *t*-tests were conducted to compare characteristics between early and late respondents (Armstrong and Overton 1977). No differences in sales or number of employees were found, which suggests that response bias was not present. To test for common method bias, Harman's one-factor test using Podsakoff et al.'s (2003) outline was applied. A principal components factor analysis was conducted on all items, resulting in the extraction of five factors. These accounted for 68% of total variance; the first factor accounted for 19% with eigenvalues greater than 1. Since no single factor was apparent in the unrotated factor structure, common method variance was therefore unlikely.

Because samples were taken at random from the UK and South Korea, a measurement invariance test was applied by using two split samples. The test aimed to identify the critical assumption that the basic structure of the model is stable across cultures, and that individuals in different countries use its scale in a similar manner (Turker, 2009; Malham and Saucier, 2014). As can be seen from Table 4, multi-group confirmatory factor analysis (CFA) estimates were made to cross-validate the model across the two countries. The results provide acceptable fits to the data, indicating that configural invariance (i.e., the same items load on the same factor) is supported (Model 1). The factor loadings were constrained but the intercepts were allowed to vary between countries to test whether loadings were the same across countries (Model 2). Finally, both the factor loadings and intercepts were constrained to test strong measurement invariance across countries (Model 3). Comparisons between nested models were conducted by exploring chi-square difference test ($\Delta\chi^2$) as well as the CFI, RMSEA and SRMR as fit indices (Chen 2007; Cheung and Rensvold 2002). The chi-square difference test between models was not significant and there was no substantial difference in fit between these models. This result proves measurement invariance, which means that the data from the two countries

do not suggest the presence of measurement bias (Milfont and Fischer, 2010) and features of the construct indicate consistent structure within the two countries (Floyd and Widaman, 1995).

Table 3 Main Products by Customisation Level

Table 4 Measurement Invariance Test across the two Countries

3.2 Measures

Lampel and Mintzberg's (1996) framework was adopted for measuring the level of customisation of UK and South Korean manufacturers. More specifically, pure standardisation provides standard products that have pre-defined options and designs. Product customisation occurs at the sales stage. Second, segmented standardisation provides products in which customers specify product packaging, delivery schedules, or delivery location. The product is standard, with pre-defined options and designs. Customisation operates at sales and distribution stages. Third, customised standardisation provides various types of product, and customers are offered a number of pre-defined options. Products are assembled to customer order by using standard components, and customisation is achieved during assembly. Fourth, tailored customisation provides various types of product, and customers are offered a number of pre-defined designs. Products are manufactured as per a customer's order, and customisation is achieved during fabrication. Finally, pure customisation provides a unique product design, and customer input is integrated at the onset of design. Products are designed to order, and customisation is achieved during design. The reasons for employing this framework are its simplicity and wide use by researchers (see Rudberg and Wikner, 2004; Squire *et al.*, 2004; Hendry, 2010) who have demonstrated and critiqued its elements.

All constructs were measured by using a five-point Likert scale. Items for VMS, partnerships with suppliers and customer relationships ranged from strongly disagree (1) to strongly agree (5) by asking the company's current position in each activity. For SC flexibility and agility, respondents were asked to 'indicate how well your company performs in the following SC activities', and items ranged from poor (1) to excellent (5).

3.3 Reliability and validity

To assess reliability and validity, both exploratory factor analysis (EFA) and CFA were conducted by using AMOS 22. Five constructs (VMS, partnerships with suppliers, customer relationships, SC flexibility and agility) were assessed with CFA. After omitting two items (PS1 and FL5) due to low factor loadings (<0.6), the remaining measures were re-assessed. The measurement model offered a satisfactory fit ($\chi^2_{[199]} = 535.53$, GFI = 0.882, SRMR = 0.050, RMSEA = 0.068, CFI = 0.919). Composite reliability (CR) also showed acceptable internal consistency (CRs > 0.789). Convergent validity was affirmed because all factor loadings exceeded 0.6, with acceptable average variance extracted (AVE$_S$ > 0.540). No case existed such that the square of a correlation between constructs was greater than the AVE. Thus, discriminant validity was established by using the procedures outlined by Fornell and Larcker (1981).

Regarding EFA, Cronbach's alpha coefficients and factor loadings for each of the variables are reported in Table 5. All loadings exceed 0.68 except for PS1 and FL5, which were removed from analysis. Convergent validity (factor loading >0.5) existed for the five variables (Hair *et al*., 2010). All of Cronbach's alpha coefficients (above 0.79) showed acceptable reliability. Thus, the constructs of SC flexibility and agility were empirically proven as distinct concepts, especially through the EFA. The results of separate EFAs for both low and high customisation also showed acceptable reliability and validity with the same items loaded (i.e.,

PS1 and FL5 were removed). Thus, the variables of the construct have a consistent and stable structure across the groups (Floyd and Widaman, 1995). Regarding generalisability to the population, the result of the random-split-sample analysis (182 and 181 respondents in each) also demonstrates the commonalities of all of the items (Turker, 2009). Table 6 shows correlations and AVEs for each construct, with means and standard deviations. Therefore, results of CFA and EFA tests suggested items have high within-factor loadings, which indicates that the measures are consistent. They also show differences between factor loadings within constructs and between constructs, indicating evidence of both convergent and discriminant validity.

Table 5 Exploratory Factor Analysis

Table 6 Inter-Construct Correlation Estimates and Related AVEs

4. Empirical results

To compare the different relationships across the low- and high-level customisation models, multi-group structural equation modelling (SEM) was tested. In the default model, none of the path coefficients were constrained across two groups. Equality constraints were then imposed on all path coefficients, resulting in significant deterioration of the model fit ($\Delta\chi^2$, $p < 0.01$). This result indicates that at least one of the path coefficients across the groups differs significantly (Byrne, 2001; Schumacker and Lomax, 2004). Thus, models across the groups are comparable.

Three SEM analyses were conducted to discover which of the independent variables had the highest and lowest correlations with SC flexibility and agility with combined, low-customisation and high-customisation samples. Through the modification indices, constructs in variety management activities and two performances shared the variance respectively based

on the model, and the empirical results of the modification indices. Combined data demonstrated an acceptable fit (CFI = 0.919; NNFI = 0.906; RMSEA = 0.068; SRMR = 0.051), and paths had high *t*-values (> 2.151) with acceptable *p*-values (< 0.05). All latent variables showed a significant and positive impact on SC flexibility and agility. Results from the combined sample supported H1a, H1b, H2a, H2b, H3a and H3b. Table 7 shows SEM results, including path coefficients, level of significance and fit indices.

The high-customisation sample was analysed next; the results suggest VMS and customer relationships correlate with SC flexibility. Partnerships with suppliers and VMS were related to SC agility (p < 0.05). Paths between customer relationships and SC agility, and between partnerships with suppliers and flexibility did not show a significant result (p > 0.05). Regarding the low-customisation sample, results suggest that all three independent variables correlate with SC flexibility and agility, except for the relationship between partnerships with suppliers and SC flexibility (p > 0.05). By comparing the results from high and low customisation, H4a was rejected and H4b was supported (i.e., the path between customer relationships and agility), which demonstrates that the relationship between variety management activities and supply chain agility differs across levels of customisation. Achieving SC agility thus requires different approaches for different levels of customisation. The partial least squares (PLS) multi-group analysis (MGA) through the bootstrap method (Henseler et al. 2011) also proves the significant difference in coefficients between customer relationships and SC agility (p < 0.05).

Table 7 Results of Structural Equation Modelling

5. Discussion

For VMS, three strategies have been suggested in the operations literature as representative: modularity as a product-based strategy, cellular manufacturing as a process-based strategy and postponement (Scavarda et al. 2010; Jacobs et al. 2011) as a structure-based strategy. However, focusing solely on internal operational factors (i.e., VMS) neglects the importance of external integration factors, which can be more crucial for effective management of product variety in an SC. Extensive SC integration is required to handle increased complexity and uncertainty in making decisions (Fisher, 1997; Mendelson and Pillai, 1999; Heikkilä, 2002). Two practices that accomplish integration across an SC are supplier partnering and building closer customer relationships (Vickery *et al.*, 2003). SC flexibility and agility were considered disparate concepts as an internal capability and external competency, respectively (Swafford *et al.*, 2008; Bernardes and Hanna, 2009). The present study empirically confirms this through EFA.

Due to the importance of alignment between variety-related organisational strategy (e.g., cost leadership and differentiation) and SC strategy (e.g., lean and agile) according to the level of customisation (Agarwal *et al.*, 2006; Stavrulaki and Davis, 2010), the influence of VMS, partnerships with suppliers and customer relationships on SC flexibility and agility should be evaluated separately under varying customisations.

The findings reveal that variety management activities, including both internal VMS and external SC integration, are imperative for SC flexibility and agility when product variety increases and could mitigate the trade-off between product variety and SC performance. Findings concerning H1–H3 also suggest that customer relationships and VMS had a greater influence on SC flexibility than did partnerships with suppliers. In contrast, partnerships with suppliers and variety management strategies had a greater effect on SC agility compared with customer relationships. In particular, to obtain the desired SC flexibility under increasing-variety contexts, monitoring customer-service feedback and responding to customers' evolving needs should be sufficiently encouraged. To attain SC agility under a trend of increasing

variety, joint problem solving and new-product development with suppliers were more significant than customer relationship. In the service sector, customer relationships can be essential to achieve SC flexibility and agility, whereas in this study of the manufacturing sector, the supplier partnership is shown to be a more essential acquisition for SC agility. Comparing the three hypotheses (i.e., H1–H3) for enhancing SC flexibility and agility shows that, first, internal VMSs were most crucial and effective. Second, the combined data also support the interesting notion that partnership with suppliers is more closely correlated with SC agility, whereas customer relationship is closely correlated with SC flexibility.

Separate analyses of low- and high-customisation samples (i.e., H4) provide critical insights into the importance of variety management under varying customisation profiles within a SC. In a high-customisation context in which the focus is on differentiation and market responsiveness (i.e., SC flexibility and agility are the winning criteria), improvements in customer relationships were particularly vital, influencing SC flexibility significantly in comparison with partnerships with suppliers. The results also reveal that, in a high-customisation context, customer relationships influenced SC flexibility (i.e., reaction capability) rather than SC agility (i.e., reaction time). Instead, partnerships with suppliers and VMS were crucial to achieving SC agility in high-customisation contexts. Note that partnerships with suppliers influenced SC agility (i.e., reaction time) rather than flexibility (i.e., reaction capability) in a high-customisation context. The advantage of increased supplier involvement (e.g., joint product development and problem solving) was that it increased the positive impact on product innovation (Nieto and Santamaria, 2007) and reduced cost and time to market (Ragatz *et al.*, 1997), which can enhance SC agility. Thus, in a high-customisation context, close customer relationships proved the most effective way to increase SC flexibility whereas partnership with the supplier was the most effective way to increase SC agility.

Although high customisation presented higher collaborative barriers with the supplier, the supplier partnership was most crucial in improving SC agility (i.e., reaction time).

In low-customisation contexts, internal VMS and customer relationships were required for SC flexibility rather than partnerships with suppliers, whereas all variety management activities, including internal VMS, partnerships with suppliers and customer relationships, influenced SC agility. These findings suggest that, in low-customisation contexts, VMS and customer relations were fundamental factors for both SC flexibility and agility. However, partnerships with suppliers promoted SC agility rather than flexibility, similar to the case for high-customisation contexts. Findings from different levels of customisation suggest appropriate strategic focus for organisations in line with the characteristics summarised by Lampel and Minzbug (1996), Shankar and Tiwari (2006) and Stavrulaki and Davis (2010).

Regarding the theoretical implications, the study first establishes the extensive structure required to mitigate the impact of product variety on the SC, in which internal VMS and external integration are suggested to explore the relationships with SC flexibility and agility performance. Second, both SC flexibility (i.e., reaction capability) and agility (i.e., reaction time) are employed as distinct concepts based on literature reviews (Christopher and Towill, 2001; Agarwal *et al*., 2006; Swafford *et al*., 2008; Bernardes and Hanna, 2009) and provide different strategic procedures through which the variety issues can be managed. Third, the literature on independent variables such as product, process and structure-based strategies (i.e., VMS), partnerships with suppliers and customer relationships contributes to the theoretical implication as variety management activities (see Table 1). Finally, the study explains empirically the differential effects that customisation as a moderating factor has on relationships between variety management activities and SC flexibility and agility. The differences in characteristics and strategic focus depending on the level of customisation (see Table 2) support the varied relationships through the results of the research.

The managerial implications include the adoption of approaches to SC flexibility and agility under different levels of customisation. A distinctive feature of the work is its empiricism. Findings support organisational decision making by providing managers with intuitive guidance on how best to manage product-variety issues in SCs under the different customisation profiles that organisations provide. The study also provides empirical evidence of the importance of holistic strategies at the business level to improve SC flexibility and agility by suggesting two significant approaches: internal VMS and external integration with suppliers and customers. In particular, in a high-customisation context (e.g. innovative products), customer relations were the most important activity to enhance SC flexibility whereas partnerships with suppliers were the most critical activity for SC agility. The findings support the complex policy making for the manufacturer, with supplier and customer relations and the goal of product variety.

6. Conclusion

Product-variety ambitions for improved competitiveness should be considered in terms of optimising the trade-off between product variety and SC performance. Thus, this study suggests two distinct concepts as dependent variables: SC flexibility and agility. Internal VMS and external integration as independent variables are proposed to achieve the required SC flexibility and agility. Partnerships with suppliers and customer relationships are employed as an external integration. Although internal VMS, such as modularity, cellular manufacturing and postponement, was effective at managing variety and enhancing SC flexibility and agility, external SC integration proved crucial. The findings support the management of variety-related issues to achieve the desired level of SC flexibility and agility in both low- and high-customisation contexts. Especially in a high-customisation context involving make-to-order or design-to-order structures, partnerships with suppliers (i.e., external factors) were the most

effective approaches for superior SC agility, whereas customer relationships (i.e., external factors) were the most effective for SC flexibility. However, both internal factors (i.e., VMS) and external factors (i.e., customer relationships and partnerships with suppliers) should be considered to increase SC agility in a low-customisation context.

The first limitation of this study relates to methodology. Although competitive, environmental and cultural disparities exist between countries and regions (Hughes and Morgan 2008), this study focuses exclusively on the manufacturing industries in two countries (the UK and South Korea). The two countries have similar levels of technology (e.g., Top 10), economic development (e.g., G20) and income distribution (e.g., Gini coefficient). In addition, the measurement invariance test proves that the basic structure of the model is cross-culturally stable. Although several tests (i.e., multi-group CFA estimate, measurement invariance test, separate exploratory factor and random split sample analysis) in this research suggest consistent and stable structure across the groups, a potential gap can always exist. Second, the study examines each manufacturer's principal customisation types to investigate relationships with customisation. It then considers only two levels of customisation, low and high, although combinations such as segmented standardisation and customised standardisation rather than single customisation types might well occur. Case studies (e.g., SC performance disparities in mixed customisation contexts) from several countries should be used to enable in-depth examination and to validate extant results (Voss, Tsikriktsis and Frohlich, 2002). Finally, internal VMS focusing on the modular concept requires a broader exploration to cover other potential strategies that might impact business performance. Another topic to be addressed in future research is the impact of product variety on SC performance, including cost efficiency and customer service (see Beamon, 1999), as a function of level of customisation. The ultimate topic for product-variety issues would be to identify the optimised extent of product variety that a company may implement without increasing the cost burden.

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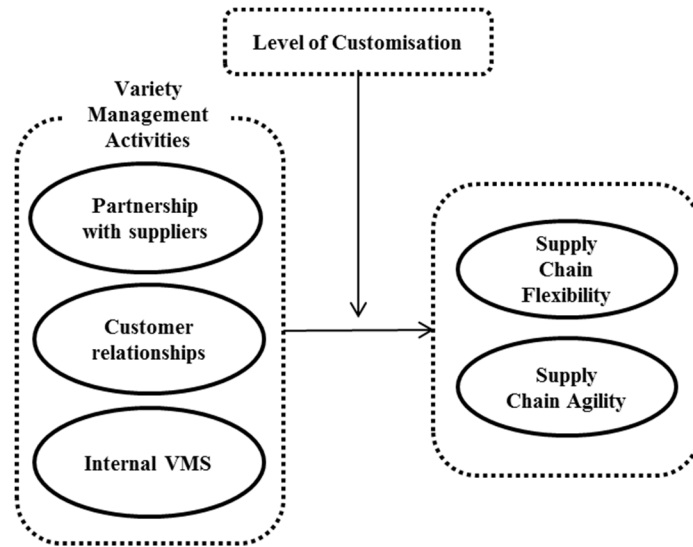
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Figure 1 Research model

Table 1 Variety Management Activities and Related Literature

Structure	Variable	Related literature
Variety management strategy (VMS)	VMS1: Modularity	Ulrich and Tung 1991, Salvador et al. 2002, Doran 2005, Blecker and Abdelkafi 2006, Scavarda et al. 2010, Jacobs et al. 2011, Patel and Jayaram 2013, Syam and Bahatnagar 2015
	VMS2: Postponement	Whang and Lee 1998, Van Hoek, Harrison, and Christopher 2001, Christopher and Towill, 2001, Nair 2005, Scavarda et al. 2010, Patel and Jayaram, 2013
	VMS3: Cellular manufacturing	Yeh and Chu 1991, Ko and Egbelu 2003, Agrawal and Hurriyet 2004, Abdi and Labib 2004, Blecker and Abdelkafi 2006, Scavarda et al. 2010
Partnerships with suppliers (PS)	PS1: Trustworthy relationships with suppliers	Ramdas and Spekman 2000, Handfield and Bechtel 2002, Ngai, Cheng, and Ho 2004, Tummala, Phillips, and Johnson 2006, Liao et al. 2011
	PS2: Close relationships during product development with suppliers	Derocher and Kilpatrick 2000, Power, Sohal, and Rahman 2001, Ngai, Cheng, and Ho 2004, Cousins et al. 2011
	PS3: Joint problem-solving and performance evaluation with suppliers	Chen and Paulraj 2004, Tummala, Phillips, and Johnson 2006
	PS4: Sharing sensitive information with suppliers	Ngai, Cheng and Ho 2004, Liao et al. 2011, Cousins et al. 2011
Customer relationships (CS)	CS1: Anticipate and respond to customers' evolving needs	Tan and Kannan 1998, Ramdas and Spekman 2000, Chen and Paulraj 2004, Zokaei and Hines 2007, Wang and Feng 2012
	CS2: Emphasise evaluation of formal and informal customer complaints	Chen and Paulraj 2004, Ranganathan, Dhaliwal and Teo 2004, Tummala, Phillips and Johnson 2006
	CS3: Monitor and measure customer service levels	Tan and Kannan 1998, Power, Sohal and Rahman 2001, Tummala, Phillips and Johnson 2006
	CS4: Follow up with customers for quality/service feedback	Tan and Kannan 1998, Chen and Paulraj 2004, Wang and Feng 2012

Table 2 General Characteristics of Customisation Types

	Customization	Pure/segmented standardization	Customized standardization	Tailored customization	Pure customization
Type	Structure	Make to stock	Assembly to order	Make to order	Design to order
Product	Product variety / Demand uncertainty / Profit margin / Order lead time / Labour skill	Low	→		High
	Product life cycle / Forecasting accuracy / Volume	High	←		Low
	Product type	Functional	↔		Innovative
Manufacturing	Production process	Continuous, large assembly/batch	Assembly line process	Small batch Job shops	Job shops project
	Product design	Cost conscious	Modular		Specialised
	Manufacturing focus	Efficiency	Efficiency/flexibility focus		Flexibility
	Production cost	Low	→		High
Logistics	Number of intermediaries	Large	←		Small
	Supplier relationship	Collaborative / High information sharing / High volume transactions			Opportunistic collaboration / More collaborative barriers / Low volume transactions
	Customer relationship	Small number of customer segment			Large number of customer segment
	Order fulfilment	Cost driven	↔		Time driven
	Logistics process focus	Efficiency	Efficiency/flexibility focus		Flexibility
SCM	Supply chain strategic capability	Lean	Legality		Agility
Market	Core competitive focus (market winner)	Low cost (cost leadership)	↔		High service (differentiation)

Source: Adapted from Lampel and Mintzberg (1996), Agarwal, Shankar, and Tiwari (2006), and Stavrulaki and Davis (2010)

Table 3 Main Products by Customisation Level

Manufacturing industry type	Low customization (cluster 1)	High customization (cluster 2)	Total	Valid %
Food, beverage, tobacco	17	9	26	7.2
Wood and furniture	17	15	32	8.8
Chemical materials and products	21	7	28	7.7
Non-metal mineral products	8	7	15	4.1
Fabricated metal products	14	19	33	9.1
Computer and communication	16	10	26	7.2
Electronic parts and components	21	20	41	11.3
Electrical machinery and equipment	20	19	39	10.7
Transport equipment	27	11	38	10.5
Textiles and leather	2	6	8	2.2
Paper products	9	2	11	3.0
Machinery and equipment	14	18	32	8.8
Basic metal products	5	3	8	2.2
Clothing and footwear	6	5	11	3.0
Other	10	5	15	4.1
Total	207	156	363	100

Table 4 Measurement Invariance Test across the two Countries

Model	χ^2	df	χ^2/df	RMSEA	SRMR	CFI
Model 1 Configural invariance	813.606	398	2.04	0.054	0.606	0.903
Model 2 M1 + Factor loading invariance	832.880	415	2.01	0.053	0.609	0.903
Model 3 M2 + intercept invariance	860.153	430	2.00	0.053	0.704	0.900

Table 5 Exploratory Factor Analysis

	Code	Factors				
		1	2	3	4	5
1. Partnerships with supplier (Cronbach's alpha=0.800; CR=0.802)						
We develop trustworthy relationships with suppliers	PS1	.465[a]				
We have close relationships in product development with suppliers	PS2	.796				
We undertake joint problem solving and performance evaluation with suppliers	PS3	.764				
We share sensitive information (financial, production, design, research) with suppliers	PS4	.802				
2. Customer relationships (Cronbach's alpha=0.870; CR=0.897)						
We anticipate and respond to customers' evolving needs	CR1		.730			
We emphasise the evaluation of formal and informal customer complaints	CR2		.774			
We monitor and measure customer service levels	CR3		.862			
We follow up with customers for quality/service feedback	CR4		.810			
3. Variety management strategy (Cronbach's alpha=0.793; CR=0.789)						
We use modular production at the assembly stage	VMS 1			.724		
We delay the process that transforms the form or function of products (Postponement)	VMS 2			.805		
We use cellular manufacturing which groups parts with similar design and processes	VMS 3			.810		
4. Supply chain flexibility (Cronbach's alpha=0.860; CR=0.884)						
Ability to change quantity of suppliers orders	FL1				.752	
Ability to change delivery times of orders placed with suppliers	FL2				.705	
Ability to change production volume	FL3				.755	
Ability to change in production mix	FL4				.737	
Ability to implement engineering change orders in production	FL5				.466[a]	
Ability to alter delivery schedules to meet changing customer requirements	FL6				.678	
5. Supply chain agility (Cronbach's alpha=0.894; CR=0.876)						
Ability to rapidly reduce product development cycle time	AG1					.747
Ability to rapidly reduce manufacturing lead time	AG2					.743
Ability to rapidly increase the level of product customization	AG3					.725
Ability to rapidly improve level of customer service	AG4					.709
Ability to rapidly improve delivery reliability	AG5					.731
Ability to rapidly improve responsiveness to changing market needs	AG6					.710
Ability to rapidly reduce delivery lead time	AG7					.683

[a] Dropped due to low factor loadings

Composite Reliability= $(\sum \text{standardized loading})^2 / \{(\sum \text{standardized loading})^2 + \sum \varepsilon_i\}$

Table 6 Inter-Construct Correlation Estimates and Related AVEs

	VMS	PS	CR	FL	AG
VMS	.555+				
PS	.354**	.576+			
CR	.333**	.367**	.687+		
FL	.409**	.333**	.427**	.605+	
AG	.426**	.384**	.374**	.615**	.540+
Mean	3.26	3.49	4.02	3.53	3.23
SD	0.87	0.84	0.76	0.72	0.73

+=Average variance extracted = $\sum$(standardized loading)^2 /($\sum$(standardized loading)^2 + $\sum\varepsilon_i$)
**=Correlation coefficients significant at α=0.01

Table 7 Results of Structural Equation Modelling

Construct	Path coefficient	t-value	Significance
Combined sample			
1. Flexibility			
Partnerships with suppliers	+.148*	2.151	.031
Variety management strategy	+.320***	4.628	.000
Customer relationships	+.269***	4.153	.000
2. Agility			
Partnerships with suppliers	+.251***	3.590	.000
Variety management strategy	+.335***	4.780	.000
Customer relationships	+.148*	2.400	.016
High customisation sample			
1. Flexibility			
Partnerships with suppliers	+.132	1.204	.229
Variety management strategy	+.244*	2.210	.027
Customer relationships	+.351**	3.046	.002
2. Agility			
Partnerships with suppliers	+.307*	2.549	.011
Variety management strategy	+.299*	2.362	.018
Customer relationships	+.031	.281	.779
Low customisation sample			
1. Flexibility			
Partnerships with suppliers	+.137	1.546	.122
Variety management strategy	+.317***	3.426	.000
Customer relationships	+.247**	3.013	.003
2. Agility			
Partnerships with suppliers	+.215*	2.523	.012
Variety management strategy	+.340***	3.805	.000
Customer relationships	+.230**	2.971	.003

$\chi^2_{[199]}$ = 535.232; CFI = 0.919; NNFI = 0.906; RMSEA = 0.068; SRMR = 0.051
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$