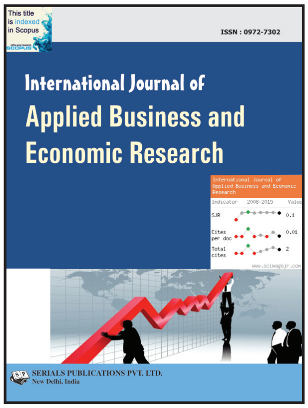

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The Effects of Information Sharing Between Module Buyer and Supplier on Mass Customization

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ABSTRACT

This study examines the effects of information sharing between module decision-maker and module supplier on modularity and mass customization capability. To prove the validity of the thesis, a comprehensive survey of various manufacturing industries in South Korea was conducted and constructs were created. An empirical test was then performed using structural equation modeling on samples of 211 manufacturing firms. The overall sample indicated positive relationships among each of variables. The results suggest that such multiple dimensions of information sharing between module decision-maker and module supplier facilitates modularity, which in turn enhances mass customization capability. This study is the first to attempt the effects of information sharing between module decision-maker and module supplier on modularity and mass customization capability empirically. Further, it provides implication into the exact nature of the influence of information sharing on modularity in the perspective of mass customization.

Keywords: Information sharing, Modularity, Mass customization capability.

1. INTRODUCTION

As competition among firms has intensified, a powerful strategic weapon to hold a dominant position has continuously changed. Securing sustainable competitive advantage, in the past, seems feasible in conjunction with good quality products and services. However, Teece (1997) posited that ensuring sustainable competitive advantage with quality goods alone is no longer effective since supply capacity in many industries exceed the demand. In addition, most purchasing decisions are made by customers, adding more complexity. It is difficult to generate stable revenues because of complexity in customer demand, shorter product life cycle and the rapid development of technology. Thus, securing a sustainable competitive advantage under uncertainties requires quick response to changing market conditions. When the markets are volatile, firms require more flexibility to cope with uncertainties (Asker, 1984).

A mass production method triggered by Henry Ford was an effective strategy, intended for mass production, resulted in lower price of customer goods. Today, customers are willing to pay more for customized products that gratify individual preference due to diversity of customer demands. Thus, the most important management issue today is identifying customer needs and satisfying the diverse demands. To accommodate volatile market and consumer's heterogeneous demands, firms endeavor a wide range of production paradigm to satisfy individual. Mass customization, as a new production paradigm, shed light on underlying notion of customer and firm satisfaction. The concept of mass customization is initially developed by Pine (1993), focusing on both marketing and operational perspectives. From a marketing perspective, it is developed to focus on benefits associate with mass customization. From an operational perspective, it is concentrated on the development of mass customization capabilities based on modularity and performance. Mass customization is adopted to overcome the limitations imposed by traditional mass production and is based on modularity production to accommodate different customer needs. Initial development and configuration of standardized modules should take place prior to receiving customer orders so that re-assemble or re-configuration of module can be deployed (Davis, 1989). Manufacturing processes should be designed by embedding independent modules so that they can be reassembled or rearranged to support different product designs (Feitzinger, 1997).

Modularization is requisite for undertaking production activity to meet short delivery time depending on the products customer order (Sanchez 1995; Worren, Moore & Cardona, 2002). Mass customization grants flexibility with modularization while maintaining a mass production capability for production to meet customer needs, resulting in cost efficiency (Ulrich, 1995; Wang, Chen, Zhao and Zhou, 2014). Thus, modularity is the indispensible factor of maximum level mass customization (Ahlstroom & Westbrook, 1999; Merle, 2010). In the early days of modularization, the manufacturer was in charge of developing/producing final module components whereas current module productions are mostly outsourced. The initial motivation of outsourcing is to reduce cost while recent expansion of module outsourcing is propelled to ensure the expertise in modularity (Hong, 2009). Module outsourcing provides, to a greater extent, opportunity to focus on core competencies for both module buyer and module supplier. Module outsourcing is no longer a simple production of module components; rather it is 'activity' to gain expertise. For example, a module buyer exclusively focuses on R&D for new technology development while a module supplier devotes to efficient module production. Such activities grant a greater depth of expertise on developing core competencies and achieving optimal level of efficient module development. This, in turn, allows module suppliers to suggest efficient module production methods to buyer. Thus, the following research questions are carefully scrutinized to understanding the factors affecting the relationship between module buyer and module supplier.

1. What are the most important factors for module buyers and suppliers when firms begin outsourcing module component?
2. What are the key factors to achieve expertise for module buyer and supplier?
3. How to build an efficient mass customization capability to meet consumer needs?

Our study therefore has collected data to investigate the impact of information sharing between module buyer and supplier on mass customization capability. This study has the following objectives. First, we collected the opinions of experts on heterogeneous industries that widely adopted modularity concept into practice and tested the validity of research model. Second, we have empirically demonstrated the relationships among information sharing, modularity and mass customization capability. Third, we used modularity as a mediating variable to assess the validity of mass customization. Collaboration among supply chain partners using information sharing strategy can lower transaction cost. The lack of information sharing in supply chain may cause the predicament known as "bullwhip effect" in which irregular orders in downstream supply chain cause inefficiency in entire supply chain partners. This may be alleviated through close information sharing between supply chain partners. Limiting uncertainty through information sharing, in turn, reduce the suppliers' risks since this strategy optimize production, inventory, and delivery planning.

Based on our findings, our empirical study attributes to the current academic debate in the following directions. First, we verify the importance of information sharing, acting as a key factor in decision making between module buyers and suppliers when module components are outsourced. Doran (2003) implies the characteristics of module buyers and suppliers in supply chain yet little empirical has been done to prove the impact of such characteristics. We therefore empirically tested the importance of information sharing in every aspect thoroughly. Second, we conduct a test to provide evidence for the importance of information sharing and examine the critical capabilities required to achieve mass customization. At last, we discover additional industries that use modularity to a wider extent on large scale mass customization.

The remainder of this research is organized as follows. We present the literature review in section 2 and Section 3,4 develops the hypothesis and research methodology. In section 5 and 6 empirical results are drawn and limitations are discussed including brief academic and management implications.

2. LITERATURE REVIEW

Information Sharing

Simantupang and Sridhara (2005) suggested the initial point of supply chain concept is information sharing. The objective of information sharing is to spread appropriate information for planning and controlling entire supply chain operation. Efficient information sharing provides a close coordination across inter-dependent firms (Whipple, Frankel & Daugherty, 2002). Examples of sharing data include: inventory managements, forecast of demand, and delivery schedules.

Customer demand is a driving force of sharing customer demand information; therefore it is important in supply chain coordination (Hur, Hartley & Hahn, 2004). When customer demand is interpreted into orders and passed onto upstream supply chain, information distortion occurs-a phenomenon known as the bullwhip effect. Information sharing, thus, becomes critical in reducing distortion of information among supply chain partners. Heide and John (1992) also define information sharing as a value added firm resource in which sharing of information allows better cooperation among supply chain partners. A good example is illustrated in the case of Wal-Mart that they transmit up-to-date sales inventory information to its supplier network via satellite in real time, result in reduction of order cycle time (Arli, Dylke, Burgess, Campus & Soldo, 2013).

Most organizations endeavor to reduce the uncertainties in operation by enhancing the reliability of relevant information. Information asymmetry among the supply chain partners result in uncertainty, leading inefficiency of the entire supply chain. Furthermore, sharing information among inter-related firms may lead to high expectations of collecting firm competent information therefore corresponding to inner and outer markets more efficiently (Heidi & John, 1992). Consequently, sharing information is recognized as a prerequisite condition for efficient supply chain and plays a pivotal role in controlling entire supply chain (Cooper, Lambert & Pagh, 1997)

Premkumar and Ramamurthy (1995) imply that information sharing focuses on information flow in supply chain integration. An optimal level of supply chain integration can be implemented using information technology that helps effective information sharing among supply chain partners (Zhou & Benton, 2007). Such information technology can be achieved using EDI, ERP or by informal means, email, phone and meeting (Huo, Zhao & Zhou, 2014)

Dyer (2000) asserts that organization learning as the most strategically significant in achieving sustainable competitive advantage. Many researchers have perceived that inter-organizational learning is crucial to the success, emphasizing that organizations should learn to cooperate with other organizations. To keep abreast of sustainable competitive advantages, firms are required to share such information; (i) information about production cost between module supplier and buyer (ii) information about improvement in delivery and inventory management or to lower production cost (iii) information about confidential or proprietary data/knowledge (Lotfi, Mukhtar, Sahran & Zadeh, 2013).

Sahin and Robinson (2002) state that information sharing is often treated as panacea for supply chain integration. Information sharing can be divided into two levels; under *no information sharing stage*, supplier only receives actual orders from customers whereas *full information sharing* stage, entire information is available to backup the particular decision making. Such information include: production cost, process status, logistics status, inventory costs, and data from all channel members. Thus, an optimal level of supply chain integration can be maximized when inter-related firms have authority to access in full information regarding to each channel members activities in real-time.

Based on prior theoretical studies, we have classified information into 3 categories: sharing information of market, information sharing about inner firm accumulated knowledge and sharing knowledge about operational perspective.

Modularity

Many literatures define modularity ambiguously and absolute definition of modularity has not been established. Generally, modularity is defined as; product components can be disassembled and reassembled to serve same functional purpose (Gershenson, Prasad & Zhang, 2003; Schilling, 2000, Campagnolo & Camuffo, 2010). Modular products tend to have fewer components for assembly therefore it is easy to assemble.

Subsequent modular studies particularly put emphasis on the product life cycle perspective, flexibility as a strategic intent, and importance of modularity in SCM integration (Salvador, Holan & Piller, 2002). This notion has encouraged two parallel streams of research, with one focused on the *operations management* domain (Lau, Yam & Tang, 2010) and the other in the *design and engineering management* domain. While research in operations management centered upon how internal operations change or should be managed when firms modularize products architectures, research in design/engineering management has focused more on the issues of defining modular products, how product architectures can be modularized, and how design activities change or should be managed. Along the same vein, recent studies on modularity defined the concept of modular in every aspect.

The benefits associated with implementing modularity are described as follows. First, function sharing in the design theory refers to the phenomenon of a single component implementing several functional elements (Ulrich & Tung, 1991; Ulrich, 1995). Products occasionally go through many transformations during product life cycle and the motivations behind these transformations are upgrading. Examples include changing the graphic card in computer or replacing air cleaner in a car, and products that are sold by a base unit in which the user can add module components when needed. Such alteration is common in the manufacturing industries. Second, if the firm uses the modular product architecture, different kinds of computers can be made from a few different kinds of module components.

Gershenson (2003) asserts that capability to change one or more module components grants flexibility. This flexibility, therefore, allows delaying in design decision until more data is ready without postponing the product development process. Another benefit associated with modularity is to diminish life-cycle costs by reducing the number of processes.

Mass Customization Capability

The concept of mass customization was first introduced by Stan Davis in Future Perfect (Davis, 1989) and further developed by Pine (1993), shedding lights on a new paradigm for the firms that offer services and products well-suited to individual needs while maintaining mass production efficiency (Tseng & Jiao, 2001; Fogliatto, Silveria & Borenstein, 2012). The core characteristic of mass customization is the ability of product variations for each individual needs and the efficiency of mass production, resulting affordable price due to low production cost achieved by mass production. Pine (1993) contended that mass customization is an effective means of production strategy focused on personalized products and services in which modular products and process should be associated with. Along the same vein, Salvador, Holan and Piller (2009) consider MC as an important factor to drive producing, developing, and delivering goods and services with customization that each individual satisfy with.

The following competencies are required to achieve mass customization. First, efficacy of customization cost; customize products without increasing manufacturing costs, must be secured (Tu, Vonderembse, Ragu-Nathan & Ragu-Nathan, 2004; Fogliatto, Silveria & Borenstein, 2012; Wang, Chen, Zhao & Zhou, 2014). When the pursuit of mass customization leads to increasing production and purchasing costs exponentially, firms may not secure competitive advantages. Also, consumers are reluctant to increase in product price because of mass customization. Thus, firms develop mass customization capability to provide customized products by utilizing flexible processes at low cost, by establishing efficient production process (Lau, Yam & Tang, 2010; Pine, 1993). Second, customization volume effectiveness, adding various products without reducing the volume of production, is required. As aggregate demand increases and markets become more segmented, firms must produce high volumes to achieve economies of scale (Goldhar & Jelinek, 1983). Last, customization responsiveness is the capability to reconfigure manufacturing process quickly for individual customer requirements (Tu, Vonderembse, Ragu-Nathan & Ragu-Nathan, 2004). Mass customization is not a feasible strategy when product customization takes longer since most customers are reluctant to wait. Thus, speed plays an important role in achieving mass customization capability (Pine, 1993). To be successful, organizations pursuing a mass customization strategy should develop firm capabilities in which low cost production, high production volume and short delivery time can be achieved simultaneously while delivering customized products to satisfy individual preferences. These inner capabilities are imperative components of mass customization (Tu, Vonderembse & Ragu-Nathan, 2001).

MC has become an imperative part of manufacturing strategy. It incorporates the ability to provide individual custom products to customers in mass markets.

3. CONCEPTUAL MODEL AND HYPOTHESES

Recent studies focused on mass customization as a valuable asset to enhance overall performance of firms but include few analysis of the mediate effect of modularity on mass customization. Our study validates that the effects of information sharing is positively correlated with modularity and mediate effects of modularity on mass customization.

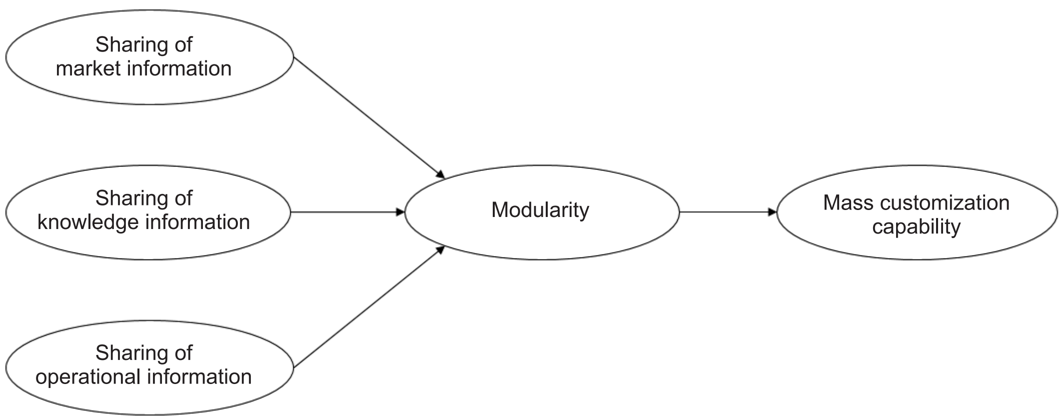

Figure 42.1: Research model

Sharing of Market Information and Modularity

Yu, Yan and Edwin Cheng (2001) assert uncertainties occur because of lack of perfect information regarding other supply chain partners. To reduce uncertainties, each supply chain members must attain adequate information on other members' activities. When active sharing of information is engaged, each supply chain partners will obtain more information about others. Increasing information sharing among supply chain members can lead to cooperation that is called a supply chain partnership. Such partnership reduces the negative effect of the *bullwhip effect* on a supply chain due to active sharing of information among supply chain members reduce uncertainties (Chen & Lee, 2012). Ellram and Hendrick (1995) show that partnering is characterized by information sharing, two way communication and trust and those variables should take into account as factors to influence among coordinating partners. That is to say, sharing information among supply chain partners significantly enhance the relationship therefore achieving a better overall performance (Truman, 2000).

Adopting modular strategy allows firms to have diverse advantages; obtaining a global competitive advantage while having quick readiness to the demands of market. The modular architecture is flexible

(Sanchez, 1995) because product variations are achievable by substituting different modular components without redesigning base units. Gershenson (2003) suggested that the greatest benefit associate with modularity, to the full extent flexibility, is postponing strategy in which delay of product module may not disrupt the entire supply chain coordination.

Product module outsourcing implies that each modular component for certain product is manufactured outside of firm in cases which firm's capability to produce such modular component is lack in-house. Thus, outsourcing a modular component is an effective short term solution for development capacity they lack-in within organization (Novak & Eppinger, 2001). Therefore, it is important to make predictions in regard to information that foresees the customer demands and volatile market (Du, Jiao & Tseng, 2001). This in turn leads to share more information between suppliers and customers. Wang and Wei (2011) bring up the importance of sharing information in regard of market and customer demands and attribute a high degree of modularity. To sum up, overall performance of modularity may be enhanced when module supplier and module buyer are committing to share detail market information. Therefore, it is hypothesized that:

H1: Firms that share more market information will have the higher level of modularity

Sharing of Knowledge Information and Modularity

Knowledge is an important factor in determining the capability to perform new process and develop organization innovation (Wang & Wang, 2012). Firms possess an ability to acquire firm specific knowledge through various knowledge accumulation activities: such activities include transferring knowledge between module buyer and module supplier, forming alliance to share firm specific knowledge. A knowledge codification is reflected in formalized process for knowledge acquisition, converting knowledge and integrating acquired knowledge (Greiner, Böhmann & Kumar, 2007). Firms have processes to combine their experience and integrate with knowledge obtained from outer sources (Sarvary, 1998). Knowledge sharing therefore acts as a bridge between module buyers and module supplier. Creation and utilization of knowledge is an essential condition for companies to survive (Sarvary, 1998).

Inter-firm cooperation is a driving factor to share firm specific knowledge since creating new knowledge to make rational choice is beyond the scope of a single firm under uncertainty. Makri, Hitt and Lane (2010) agree that learning unattainable knowledge from other inter-related organizations are a method to attain strategic competency. The time between identifying problem and its resolution may not be feasible for firms to develop the knowledge internally and to respond efficiently (Dierickx & Cool, 1989). Willcocks and Kern (1999) insisted that exchanging communication and information play a crucial role in building trust. The communication mechanism normally utilized in outsourcing activities lead to better trust and trust can improve the level of formal and informal communication (Anderson & Narus, 1990; Dwyer, Schurr & Oh, 1987). Thus, meaningful communication is an essential antecedent for trust. Regular communication help to avoid conflicts, promote solutions to problems and alleviate the level of uncertainties (Aiken & Hage, 1968; Easton, 1992). We, therefore, setup the following hypothesize.

H2: Firms that share more knowledge information will have the higher level of modularity

Sharing of Operation Information and Modularity

Multinational firms are accelerating information flow throughout entire supply chain network to meet the increasing demands of market (Spekman, Kamauff & Myhr, 1998, Ding, Guo & Liu, 2011). Supply chain partners constantly share information that enhances their ability to meet customer needs as well as to spread the risk across the entire supply chain network. An ultimate supply chain includes not only downstream and upstream flows of products but also information sharing between suppliers to the customer (Mentzer, Min & Zacharia, 2000, Ma, Wang, Che, Huang & Xu, 2013). Mutual sharing information among supply chain members is needed when implementing a Supply chain strategy for planning and monitoring processes (Cooper, Lambert & Pagh, 1997; Cooper & Ellram 1993). Cooper and Lambert put emphasis on frequent information updating among the supply chain members for effective supply chain management. Open sharing of information such as forecasting, checking inventory levels and promoting sales reduces the uncertainty among supply partners thereby enhancing the performance (Andel, 1997; Lewis & Talalayevsky 1997). Margaret and Mavondo (2003) also imply that transaction cost could be reduced between suppliers and customers in SCM when sharing of operation information increased.

Operation information can be subcategorized into firm activities involved in sales data, delivery, order, production scheduling, inventory and etc. Moberg, Culter, Gross and Speh (2002) suggest operation information is necessary to maximize inter-related firm transaction. If module suppliers depend solely on orders for future production, the problem may arise since order data from module buyer often misinterpret the true nature of market- a phenomenon known as "bullwhip effect" (Lee, Padmanabhan & Whang, 1997, Bray & Mendelson, 2012). Any information in the form of orders misleads upstream supply chain partners in inventory and decisions regarding production. It eventually hurts the overall efficiency of supply chain causing excess inventory, excess purchase of materials, excess warehousing expenses, and high shipping costs. To avoid such inefficiency, inventory information along with sales data should be shared. The best example of sharing such information can be seen in P&G and IBM that they receive point-of-sales (POS) data on a regular basis. Manufacturers can utilize production and delivery schedule of suppliers to enhance production schedule. For example, accessing to the production schedule for order and delivery requirement information is common in many car manufacturers. Information about production/delivery schedule helps customers to plan their own production schedule. Sharing operation information, therefore, contributes to facilitate better communication and coordination within supply chain partners and act as an enabler for linking technology and knowledge (Williams, 1997). We, therefore, setup the following hypothesis.

H3: Firms that share more operation information will have the higher level of modularity

Modularity and Mass Customization

Modularity is unique method that deliberately allows high degree of autonomy based on standardized components. (Sanchez & Mahoney, 1996; Wang, Chen & Zhao, 2014). These characteristics can be said to maximize flexibility. Ulrich and Tung (1991) explain the benefit associated with adopting modularity. The advantages of adopting product modularity include (i) achieve economy of scale due to component utilization across product families (ii) easier product upgrading because of functional module (iii) variety of product production (iv) decrease order lead time due to fewer components to assemble. Because of interchangeability of modules, modularity grants more flexibility in which flexibility earned by modularity allows design decision to be postponed. Modular design has been used in many areas to create products with interchangeable functions. (Gershenson, Prasad & Zhang, 2003). Modular products offer significantly increased flexibility in gratifying end-users requirements through standard interfaces and grouping of these interfaces for functional purpose. Modularity also provides variety of selection to deal with ever-increasing demand for each customer and to satisfy the needs by designing a similar interface.

Along the same vein, optimal level of mass customization can be achieved through modularity and key to attain low-cost customization. Pine (1993) states that a high level of mass customization requires modularity in production. McCutcheon, Raturi and Meredith (1994) agree that modularity provides heterogeneity in product and improve speed to market, increasing the customization responsiveness. Mass customization normally is defined as assembling products for customer requirements using modular components to accomplish economies of scale (Duray, Ward & Milligan, 2000; Kuo, 2013). The use of modular platform approach has been seen in automobile industry where many firms adopt such discipline with different degree of implementation or interpretation. For example, Volkswagen uses a common module platform to produce several models, providing several advantages include; shorter product development time, increase product variation, and enhance productivity. Thus, we hypothesize the following.

H4: High levels of modularity capabilities will have positive effects on mass customization capability.

4. RESEARCH DESIGN AND METHODOLOGY

Prior studies on modularity and mass customization has been debated yet so little empirical studies have been done to find high levels of information sharing will result in high levels of modularity and into mass customization.

Our study thoroughly analyzes the following research issues. (1) the relationship among information sharing, modularity, and mass customization capability, (2) the influence of information sharing (market information, knowledge information, operational information) on modularity between module decision-maker and module supplier, and (3) the impact of modularity on mass customization. We synthesize the research model based on careful literature review. The following sections suggest that manufacturing structure strategy, in the form of modularity, fully mediates the effects of information sharing on mass customization. We expect that information sharing between module decision-maker and module supplier will support and facilitate their modularity and that, in turn, this manufacturing structure will affect mass customization capability. The primary research instrument for the study is a rigorously validated questionnaire.

Sampling and Data Description

The aim of this study is to validate the impact of information sharing on modularity and influence of modularity on mass customization. The following section delineates the research method for large scale data collection. Our unit of analysis is the manufacturing company. We surveyed 211 Korean manufacturing firms in the Korean Business List to obtain our data. To attain adequate samples and increase response rate, we implemented Frohlich's (2002) strategy such as leverage method (ask institutes with many industry connections for distributing questionnaires to pertinent targets). Korean manufacturing firms were selected because Korean manufacturing firms are highly advanced that requires modularity and mass customization, to meet the heterogeneous demand.

Expert feedback on 5 constructs developed from previous literature was carefully analyzed by 3 industry practitioners and 3 faculty members in the fields of supply chain management. Few items were removed and reworded from the initial list of items. The survey items, further, clarified through pre-pilot to test the research hypothesis, including strict tests for reliability and validity.

Choosing pertinent target firms that should have deep comprehension of modularity and mass customization are the primary concern for this research. Our study focus on Korean manufacturing firms including high tech, automobile, shipbuilding, computer, communication device and etc. The targeted respondents were the operations manufacturing/procurement/supply chain/management – assistant manager, general manager, directors and CEO as these executives have the best knowledge when answering the questionnaire.

The survey was web-based, mail-based and the final version of the questionnaire was sent by mail to 1620 targeted firms. To assure a satisfied response rate, we included cover letter indicating (1) the implication and purpose of the research (2) options to response: online survey and submission. A total of 224 questionnaires were returned, 209 of which were usable because of missing values. The final respondent rate was 13.8%. About 60% of the survey respondents held the title of general manager, director, CEO indicating that samples were truly reflect the in-depth knowledge of modularity and mass customization. We were confident that these respondents have more than 10 years of leveraging the expertise in modularity and mass customization and are able to respond requested in the survey. Respondent's position profile is listed in Table 42.1.

Questionnaires that were returned with missing values were regarded as unusable and were excluded in our anaylsis. Respondent characteristics are thoroughly analyzed including electronics (20.0%), automobile (14.2%), telecommunication (13.3%), computer (12.8%). Table 42.1 displays respondents departments and current positions: SCM department (31.7%), production department (38.9%), management (29.4%), assistant manager (39.8%), general manager (35.5%), and director/CEO (24.7%).

Table 42.1
Descriptive statistics in terms of industry, department, position

	Category	*Frequency*	*(%)*
Industry	Electronics	42	20
	Automobile	30	14.2
	Telecommunication	28	13.3
	Computer	27	12.8
	Metal Processing	23	10.9
	Machinery	22	10.4
	High Tech	21	9.9
	Shipbuilding	18	8.5
	Total	211	100
Department	Production	82	38.9
	SCM	67	31.7
	Management	62	29.4
	Total	211	100
Position	Assistant manager	84	39.8
	General Manager	75	35.5
	Director/CEO	52	24.7
	Total	211	100

Measurement Items

To measure the independent variable, sharing of market information, we adopted scale used by Gosain, Malhotra and Sawy (2004), Wang and Wei (2011), Titah, Shuraida and Rekik (2016). The definition, sharing of market information, in this research is a degree of sharing information about competitors, markets and customers that were thoroughly analyzed. The measure for sharing of market information was measured using 7 scale Likert with left end marked "strongly disagree and right end marked "strongly agree". Sharing of knowledge information is defined as a degree to which accumulated knowledge was acquired by firms' own research/development and share information (Kale, Singh & Perlmutter, 2000). Drawing on the existing literature based on Truman (2000), we used four seven-point Likert items to measure sharing of knowledge information. Based on the previous research proposed by Mentzer, Min and Zacharia (2000) and Moberg, Culter, Gross and Speh (2002), we used four seven point items to measure sharing of operational information, to capture the extent to which the firm's willingness to share information in terms of order, shipping, material and scheduling activity.

There is one mediating variable in our research, modularity, measured using the scales utilized by Worren, Moore and Cardona (2002) with slight modifications. These modifications were thoroughly assessed by 2 industry practitioners and 1 academic expert during the development of questionnaire to clarify the ambiguity.

We defined mass customization as a strategic intent of personalized products through modularized product design, flexible process and integration between supply chain partners (Silveria, Borenstein & Fogliattio, 2001). To measure the dependent variable, mass customization, we adopted scales used by Tu, Vonderembse, and Ragu-Nathan (2001) and Chung, Byrd, Lewis and Ford (2005) which has been confirmed in terms of reliability and validity.

We utilized four seven scale items to measure mass customization with left point marked "strongly disagree" and right point marked "strongly agree". Table 42.2 is measurement items and sources.

Table 42.2
Measurement items and sources

Construct	*Item*	*Source*	*Cronbach'a*
Sharing of market information	We share information about product change with partners	Gosain et. al. (2004), Wei and Wang, (2010)	0.887
	We share information about sales/marketing with partners		
	We share information about market demands and forecasts with partners		
	We share information about customer needs and preferences with partners		
Sharing of knowledge information	We share a variety of issues with partners on a regular basis	Truman (2000)	0.910
	We share information about new ideas with partner		
	We obtained differentiated knowledge from partners		
	We share value added knowledge with partners to improve outcomes		
Sharing of operation information	We share order information with partners	Mentzer et. al., (2002), Moberg et. al., (2002)	0.874
	We share shipping information with partners		
	We share material requirements planning information with partners		
	We share production schedule with partners		

Construct	*Item*	*Source*	*Cronbach'a*
Modularity	We use modularized design Our products can add modules to a standard base unit upon request Our product modules can be rearranged by end users to suit their needs Our production process can be adjusted by adding new process modules Our production process modules can be adjusted for changing production needs	Worren et. al., (2002), Tu et. al, (2004)	0.936
Mass customization capability	We can add variety of product at low increasing cost We can produce customized products on a large scale We can produce customized products quickly Our organization structure is lean and agile to produce customized products We can deliver various products to accommodate customer's special needs	Tu et. al, (2001), Chung et. al., (2005)	0.937

Scale Purification and Construct Validation

Reliability and Validity Test

Our structural model was to test for validity and reliability. Multiple criteria were considered to guarantee the reliability and validity of our measures.

First, Convergent validity was assessed using composite reliability, Cronbach's alpha, and average variance. Convergent validity requires to be measured since constructs that are expected to be related are, as a matter of fact, related. Reliability was attested by inspecting both factor loadings of items in each constructs internal consistency of constructs. As shown in Table 42.5 Consistency of the constructs were measured using Cronbach's alpha which was 0.833 for sharing of market information, 0.909 for sharing of knowledge information, 0.881 for sharing of operation information, 0.936 for modularity and 0.944 for mass customization. The results indicate that the internal consistency of all five measures exceeded the recommended cutoff value suggested by Nunally (1978). The average variances extracted (AVE) for our constructs ranging from 0.713 to 0.772 that are above an acceptable level 0.5 (Fornell & Larcker, 1981), verifying that convergent validity is in fact confirmed. Composite reliability in Table 42.3 indicates the acceptable value of overall convergent validity.

Table 42.3
Convergent validity

	Indicator	*NS-regression coefficient*	*Standard error*	*C.R.*	*S-regression coefficient*	*CR**	*AVE***
Sharing of market information	SMI_1	1			0.79	0.883	0.716
	SMI_2	1.138	0.086	13.258	0.873		
	SMI_3	1.151	0.087	13.253	0.873		
Sharing of knowledge information	SLI_1	1			0.875	0.909	0.77
	SLI_2	0.945	0.058	16.201	0.874		
	SLI_3	1.026	0.062	16.558	0.885		

Sharing of operational information	SOI_1	1			0.854	0.881	0.713
	SOI_2	1.037	0.066	15.601	0.897		
	SOI_3	0.864	0.068	12.765	0.778		
Modularity	MO_1	1			0.832	0.936	0.747
	MO_2	1.047	0.054	19.506	0.847		
	MO_3	1.143	0.07	16.308	0.902		
	MO_4	1.117	0.066	17.037	0.936		
	MO_5	1.035	0.08	12.98	0.798		
Mass customization	MCC_1	1			0.905	0.944	0.772
	MCC_2	1.048	0.058	18.226	0.969		
	MCC_3	0.926	52	17.897	0.868		
	MCC_4	0.936	0.053	17.568	0.861		
	MCC_5	0.888	0.062	14.34	0.78		

*CR: Composite reliability, **AVE: Average variance extracted

Discriminant validity, in fact, tests concepts we measure should be unrelated (Stratman & Roth, 2002). Discriminant validity was measured by comparing AVE of each construct to its correlation with other constructs. Table 42.4 below presents that square root of AVE is greater than correlation values, suggesting appropriate discriminant validity for each construct.

Table 42.4
Discriminant validity

Construct	*SMI*	*SKI*	*SOI*	*MOD*	*MCC*
Sharing of market information (SMI)	0.716				
Sharing of knowledge information (SKI)	0.662	0.770			
Sharing of operational information (SOI)	0.693	0.711	0.713		
Modularity (MOD)	0.534	0.541	0.579	0.747	
Mass customization capability (MCC)	0.480	0.493	0.499	0.633	0.772

*n = 211 observations: All correlations are significant at the 0.01 level
**AVEs are on the diagonal; square correlations are off-diagonal.

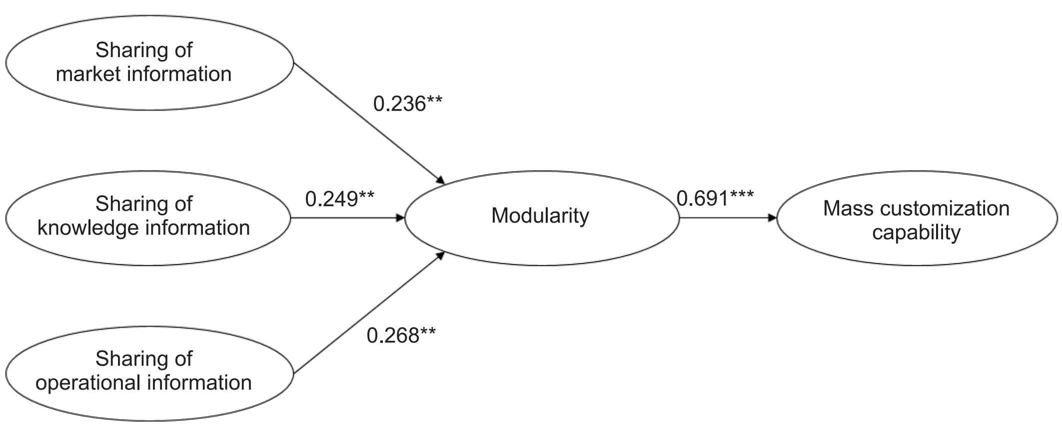

Figure 42.2: Result of Structural Equation Model
$^{***}p < 0.01$, $^{**}p < 0.05$

Data Analysis and Hypotheses Testing

AMOS method was utilized to test the relationship among 5 variables. Figure 42.2 displays AMOS path analyses results. The goodness of fit of the measure in Figure 42.2 was evaluated, using various fit index indices such as goodness-of-fit index GFI = 0.904 (>0.9), root mean square error of approximation RMSEA = 0.045 (<0.05), normed fit index NFI = 0.942 (>0.9), comparative fit index CFI = 0.983 (>0.9), adjusted goodness-of-fit index AGFI = 0.886 (<0.9), root mean square residual RMR = 0.05 (≤0.05). All indices meet the recommended minimum values and prove that the measurement model is reliable and strongly supported by the data collected.

Hypothesis 1 is strongly supported (0.236, $p < 0.05$), makes it evident that sharing of market information may positively influence the modularity. Consistent with the hypothesized model, the result H2 support the conclusion that high levels of sharing information knowledge leads to the high levels of modularity 0.249** (p < 0/05). Hypothesis 3 is also supported, which indicates that adoption in higher sharing operational information between interrelated firms results in high levels of modularity 0.268** ($p < 0.05$). Hypothesis 4, the AMOS path coefficient is 0.691** ($p < 0.05$) which is statistically significant at $p < 0.05$. The implication of these hypothesis testing results are discussed in the next section.

In a model with both the independent variable and the mediator predicting the outcomes, it should be validated that the mediator is associated with the outcome as well. Though the Bootstrapping method used in AMOS is widely used, we adopted Sobel test method since it is more accurate and determines the significance of indirect effect of the mediator by testing hypothesis. When the z-value is greater than 1.96 or less than −1.96, the null hypothesis is rejected and the mediating effect is determined as statistically significant. We concluded that the mediating effect exists since the value of z is statistically greater than recommended value (sharing of market information $z = 2.027$, sharing of knowledge information $z = 2.387$, sharing of operational performance $z = 2.554$)

Table 42.42.5
Result of Sobel test

Path	*Standardized coefficient*	*Standard error*	*Sobel-Z score*	*Result*
Sharing of market information → Modularity	0.236	0.113	2.027	Supported
Modularity → Mass customization	0.691	0.082		
Sharing of learning information → Modularity	0.249	0.1	2.387	Supported
Modularity → Mass customization	0.691	0.082		
Sharing of operational information → Modularity	0.268	0.1	2.554	Supported
Modularity → Mass customization	0.691	0.082		

Based on the AMOS path coefficients, the results support all hypotheses. The empirical result of hypothesis 1 is statistically significant at $p < 0.05$ and consistent with hypothesized model that sharing of market information is significantly related to modularity. Firms that actively engage in sharing market information enables to reflect the true nature of information about consumers and markets so that practical modular development is feasible. Hypothesis 2 measures the relationship between the sharing of knowledge information and modularity, yielding reliable statistical significance. As product modules are outsourced, knowledge information sharing becomes imperative to verify and create module components between suppliers and buyers. Sharing much knowledge as possible between interrelated firms may grant firms to accumulate in-depth firm specific knowledge giving competitive advantages over competitors. Hypothesis 3 is supported, indicating that real time operational information between inter-related firms enhance the higher level of modularity. Doing so may grant simultaneous process postponement and share real time scheduling activities for production, contributing fewer inventories on assembly lines. As posited in hypothesis 4, a high level of modularization is positively correlated with mass customization, the result of testing H4 support the existing literatures in the conclusion that modularity must be preceded before mass customization. To have successful mass customization, product should be customizable. A successful MC product should be modularized, flexible, and versatile (Silveria et. al., 2001). It enables simple and low cost manufacturing of products. Our finding suggests that a higher degree of modularity leads to frequent production of heterogeneous products at low cost. This, in turn, result will likely to enhance the capability of mass customization.

5. CONCLUSION AND CONTRIBUTIONS

In this study we validated the mediating effects of modularity on the relationship between the sharing of market information/knowledge information/operation information and mass customization. The findings revealed the conceptual framework for information sharing between module buyer and module supplier as a strategic intent to perform successful mass customization.

Existing literatures merely suggests modular theory as an effective way to maximize mass customization. As mentioned previously, the entire production of modular components are not strained within a single firm rather it occurs among several inter-related firms that produce modules. Modular components are assembled, re-configured, and re-assembled through outsourcing strategy that depends on closely cooperating companies in supply chain. Modularity, in this perspective, should be accomplished in supply chain point of view. This study, therefore, presents a conceptual framework by presenting the importance of information sharing between module buyer and module supplier in terms of improving overall performance.

Second, our study suggests modularity is a way to achieve efficiency in mass customization, further extend this concept to the transaction between firms for the importance of information sharing. Many literatures on modularization, hitherto, heavily focused on module buyers' perspective. However, this study focused on the relationship between module buyer and module supplier. In module outsourcing perspective, information sharing between module buyer and module supplier plays critical role to quickly produce products that meet heterogeneous customer demands.

Third, this study demonstrates modularity is positively influence on mass customization capability. Although, prior studies in relation to modularity and mass customization partially agreed on the relationship between modularity and mass customization yet little empirical evidence on what influences modularity and its mediating effects on mass customization. Our study measures the direct relationship between modularity and mass customization capability using questionnaire items drawn from existing literatures and industry expert feedbacks to setup concrete items. The result in our empirical study commensurate with existing studies in which modularity act as an enable of efficient production for mass customization.

Our study also has important additional practical implications for manufacturing managers. First, firms may establish stable environment in order to generate revenues by reducing uncertainties. The greatest uncertainty, among many factors that cause uncertainties, is to predict the customer and market demands. To actively respond to such predicament, firms should readjust the organization structure by developing dynamic capabilities. This can be done by considering all supply chain members including upstream supplier, downstream buyer, and customer for mass customization. As a result, building a close network to share information between module buyer and module supplier is necessary.

Second, this study presents the importance of information sharing in relation between module buyer and module supplier. Firm's overall performance can be enhanced by appropriate market analysis including indentify market trend and customer needs. Change such as reorganizing organizational structure gear to market-oriented industry is required to assess the information regarding current market trend and customer needs. Such flexible organization is requisite condition for surpassing the competitors when organization, to a great extent, utilizes information acquired from outside for practical application. Market-oriented organization is required by establishing a close network for information sharing between module buyer and supplier. For example, implementing CPFR (collaborative planning forecasting and replenishment) is one way to achieve market oriented organization. Also, manufacturing companies face a serious predicament in terms of perceiving the changes in customer needs directly due to various channel configurations in supply chain. Thus, it is important to recognize the changes in market/customer needs utilizing S&P (sales & operation planning) among supply chain members. This, in turn, secures the flexibility in production system acting as an enabler to provide products/services that meet the needs of customers. Doing so may contribute to maintaining a competitive advantage by providing a differentiated service in market.

6. LIMITATIONS AND FUTURE RESEARCH

While our study makes a significant contribution to the academic and practical, there are few limitations however which could be next topics of future research.

First, this study is limited in regard to the types and scopes of modularity and mass customization. Modularity can be segmented into different types depend on the degree of modularization and its intended usage. Mass customization, along the same vein, is not designed to suit for all industry segments. In general, modularity has a positive influence on mass customization yet our predictions based on module type and range as well as the degree of mass customization shows that the influence may vary in degree. Therefore, future study requires supplementing additional information, taking into account the type and range of modularization, the degree of mass customization and characteristics of industry.

Second, our study has not yet investigated the differences between module buyer and supplier. Due to nature of information sharing, differences in information sharing characteristics may exist between information receiver and sender. Typically, the flow of information sharing is restricted because of the nature of information sharing between module buyer (large size multinational entity) and its supplier (small size SME) in Korea. However, our study has not considered a characteristic of large companies that hold large information and SME that relatively retain a little information. Thus, future study should take into consideration by separating module buyer and its supplier to find out the true nature of information sharing.

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