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Learning for Customization Capability through Agility: The Case of the IT Industry

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Abstract

Purpose ─ The purpose of this paper is to examine this effect from the knowledge-based view (KBV).

Design/methodology/approach ─ Data were collected from information technology (IT) firms in Taiwan. We contacted manufacturing managers to collect data. The questionnaires were distributed to 795 IT firms and 163 returned questionnaires were deemed usable.

Findings─Furture, the findings the partial least squares (PLS) method indicate that learning relates positively to agility, which in turn relates positively to customization capability. In addition, learning relates positively to customization capability. Additionally, the mediating effect of agility on the relationship between learning and customization capability is significant.

Research limitations/implications ─ Given the wide range of potential antecedents to agility and the limited theoretical and empirical research that has been conducted to date on factors that lead to agility, future research studies might widen

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their examination to include other potential factors. Further, the self-reported measures for all constructs were obtained from the manufacturing managers, which may increase the potential for common method bias. Future research studies that rely on top or middle managers as their sources could help clarify whether the results reported herein are informant-sensitive.

Practical implications－Managers need to actively manage the human capital of their firms through a variety of organizational learning practices to stimulate the capability in managing agile manufacturing and forming customization capability. To facilitate the link between learning and favorable customization capability, managers need to recognize the importance of agility. They should utilize external and internal learning to cultivate a better level of customer agility, partnering agility, and operational agility, which in turn will result in better customization capability.

Originality/value － This is one of the first studies to present a new conceptualization of the relationship between learning and agility, demonstrating how agility can be affected by learning. This study also fills the gap in the literature that calls for an empirical examination of the mediating effect of agility in the relationship between learning and customization capability.

Keywords: learning, customization capability, agility, PLS, knowledge-based view

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透過敏捷性探討學習對客製化能力之影響—以資訊科技業為例

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摘要

本研究透過知識基礎觀點來檢視敏捷性在學習與客製化能力間是否具有中介效果。資料蒐集取自台灣資訊科技業，製造部門經理為主要研究對象。本研究發放 795 份實體問卷共回收 163 份，有效回收率為 20.5%。透過 PLS 統計分析軟體得知，學習對敏捷性有正向影響，而敏捷性對客製化能力有正向影響。本研究亦證實敏捷性在學習與客製化能力之間具有中介效果。鑑此，管理者應該積極管理公司之人力資本，透過各種組織學習活動來促進敏捷性製造並形成客製化能力。此外，管理者更應該利用外部與內部學習來培養顧客敏捷性、夥伴敏捷性及營運敏捷性，以促成客製化能力的建立。

關鍵詞：知識基礎理論、學習、客製化能力、敏捷性、PLS

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1. Introduction

With increasing market and customer sophistication, businesses are offering customized and differentiated products and services to customers. Information technology (IT) further increases the reach and richness of firms in tailoring individual products or services in a flexible and instantaneous manner and hence provides extended firm customization capabilities. To facilitate customization capability, research in the area of customization in the marketing or manufacturing context has investigated manufacturing flexibility (Gupta & Somers 1996), capabilities (Hegde et al. 2005), management practices (Kristal et al. 2010; Liu & Deitz 2011; Liu et al. 2010; Tu et al. 2004a; Tu et al. 2004b), technologies and systems (Da Silveira et al. 2001; Istook 2002; Peng et al. 2011), product modularity (Ahmad et al. 2010), functional integration (Liu et al. 2012b), organizational structure (Huang et al. 2010), environmental uncertainty (Liu et al. 2012a), and customer involvement (Hegde et al. 2005; Tu et al. 2004), which are the means (or conditions) by which firms can enhance customization. Therefore, an increasing amount of anecdotal evidence indicates the urgent need to advance the existing literature by exploring the antecedents to customization capability. Toward this end, our study focuses on investigating how IT firms develop resources and capabilities associated with the manufacturing process in pursuit of customization capability.

Pine II, Victor and Boynton (1993) argue that learning is a prerequisite for the development of customization capability. Firms adopt the paradigm of learning, which emphasizes flexibility, responsiveness, creativity, and timeliness, to build a fast-cycle-time climate (Meyer 1993). Take supply chain management for example, learning is vital ability for firms to continuously fine-tune their knowledge and behaviour toward effectively satisfying all customers' needs within the supply chain (Hauser et al. 1996). Accordingly, firms acquire, create, and deploy knowledge through the learning processes during the implementation of customization. After combining with knowledge, a firm's customization capability is enhanced and becomes more valuable, rare, and inimitable. Thus, the learning environment is the foundation for firms that seek to understand and satisfy customer needs. Consequently, firms make significant investments into developing and managing supply chain knowledge because supply chain knowledge has a positive influence on performance (Nagati & Rebolledo 2013; Schoenherr et al. 2014; Wowak et al. 2013). These are important contributions to

the knowledge and operations management research, establishing the motivation and the foundation for further studies on "learning" in supply chains.

However, few of the existing customization capability studies emphasize the importance of learning that is required to support customization capability. Notably, Huang, Kristal and Schroeder (2008) drew upon the knowledge-based view (KBV) of the firm and empirically tested the role of learning routines in cultivating customization capability. However, their study only examined process-related issues and failed to provide a comprehensive investigation of the relationship between learning and customization capability. Therefore, this study provides the explanatory variance missing in the literature that has not examined the black box relationship between learning and customization capability.

Recently, the pace of competition in the marketplace is getting faster, and the gap of information asymmetry between suppliers and customers is shortened because customers can acquire information more easily than before. Modern customers have their own ideal specifications of products/services in mind. Although a firm has access to the unique knowledge of customers, it may need to be able to respond quickly to customer needs to ensure the effective utilization of knowledge in the learning process for customization capability. Unique knowledge is generated in individual firms, accompanying the implementations of agile manufacturing. As a new manufacturing paradigm, agile manufacturing plays an important role as the enabler for firms to respond quickly and effectively to current market demands as well as being proactive in developing future market opportunities (Brown & Bessant 2003). In addition, to ensure a quick response and cost control, firms need a manufacturing strategy that can meet customer needs with acceptable costs. Therefore, how to meet these customer needs in a reasonable amount of time and with reasonable costs becomes firms' first priority.

We propose that agile manufacturing is the most effective means for firms in such a competitive environment because it enables firms to quickly find market demand, meet customer needs, and even predict potential changes. In the regard, developing a capability defined as *agility* within organizations that involves constantly scanning for signals of potential customer responses and is able to deploy resource to help solve customer problems has become important (Sambamurthy et al. 2003) for clarifying the relationship between agility and customization capability. Our understanding of the relationship between firm agility and customization capability is limited. Most literature to date has largely overlooked agility as a potential outcome, focusing instead on standard firm performance metrics (Oh & Pinsonneault 2007). The literature on agility

has primarily focused on conceptual concerns and the benefits of agility (Galliers 2007; Hitt et al. 1998; Overby et al. 2006; Rai et al. 2006; Sambamurthy et al. 2003; Weill et al. 2002). The few papers that have examined the link between agility and customization capability suggest a relationship between them.

Based on KBV, it emphasizes that knowledge is an especially important strategic resource to firms, and the learning processes within firms are the main routines of knowledge generation (Huang et al. 2008). Learning, the process of knowledge generation, seems likely to be the strategic resource that enables firms to outperform (e.g., Das & Teng 2000; Hult et al. 2000). For example, internal and external knowledge transfer activities are important enablers of supply chain flexibility (Blome et al. 2014). As noted above, we propose that agility may influence the relationship between learning and customization capability. Accordingly, the purpose of this paper is to examine the mediating effect of agility between learning and customization capability from the KBV.

Addressing these issues is important, both from a theoretical and a practical perspective. From a theoretical perspective, we apply the KBV of the firm, which has become so crucially important. While a variety of contingencies have been investigated within the realm of operations management, no study was found that specifically focused on the mediating effects of agility. We do so in this study. In addition, from a practical perspective, further insight into how to foster agility to respond to today's challenges is essential. With more flexibility inherent in the supply chains, some of these supply shortfalls could have been avoided (cf. Blome & Schoenherr, 2011). We forward in the present paper the notion that flexibility can be achieved via effective knowledge transfer processes. We caution, however, that at the same time complexities inherent in the product and the supply need to be considered, which may hamper the effectiveness of knowledge transfer activities in generating supply chain flexibility. We consider these complexities as contingencies and offer insight into their influence, offering valuable advice to practitioners managing supply chains.

Figure 1 depicts the research model. Learning can be leveraged to develop agility, which is important to customization capability. Furthermore, learning helps facilitate customization capability. The remainder of the paper proceeds as follows. The next section considers the relevant literature and sets out the hypotheses of this study. The methodology for the study follows. Then, the paper presents the results of the empirical study in achieving the goals set out above. In the last section, the paper discusses implications for research and practices and highlights future research directions.

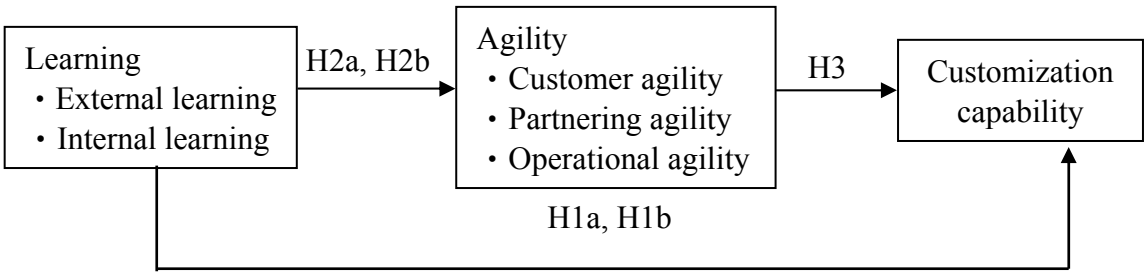

Figure 1: Research model

2. Literature Review and Hypothesis Development

2.1 Knowledge-Based View

The KBV emphasizes the role of knowledge in determining organizational performance. As such, knowledge represents itself in the form of information and know-how, and a firm's ability to create and transfer this knowledge can yield competitive differentiation (Kogut and Zander 1992). Knowledge develops within firms from experiential learning facilitated by organizational routines and problem-solving activities and creates value from its effective application (Grant 1996). Of note here is that knowledge under this view needs to be constructed, and appropriate processes need to be in place to do so. The KBV indicates that organizational knowledge is important to explaining organizational learning (Zahra & Nielsen 2002). The main focus of KBV is on value creation through learning. Thus, its core purpose is to understand how organizational learning should be pursued to improve a firm's activity (i.e., agility) and capability (i.e., customization capability).

2.2 Learning and Customization Capability

According to Schroeder, Bates and Junttila et al. (2002), we place emphasis on two learning routines, namely internal and external learning. *Internal learning* encompasses the training of multifunctional employees (Gerwin & Kolodny 1992) and the incorporation of employee suggestions into process and product development (Hall 1987). Huang et al. (2008) indicate that the first component of internal learning is that of training employees to have multiple functional skills, accumulates common knowledge among individual employees, and helps them assimilate new ideas. The

second component of internal learning involves employee suggestions for their operation and implies support and effort from top management to encourage learning and to further build an open learning environment. *External learning* is considered interorganizational learning through problem solving with customers and suppliers (Schroeder et al. 2002). Huang et al. (2008) indicate that external problem solving can take many forms, including the involvement of customers and suppliers in product and process design and improvement, and the communication of operational performance issues with customers/suppliers. Knowledge transfer between supply chain partners, including customers, suppliers, and manufacturers, enables a production network to "out-innovate" production networks with effective knowledge-sharing routines (von Hippel 1988). Thus, close collaborations with customers/suppliers permit the transmission, recombination, or creation of specialized knowledge (Grant 1996).

Pine II, Peppers, and Rogers (1995) refer to customization as the manufacture (delivery) of a product (service) in response to a particular customer's needs. By extension, *customization capability* refers to a firm's competence at designing, producing, and delivering a high volume of differentiated products that meet specific customer needs in a timely manner at close to mass-production prices (Tu et al. 2001). Thus, customization capability is facilitated by the possession of operant resources through which supply chain network members support customer value co-creation processes. In this study, customization capability is defined as the ability to customize products without increasing manufacturing costs, to add product variety without sacrificing production volume and to reorganize manufacturing processes quickly in response to individual customer requirements (Tu et al. 2001). This definition is supported by a number of other customization researchers (e.g., Ahlstrom and Westbrook 1999, Liu et al. 2006, MacCarthy et al. 2003, Pine II 1993). It directly evaluates an organization's manufacturing competence related to customization capability. Accordingly, firms have customization capability can be reduced to four main aspects: (1) high-volume customization, (2) customization cost efficiency, (3) customization responsiveness, and (4) customization quality (Lai et al. 2012).

Customization capability requires an understanding of the underlying products and processes. Building upon Nonaka's (1994) knowledge-creation framework, we illustrate that customized product and process can be generated through internal and external learning. For example, internal learning gets employees involved in internal problem solving of manufacturing processes so that they can use their insights to develop effective solutions, improving the effectiveness of the processes without increasing

manufacturing costs and sacrificing production volume. Similarly, external learning, along with collaborative relationships with customers and suppliers, allows a company to incorporate their partners' knowledge into product and process design and improvement, helping to response customers' requirements. Accordingly, external and internal learning leads to the development of customization capability through the creation of knowledge and ultimately the translation of this knowledge into the customized product and process. Therefore, external and external learning are prerequisite for the development of customization capability (Huang et al. 2008; Pine II et al. 1993).

Further, Kotha (1995, 1996) uses the case of the National Bicycle Industrial Company (NBIC) of Japan to illustrate the important role of organizational learning in the building of customization capability. Building upon the KBV, NBIC developed and maintained competitive advantage lies in its capability to create product knowledge by organizational and individual learning. Additionally, the development of learning perspective is recommended for customizers (Pine II et al. 1995). Lack of developing learning relationships have been cited as a major drawback in customization strategy of Nissan which resulted in escalation of costs and loss of quality and flexibility (Hart 1995). Therefore, we suggest that internal and external learning contribute to customization capability and propose the following two-part hypothesis:

Hypothesis 1a: External learning has a positive effect on customization capability.
Hypothesis 1b: Internal learning has a positive effect on customization capability.

2.3 Learning and Agility

Agility is regarded as a competitive means in the manufacturing industry in a new generation (Fliedner &Vokurka 1997; Sahin 2000) and is defined as a firm's ability to interact well with customers, to appropriately leverage resources and to effectively integrate operational processes (Sambamurthy et al. 2003). Agility contains two elements: the exploration and exploitation of opportunities in an uncertain environment for profiting (March 1991). Exploration is the organizational examination of new alternatives and acquirements of information on currently unknown opportunities for competition. Exploitation is the use of resources that already exist through the improvement and extension of competencies, technologies, and knowledge. Additionally, Sharifi and Zhang (2001) extract two major factors from agility: (1)

responding to anticipated and unexpected changes in a reasonable amount of time; and (2) exploiting and taking advantage of changes as opportunities. As this study is based on the research of Sambamurthy, Bharadwaj and Grover et al. (2003), we indicate that agility encompasses three interrelated capabilities: customer agility, partnering agility, and operational agility. *Customer agility* is the collaboration with customers in exploring and exploiting opportunities for innovation and competitive action moves. *Partnering agility* is the ability to leverage the resources of supply members through alliances, partnerships, and joint ventures. *Operational agility* is the ability to enable firms' business processes to reach efficiency and effectiveness in the exploitation of opportunities for innovation and competitive actions.

Prior research investigates the influence of learning on agility is scarce (e.g., Braunscheidel & Suresh 2009; Lu & Ramamurthy 2011; Sambamurthy et al. 2003; Tallon & Pinsonneault 2011). According to Adler and Clark (1991), internal and external learning help to develop exceptional flexibility and efficiency simultaneously within a manufacturing plant. Other researchers have also presented conceptual arguments and anecdotal evidence supporting the crucial role of organizational learning-related, routine-changing routines in enabling organizations to adapt to a rapidly changing environment (Becker et al. 2005; Mohrman & Mohrman 1993). As such, we expect greater proficiency in knowledge transfer to effectuate greater levels of agility. With effective internal and external learning processes in place, appropriate knowledge can be transferred most effectively and efficiently to the appropriate recipient, enabling agility. Grounding our arguments in the KBV to efficiently respond to a changing environment, an agile firm should be a learning organization (Gunasekaran & Yusuf 2002). Accordingly, we propose the following hypothesis:

Hypothesis 2a: External learning has a positive effect on agility.
Hypothesis 2b: Internal learning has a positive effect on agility.

2.4 Agility and Customization Capability

With firms moving towards customization the firm has to learn how to effectively cope with shortening response times to customers and increasing product and service variety. Agility enables a firm to successfully produce and market various products at a low cost, with high quality, with short lead times, and in different lot sizes and provide added value to customers with customized options for products (Fliedner & Vokurka

1997). Thus, agility tends more towards customization (Harrison 1997). Based on KBV, when demand changes rapidly, manufacturers need new knowledge to guide customization (Huber 1991). In this case, new knowledge and resources must be created, exchanged, and acquired through collaboration with partners. Following Lai et al.'s (2012) work, by collaborating with customers, a firm can obtain accurate demand information promptly, which leads to better decision-making in customizing products and services to meet customer needs. By enhancing collaboration with its suppliers, the firm can explore and increase the range of possible solutions for meeting customer requirements and reduce costs and/or lead-time. As such, manufacturers operating in such an environment require closer collaboration with partners. We have argued that customer agility, partner agility, and operational agility drive and enable customization practices. Accordingly, manufacturers can enhance agility and subsequently develop a greater customization capability. We propose the following hypothesis:

Hypothesis 3: Agility has a positive effect on customization capability.

2.5 Mediating Effect of Agility

The preceding hypotheses (1, 2, and 3) link the relationships between learning, agility, and customization capability. Learning is a complex and difficult task. Especially when tacit knowledge is involved, the underlying causal ambiguity may prevent firms from learning effectively. In some cases firms may even pursue a wrong learning trajectory (Lippman & Rumelt 1982). If these effects are present, the overall relationship between learning and customization capability may not necessarily be significant. Only the effective part of the learning, which will be reflected in agility, can lead to customization capability. Implicitly, the discussion suggests that learning affects firms' customization capability through their capacities in agility manufacturing. That is, firms can use a set of learning practices to cultivate the level of capacity in knowledge acquisition, sharing, and application, which in turn promote employees' propensity to respond to customer needs quickly and enhance their customization capability. Based on the KBV, knowledge created by learning must be translated into agility to realize its potential in customization capability. Thus, this study argues that agility plays a mediating role in the relationships between the independent variables of learning and dependent variable of customization capability. Following this line of reasoning, this study proposes the following hypothesis.

Hypothesis 4a: Agility mediates the relationship between external learning and customization capability.

Hypothesis 4b: Agility mediates the relationship between internal learning and customization capability.

3. Research Methodology

3.1 Measures

The questionnaire was designed, modified, and adopted to refer from academic literatures. All of the constructs were measured with a minimum of three items. Each item was closed-end and employed a five-point Likert-style rating scale ranging from 1 = "strongly disagree" to 5 = "strongly agree." *External learning* was measured by supplier collaboration and customer collaboration (Huang et al. 2008). *Internal learning* was measured by learning employees and the learning environment (Huang et al. 2008). Agility was mainly based on the analysis by Sambamurthy et al. (2003) and measured by customer agility, partnering agility, and operational agility. *Customer agility* was measured by collaborating with customers in exploring and exploiting opportunities. *Partnering agility* was measured by leveraging the resources of supply members through alliances, partnerships, and joint ventures. *Operational agility* was measured by enabling business processes to reach efficiency and effectiveness in the exploitation of opportunities. *Customization capability* was mainly adopted from Tu, Vonderembse, and Ragu-Nathan (2001) and measured using four items that refer to responding to customization requirements quickly, translating customer requirements into technical designs quickly, customizing products on a large scale, and customizing products while maintaining a large volume.

3.2 Sample and Data Collection

Data were collected from IT firms in Taiwan. We chose the IT industry for this study for two main reasons. First, the industry has a hypercompetitive and highly dynamic environment. IT firms need to quickly response to market demands and establish a more flexible/open environment to sustain competitive advantages and effectively provide advanced innovative products and services to customers (Patrakosol & Olson 2007). Second, a useful summary of customization directions provided by Da Silveira, Borenstein, and Fogliatto (2001) indicates that there are requirements for

customization: (1) customer demand for variety and customization must exist; (2) market conditions must be appropriate; (3) the value chain should be ready; (4) technology must be available; (5) products should be customizable; and (6) knowledge must be shared. These directions are relevant to this study because all of these requirements constitute our customization capability research. Hence, IT firms are much more suitable to be investigated by this study.

Table 1: Operational definitions of constructs

Variables	Operational definitions	Sources
External learning	1. Supplier collaboration 2. Customer collaboration	Huang et al. (2008)
Internal learning	1. Learning employee 2. Learning environment	
Customization capability	1. Responding to customization requirements quickly 2. Translating customer requirements into technical designs quickly 3. Customizing products on a large scale 4. Customizing products while maintaining a large volume	Tu et al. (2001)
Agility	1. Customer agility 2. Partnering agility 3. Operational agility	Sambamurthy et al. (2003)

For this study, IT firms were collected from the "Top 5000-The largest corporations in Taiwan" listings published by the China Credit Information Service Incorporation. The sampling frames were 821. Except for 26 companies, which were without related departments, the final sampling frames were 795. We chose to contact manufacturing managers to collect data because of their direct contact with customers and their understanding of the nature of the manufacturing process. Hence, manufacturing managers' familiarity and professional experience with the customization process would help evaluate the real conditions of the IT industry. The manufacturing department of each of the 795 companies was sent a letter that included one questionnaire and a self-addressed stamped return envelope. A cover page described our research objectives and promised to provide them with the research findings if we received their response. We also ensured them that their responses would remain confidential. The respondents were requested to reply to all questions based on their

experiences and actual manufacturing campaigns. There were 66 responses received in total after three weeks of the first mailing. Follow-up requests (to non-respondents) were conducted for two months; the total numbers of usable responses added up to 163 units. The effective response rate was 20.5 %.

To determine whether non-response bias exists in our retrieved questionnaires, we compared the samples from early respondents with samples from late ones. Among the total 163 valid questionnaires, the first mailing was named early (n = 66), whereas the follow-up contacts were considered late (n = 97). We conducted an independent-samples *t*-test to compare the primary data of these two groups of respondents (Armstrong & Overton 1977). The results show that no statistically significant differences exist between these two groups of respondents in their major firm attributes, such as the years of firm established (p = .22), firm capital (p = .16), and number of employees (p = .10). Because the data were self-reported, we used Harmon's one-factor test to examine whether a common-method bias was present. The items used to measure the dependent and independent variables were entered into a single exploratory factor analysis. The results did not suggest a common-method bias because a single factor did not emerge, nor did one factor account for most of the variance. The demographics of the firms surveyed are presented in Table 2. Among them, 29.4 % had been established for 6-10 years and 27.6 % had been established over 20 years; 47.2 % of firms owned capital from 100 million to 1 billion, and 40.5 % had 101 to 500 employees.

Table 2: Demographics of the sample firms

Variable name	Category	N	Rate (%)
Years since established	3 years and fewer	3	1.8
	Over 3 years to 5 years	8	4.9
	Over 6 years to 10 years	48	29.4
	Over 11 years to 15 years	31	19.0
	Over 16 years to 20 years	28	17.2
	Over 20 years	45	27.6
	Aggregate	163	100
Firm capital	100 millions and fewer	9	5.5
	Over 100 millions to 1 billion	77	47.2
	Over 1 billion to 3 billions	34	20.9
	Over 3 billions to 5 billions	13	8.0
	Over 5 billions to 10 billions	11	6.7
	Over 10 billions	19	11.7
	Aggregate	163	100

Number of employees	100 and fewer	21	12.9
	101 to 500	66	40.5
	501 to 1000	27	16.6
	1001 to 2000	7	4.3
	2001 to 3000	12	7.4
	Over 3000	30	18.4
	Aggregate	163	100

Note: a) "N" indicates the frequency of the respondents (a unit presents a firm) corresponding to the row.
b) "Rate (%)" presents the percentage of frequency of the respondents corresponding to the row.

4. Data Analysis and Results

Partial least squares (PLS) was used to address a sophisticated analysis of the data because of the ability to predict a model for a specific study (Urbach & Ahlemann 2010). Second, the sample size for PLS power analysis is based on the largest number of predictors (Urbach & Ahlemann 2010); thus, it is insensitive to sample size consideration (Hair et al. 2010) compared to the covariance-based structural equation modelling (CBSEM) (Hair et al. 2011). Third, PLS best applies if the phenomenon to be investigated is relatively new (Urbach & Ahlemann 2010). Hence, PLS is the appropriate choice for three reasons. First, the study aims to predict and explore (Hair et al. 2011; Urbach & Ahlemann 2010) the role of agility and its possible relationship between learning and customization capability. Secondly, the sample size was 163. The advantage of the PLS approach is its ability to work with small sample sizes (Urbach & Ahlemann 2010). Finally, the phenomenon to be investigated is relatively new, which supports the requirement of the study. In other words, we had an important number of variables and little theoretical backup of the relationships we wanted to investigate.

4.1 Measurement Properties

We used Cronbach's alpha and composite reliability (CR) as the indexes of the internal consistency of construct reliability. The Cronbach's alpha values of all six constructs range from 0.71 to 0.87, which are all above 0.70 and indicate a high internal consistency of measure reliability (Nunnally 1978). In addition, the composite reliability is indicated by examining ρc for constructs, and all of the CR values of constructs are above the suggested threshold of 0.80, indicating that the measurement is reliable. Table 3 summarizes the measurement properties associated with each construct. We examined the discriminant validity and use average variance extracted (AVE) as the

indicator to assess the variance shared between each construct and its measurement items (Fornell & Larcker 1981). A construct is considered to have discriminant validity if the square root of the AVE of the construct is greater than its correlations with any of the other latent constructs (Barclay et al. 1995). Table 4 organizes the results of the examination of the discriminant validity. The results indicate that all constructs are distinct from one another. Hence, discriminant validity is satisfied. Consequently, the collective evidence suggests that the constructs demonstrate good measurement properties.

Table 3: Results of measurement properties

Construct Name	Construct Identifier	Items	Factor Loading	Cronbach Alpha	Composite Reliability
External learning	EL	EL1	0.86	0.71	0.84
		EL2	0.81		
		EL3	0.72		
		EL4	0.78		
Internal learning	IL	IL1	0.77	0.83	0.88
		IL2	0.86		
		IL3	0.82		
		IL4	0.71		
Customization capability	CC	CC1	0.81	0.81	0.87
		CC2	0.73		
		CC3	0.84		
		CC4	0.80		
Customer agility	CA	CA1	0.84	0.87	0.89
		CA2	0.92		
		CA3	0.82		
Partnering agility	PA	PA1	0.77	0.86	0.85
		PA2	0.85		
		PA3	0.82		
Operational agility	OA	OA1	0.70	0.76	0.87
		OA2	0.88		
		OA3	0.90		

Table 4: Means, SD, correlations and average variance extracted (n = 163)

Construct		Mean	SD	AVE	(a)	(b)	(c)	(d)	(e)	(f)
EL	(a)	4.10	.55	0.64	**0.80**					
IL	(b)	3.64	.59	0.60	.57**	**0.77**				
CC	(c)	4.06	.59	0.64	.42**	.39**	**0.80**			
CA	(d)	3.75	.72	0.74	.59**	.60**	.43**	**0.86**		
PA	(e)	3.43	.67	0.66	.54**	.62**	.39**	.71**	**0.81**	
OA	(f)	3.55	.59	0.69	.53**	.62**	.35**	.73**	.67**	**0.83**

Notes: a) Values in the shaded diagonal are the square root of the AVE.

b) ** $p < .01$

4.2 Results for the Main Effects

The values of path coefficients, statistical significance, and R-squares are provided in Figure 2. A bootstrapping approach is used to obtain the statistical significance of the path coefficients using *t*-values. As shown in the structural model results in Table 5, the positive and significant relationships between external learning and customization capability ($\beta = 0.27$, $t = 4.27$, $p < .001$) as well as internal learning and customization capability ($\beta = 0.19$, $t = 2.26$, $p < .01$) are confirmed, and Hypotheses 1a and 1b are supported. The positive and significant relationships between external learning and agility ($\beta = 0.33$, $t = 5.03$, $p < .001$) as well as internal learning and agility ($\beta = 0.49$, $t = 8.58$, $p < .001$) are confirmed, and Hypotheses 2a and 2b are supported. A positive and significant relationship between agility and customization capability is confirmed ($\beta = 0.42$, $t = 6.34$, $p < .001$), and Hypothesis 3 is supported. The results suggest a satisfactory fit to the research model. Additionally, the PLS analysis produces R-squared values, and the results indicate that external and internal learning explain 55 % of the variance in agility; external learning, internal learning, and agility explain 27 % of the variance in customization capability. These values are significant at $p < .001$ and provide considerable evidence that suggests a high predictive power of the research model.

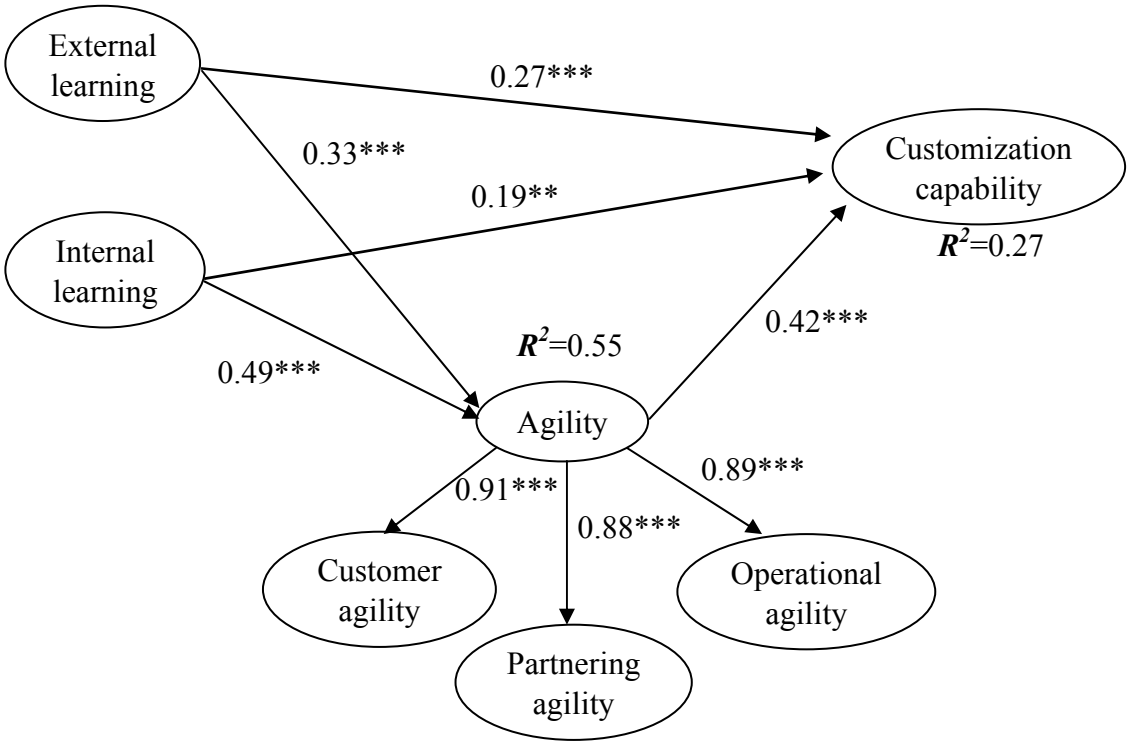

Figure 2: Results of the structural model

Table 5: Results of hypotheses

Path / Hypothesis Hypothesized relationships				Path coefficient	*t*-value	Results
External learning	→	Customization capability	H1a	0.27	4.27***	Supported
Internal learning	→	Customization capability	H1b	0.19	2.26**	Supported
External learning	→	Agility	H2a	0.33	5.03***	Supported
Internal learning	→	Agility	H2b	0.49	8.58***	Supported
Agility	→	Customization capability	H3	0.42	6.34***	Supported

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

4.3 Results for the Mediating Effects

In testing the mediating role of agility, we followed the work of Luo and Bhattacharya (2006), which indicated that four specific criteria must be met: (1) the

predictor variable (external and internal learning) should significantly influence the mediator (agility); (2) the mediator (agility) should significantly influence the dependent variable (customization capability); (3) the predictor variable (external and internal learning) should significantly influence the dependent variable (customization capability); and (4) after we control for the mediator variable (agility), the impact of the predictor variable (external and internal learning) on the dependent variable (customization capability) should no longer be significant (for full mediation) or reduced in strength (for partial mediation). In Models 1 and 2 (see Table 6), the significant paths suggest that the first two conditions are met. That is, external and internal learning affect agility. Furthermore, agility affects customization capability. In addition, entering the mediator of agility (Model 3) decreases the strength of the effect of external learning on customization capability (although the effect remains significant) (Model 4), indicating partial mediation. Similarity, agility decreases the effect of internal learning on customization capability (not significant) (Model 4), indicating full mediation. Correspondingly, these results suggest that the mediation effects in Hypotheses 4a and 4b are mediated by agility. As such, external and internal learning would increase customization capability through the mediator of agility, and Hypotheses 4a and 4b are supported.

Table 6: Results of PLS for mediation effect

Paths	Model 1 (IV for MV)	Model 2 (MV for DV)	Model 3 (IV for DV)	Model 4 (Control for MV)
Firm age	-	-0.02	-0.07	-0.04
Firm capital	-	-0.03	0.01	-0.01
Employee	-	0.25*	0.18	0.21
External learning → Agility	0.33***	-	-	-
Internal learning → Agility	0.49***	-	-	
Agility → Customization capability	-	0.42***	-	0.24*
External learning → Customization capability	-	-	0.26***	0.19**
Internal learning → Customization capability	-	-	0.19**	0.07
R^2				

Agility	0.55	-	-	-
Customization capability	-	0.24	0.25	0.27

Notes: a) * $p < .05$; ** $p < .01$; *** $p < .001$

b) IV, independent variable; MV, mediating variable; DV, dependent variable.

c) Model 3 (IV for DV) does not include the mediator of agility; Model 4 (Control for MV) includes the mediator of agility.

5. Discussion and Conclusions

This study examines the role of agility in the relationships between external learning, internal learning, and customization capability. Our results indicate that external and internal learning relate positively to agility, which in turn relates positively to customization capability. In addition, external and internal learning relate positively to customization capability. The findings show support for the mediating effects of agility on the relationships between external learning, internal learning, and customization capability. The study drew on a data set collected from a sample of IT firms, and we theoretically derived scales for learning, agility, and customization capability. Our scales exhibited good validity, and the results validated our expectations. Our findings suggest that (1) a higher degree of external and internal learning results in better customization capability; (2) external and internal learning have strong associates with agility; (3) agility has a strong association with customization capability; and (4) agility has a mediating effect between external learning, internal learning, and customization capability.

5.1 Implications for Research

Our results have three significant implications for research. First, this is one of the first studies to present a new conceptualization of the relationship between learning and agility, demonstrating how agility can be affected by learning. Our findings clearly show that learning can contribute to the formation of agility and customization capability. This conceptualization has significant implications for how researchers think about the valuation of external and internal learning for agility. Second, we analysed the second-order construct of agility and validated its influence on customization capability. We found that agility is a critical dimension for facilitating customization capability. Reflecting this issue, research on developing agility should focus on customer agility,

partner agility, and operational agility, especially in a service-oriented economy. There is evidence that the hierarchy of these dimensions introduced in this study can help researchers in the conceptualization of agility. Therefore, we supplement the operations and production management research by indicating that well-developed agility can be an alternative way for firms to deliver product/service information and respond to customer needs quickly. This leads to a more comprehensive view of the agile manufacturing of firms.

Third, this study contributes to the literature by empirically examining the relationships between external learning, internal learning, agility, and customization capability. The results prove that external and internal learning positively explain customization capability; however, agility acts as a mediator to attenuate these positive relationships. Thus, we demonstrate that agility is a mediating mechanism through which organizational learning benefits customization capability. The findings of this study fill the gap in the literature that is lacks an empirical examination of the mediating role of agility in the relationship between learning and customization capability. In summary, agility has been recognized as the method of choice to respond to customer needs to improve firms' competitive advantages. Our findings indicate that the interaction with agility plays the critical intermediate role between organizational learning and customization behaviours.

5.2 Implications for Practice

This study has four significant practical implications. If a firm can become a learning organization, it can respond to customer needs and satisfy them. First, with regard to learning, firms should implement external and internal learning. In terms of external learning, the close coordination in a supply chain reduces the transaction costs among firms and the high interdependence between firms promotes the integration density of these firms (Gulati & Singh 1998). This means that firms need to collaborate with partners that offer different knowledge and with customers who offer their own knowledge to facilitate external learning. For internal learning, managers need to build appropriate knowledge platforms that help nurture tacit and explicit knowledge interaction. In addition, providing greater incentives motivates employees to exchange, learn, translate, and absorb knowledge to access new knowledge (Nonaka et al. 2000; Nonaka & Konno 1998; Tsai & Li 2007).

Second, in considering the agility, firms should need to consider the effective

integration of organizations, people, and technology under the constructions of flexible organizational structures supporting highly skilled, knowledgeable and motivated people (Goldman & Nagel 1993; Gunasekaran 1999). Consequently, firms may quickly respond to unanticipated demand changes with customer value-based products/services in a competitive environment (Nagel et al. 1991). In addition, we suggest that when firms consider a synthesis of existing technologies and methods of integrating production systems, they may be able to sense changes to organize capital, knowledge, and relations, to meet changing customer needs in a timely manner and to convert the challenges of changes in the market into opportunities (D'Aveni 1994; Goldman et al. 1995).

Third, customization is the strategy for firms to meet customer needs by being flexible and quickly responding to changing market conditions (Davis 1987; Kotler 1989; Pine II 1993). Firms should provide individually designed products and services to every customer through high process flexibility and integration in high volumes and at reasonable costs (Da Silveira et al. 2001). For a customized product/service, it would certainly be the best means to respond to customer individualized desires (Krishnamurthy & Yauch 2007). Because the main objective of firms is to enrich and satisfy their customers (Goldman et al. 1995), we suggest that managers should be familiar with both the production line within their own company and partners' production situations for collaboration in the partnering atmosphere of future corporations (Jin-Hai et al. 2003).

Finally, managers need to actively manage their firms' human capital through a variety of organizational learning practices to stimulate their capability in managing agile manufacturing and forming customization capability. Furthermore, a better level of agility can stimulate proactive and responsive customer orientation that may eventually lead to better customization capability. To facilitate the link between learning and favourable customization capability, managers first need to recognize the importance of agility. Then, they should utilize external and internal learning to cultivate a better level of customer agility, partnering agility, and operational agility, which in turn will result in building customization capability.

5.3 Limitations and Future Research

Although this study provides valuable insights, some potential limitations should be recognized. First, the study relied on a sample of manufacturing managers in

Taiwan-based IT firms. A manager's perceptions of organizational learning and customization practices are grounded in industry-specific assumptions. Given that they are very knowledgeable in their practices and have exhibited proficiency in the profession, we believe they are appropriate for this study's purpose. However, to afford a greater generalizability of our findings, we invite researchers to replicate our study in different contexts. Second, the self-reported measures for all constructs were obtained from the manufacturing managers, which may increase the potential for common method bias. Future research studies that rely on top or middle managers as their sources could help clarify whether the results reported herein are informant-sensitive.

Third, given the wide range of potential antecedents to agility and the limited theoretical and empirical research that has been conducted to date on factors that lead to agility, future research studies might widen their examination to include other potential factors. Fourth, a longitudinal study involving data collection from customer-supplier relationships may provide greater insights into the development of agility as well as its effect on customization capability. Fifth, given the potential impact of our research model and the domain of our investigation, future studies can include other areas, such as the roles of trust, commitment, knowledge/technology integration mechanisms, and customer orientation in operations and production management. Sixth, this study did not examine manufacturing managers' traits. The future research needs to consider this issue. Finally, issues pertinent to cross-cultural/cross country (nations) interpretations of the domain were not addressed and could be a topic for future research.

References

Adler, P.S. and Clark, K.B. (1991), 'Behind the learning curve: A sketch of the learning process', *Management Science*, Vol. 37, No. 3, pp. 267-281.

Ahlstrom, P. and Westbrook, R. (1999), 'Implications of mass customization for operations management', *International Journal of Operations & Production Management*, Vol. 19, No. 3/4, pp. 262-274.

Ahmad, S., Schroeder, R.G. and Mallick, D.N. (2010), 'The relationship among modularity, functional coordination, and mass customization', *European Journal of Innovation Management*, Vol. 13, No. 1, pp. 46-61.

Armstrong, J.S. and Overton, T.S. (1977), 'Estimating nonresponse bias in mail surveys', *Journal of Marketing Research*, Vol. 14, No. 3, pp. 396-402.

Barclay, D.W., Thompson, R. and Higgins, C. (1995), 'The partial least squares (PLS)

approach to causal modeling: Personal computer adoption and use an illustration', *Technology Studies*, Vol. 2, No. 2, pp. 285-309.

Becker, M.C., Lazaric, N., Nelson, R.R. and Winter, S.G. (2005), 'Applying organizational routines in understanding organizational change', *Industrial and Corporate Change*, Vol. 14, No. 5, pp. 775-791.

Blome, C. and Schoenherr, T. (2011), 'Supply chain risk management in financial crises—A multiple case-study approach', *International Journal of Production Economics*, Vol. 134, No. 1, pp. 43-57.

Blome, C., Schoenherr, T. and Eckstein, D. (2014), 'The impact of knowledge transfer and complexity on supply chain flexibility: A knowledge-based view', *International Journal of Production Economics*, Vol. 147, Part B, pp. 307-316.

Boosmama, A. and Hoogland, J. (2001), 'The robustness of LISREL modeling revisited', in Cudeck, R., du Toit, S. and Sörbom, D. (Eds.), *Structural Equation Modeling: Present and Future*, Scientific Software International, Chicago, IL, pp. 139-168.

Braunscheidel, M.J. and Suresh, N.C. (2009), 'The organizational antecedents of a firm's supply chain agility for risk mitigation and response', *Journal of Operations Management,* Vol. 27, No. 2, pp. 119-140.

Brown, S. and Bessant, J. (2003), 'The manufacturing strategy-capabilities links in mass customization and agile manufacturing-an exploratory study', *International Journal of Operations & Production Management*, Vol. 23, No. 7, pp. 707-730.

Da Silveira, G., Borenstein, D. and Fogliatto, F.S. (2001), 'Mass customization: literature review and research directions', *International Journal of Production Economics*, Vol. 72, No. 1, pp. 1-13.

Das, T.K. and Teng, B.S. (2000), 'A resource-based theory of strategic alliances', *Journal of Management*, Vol. 26, No. 1, pp. 31-61.

D'Aveni, R.A. (1994), *Hypercompetition: Managing the Dynamics of Strategic Maneuvering*, Free Press, New York.

Davis, S.M. (1987), *Future Perfect*, Addison-Wesley Publishing, MA.

Fliedner, G. and Vokurka, R.J. (1997), 'Agility: Competitive weapon of the 1990s and beyond?', *Production and Inventory Management Journal*, Vol. 38, No. 3, pp. 19-24.

Fornell, C. and Larcker, D.F. (1981), 'Evaluating structural equation models with unobservable variables and measurement error', *Journal of Marketing Research*, Vol. 18, No. 1, pp. 39-50.

Galliers, R.D. (2007), 'Strategizing for agility: confronting information systems inflexibility in dynamic environments', in Desouza, K.C. (Ed.), *Agile Information Systems: Conceptualization, Construction, and Management*, Butterworth-Heinemann, New York, pp. 1-15.

Gerwin, D. and Kolodny, H. (1992), *Management of Advanced Manufacturing Technology: Strategy, Organization, and Innovation*, Wiley-Interscience, New York.

Goldman, S.L. and Nagel, R.N. (1993), 'Management, technology and agility: the emergence of a new era in manufacturing', *International Journal of Technology Management*, Vol. 8, No. 1/2, pp. 18-38.

Goldman, S.L., Nagel, R.N. and Preiss, K. (1995), *Agile Competitors and Virtual Organizations: Strategies for Enriching the Customer*, Van Nostrand Reinhold, New York.

Grant, R.M. (1996), 'Toward a knowledge-based theory of the firm', *Strategic Management Journal*, Vol. 17, No. S2, pp. 109-122.

Gulati, R. and Singh, H. (1998), 'The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances', *Administrative Science Quarterly*, Vol. 43, No. 4, pp. 781-814.

Gunasekaran, A. (1999), 'Agile manufacturing: A framework for research and development', *International Journal of Production Economics*, Vol. 62, No. 1/2, pp. 87-105.

Gunasekaran, A. and Yusuf, Y.Y. (2002), 'Agile manufacturing: a taxonomy of strategic and technological imperatives', *International Journal of Production Research*, Vol. 40, No. 6, pp. 1357-1385.

Gupta, Y.P. and Somers, T.M. (1996), 'Business strategy, manufacturing flexibility, and organizational performance relationships: a path analysis approach', *Production and Operations Management,* Vol. 5, No. 3, pp. 204-233.

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. (2010), *Multivariate Data Analysis*, Prentice Hall, Upper Saddle River, USA.

Hair, J.F., Ringle, C.M. and Sarstedt, M. (2011), 'PLS-SEM: Indeed a silver bullet', *Journal of Marketing Theory and Practices*, Vol. 19, No. 2, pp. 139-152.

Hall, R.H. (1987), *Organizations: Structures, Processes and Outcomes*, Prentice-Hall, Englewood Cliffs, NJ.

Harrison, A. (1997), 'From leanness to agility', *Manufacturing Engineer*, Vol. 76, No. 6, pp. 257-260.

Hart, C.W.L. (1995), 'Mass customization: Conceptual underpinnings, opportunities and limits', *International Journal of Service Industry Management,* Vol. 6, No. 2, pp. 36-45.

Hauser, J.R., Simester, D.I. and Wernerfelt, B. (1996), 'Internal customers and internal suppliers', *Journal of Marketing Research,* Vol. 33, No. 3, pp. 268-280.

Hegde, V.G., Kekre, S., Rajiv, S. and Tadikamalla, P.R. (2005), 'Customization: Impact on product and process performance', *Production and Operations Management*, Vol. 14, No. 4, pp. 388-399.

Hitt, M.A., Keats, B.W. and DeMarie, S. (1998), 'Navigating in the new competitive landscape: Building strategic flexibility and competitive advantage in the 21st century', *Academy of Management Executive*, Vol. 12, No. 4, pp. 22-42.

Huang, X., Kristal, M.M. and Schroeder, R.G. (2008), 'Linking learning and effective process implementation to mass customization capability', *Journal of Operations Management*, Vol. 26, No. 6, pp. 714-729.

Huang, X., Kristal, M.M. and Schroeder, R.G. (2010), 'The impact of organizational structure on mass customization capability: A contingency view', *Production and Operations Management*, Vol. 19, No. 5, pp. 515-530.

Huber, G.P. (1991), 'Organizational learning: The contributing processes and the literatures', *Organization Science*, Vol. 2, No. 1, pp. 88-115.

Hult, G.T.M., Hurley, R.F., Giunipero, L.C. and Nichols, E.L. (2000), 'Organizational learning in global supply management: A model and test of internal users and corporate buyers', *Decision Sciences*, Vol. 31, No. 2, pp. 293-325.

Istook, C.L. (2002), 'Enabling mass customization: computer driven alteration methods', *International Journal of Clothing Science and Technology*, Vol. 14, No. 1, pp. 61-76.

Jin-Hai, L., Anderson, A.R. and Harrison, R.T. (2003), 'The evolution of agile manufacturing', *Business Process Management Journal*, Vol. 9, No. 2, pp. 170-189.

Kogut, B. and Zander, U. (1992), 'Knowledge of the firm, combinative capabilities, and the replication of technology', *Organization Science*, Vol. 3, No. 3, pp. 383-397.

Kotha, S. (1995), 'Mass customization: implementing the emerging paradigm for competitive advantage', *Strategic Management Journal,* Vol. 16, S. 1, pp. 21-42.

Kotha, S. (1996), 'Mass-customization: A strategy for knowledge creation and organizational learning', *International Journal of Technology Management,* Vol. 11, No. 7/8, pp. 846-858.

Kotler, P. (1989), 'From mass marketing to mass customization', *Planning Review*, Vol. 17, No. 5, pp. 10-47.

Krishnamurthy, R., and Yauch, C.A. (2007), 'Leagile manufacturing: A proposed corporate infrastructure', *International Journal of Operations & Production Management*, Vol. 27, No. 6, pp. 588-604.

Kristal, M.M., Huang, X. and Schroeder, R.G. (2010), 'The effect of quality management on mass customization capability', *International Journal of Operations & Production Management*, Vol. 30, No. 9, pp. 900-922.

Lai, F., Zhang, M., Lee, D.M.S. and Zhao, X. (2012), 'The impact of supply chain integration on mass customization capability: An extended resource-based view', *IEEE Transactions on Engineering Management*, Vol. 59, No. 3, pp. 443-456.

Lippman, S.A. and Rumelt, R.P. (1982), 'Uncertain imitability: An analysis of interfirm differences in efficiency under competition', *The Bell Journal of Economics*, pp. 418-438.

Liu, G.J. and Deitz, G.D. (2011), 'Linking supply chain management with mass customization capability', *International Journal of Physical Distribution & Logistics Management*, Vol. 41, No. 7, pp. 668-683.

Liu, G.J., Shah, R. and Babakus, E. (2012a), 'When to mass customize: The impact of environmental uncertainty', *Decision Sciences*, Vol. 43, No. 5, pp. 851-887.

Liu, G.J., Shah, R. and Schroeder, R.G. (2006), 'Linking work design to mass customization: A sociotechnical systems perspective', *Decision Sciences*, Vol. 37, No. 4, pp. 519-545.

Liu, G.J., Shah, R. and Schroeder, R.G. (2010), 'Managing demand and supply uncertainties to achieve mass customization ability', *Journal of Manufacturing Technology Management*, Vol. 21, No. 8, pp. 990-1012.

Liu, G.J., Shah, R. and Schroeder, R.G. (2012b), 'The relationships among functional integration, mass customization, and firm performance', *International Journal of Production Research*, Vol. 50, No. 3, pp. 677-690.

Lu, Y. and Ramamurthy, K.R. (2011), 'Understanding the link between information technology capability and organizational agility: An empirical examination', *MIS Quarterly*, Vol. 35, No. 4, pp. 931-954.

Luo, X. and Bhattacharya, C.B. (2006), 'Corporate social responsibility, customer satisfaction, and market value', *Journal of Marketing*, Vol. 70, No. 4, pp. 1-18.

MacCarthy, B., Brabazon, P.G. and Bramham, J. (2003), 'Fundamental modes of operation for mass customization', *International Journal of Production Economics*,

Vol. 85, No. 3, pp. 289-304.

March, J.G. (1991), 'Exploration and exploitation in organizational learning', *Organization Science*, Vol. 2, No. 1, pp. 71-87.

Meyer, C. (1993), *Fast Cycle Time: How to Align Purpose, Strategy, and Structure for Speed*, Free Press, New York.

Mohrman, S.A. and Mohrman, Jr.A.M. (1993), 'Organizational change and learning', in Galbraith, J.R. and Lawler, E.E. (Eds.), *Organizing for the Future: The New Logic for Managing Complex Organizations*, Jossey-Bass Publishers, San Francisco, CA, pp. 87-108.

Nagati, H. and Rebolledo, C. (2013), 'Improving operational performance through knowledge exchange with customers', *Production Planning & Control*, Vol. 24, No. 8/9, pp. 658-670.

Nagel, R.N. and Dove, R. (1991), *21st Century Manufacturing Enterprise Strategy: An Industry Led View*, Iacocca Institute, Bethlehem, PA.

Nonaka, I. (1994), 'A dynamic theory of organizational knowledge creation', *Organization Science*, Vol. 5, No. 1, pp. 14-37.

Nonaka, I. and Konno, N. (1998), 'The concept of 'Ba': Building a foundation for knowledge creation', *California Management Review*, Vol. 40, No. 3, pp. 40-54.

Nonaka, I., Toyama, R. and Konno, N. (2000), 'SECI, Ba and leadership: A unified model of dynamic knowledge creation', *Long Range Planning*, Vol. 33, No. 1, pp. 5-34.

Nunnally, J.C. (1978), *Psychometric Theory*, McGraw Hill, New York,

Oh, W. and Pinsonneault, A. (2007), 'On the assessment of the strategic value of information technologies: Conceptual and analytical approaches', *MIS Quarterly*, Vol. 31, No. 2, pp. 239-265.

Overby, E., Bharadwaj, A. and Sambamurthy, V. (2006), 'Enterprise agility and the enabling role of information technology', *European Journal of Information Systems*, Vol. 15, No. 2, pp. 120-131.

Patrakosol, B. and Olson, D.L. (2007), 'How interfirm collaboration benefits IT innovation', *Information & Management*, Vol. 44, No. 1, pp. 53-62.

Peng, D.X., Liu, G.J. and Heim, G.R. (2011), 'Impacts of information technology on mass customization capability of manufacturing plants', *International Journal of Operations & Production Management*, Vol. 31, No. 10, pp. 1022-1047.

Pine II, B.J. (1993), *Mass Customization: The New Frontier in Business Competition*, Harvard Business School Press, Boston, MA.

Pine II, B.J., Victor, B. and Boynton, A.C. (1993), 'Making mass customization work', *Harvard Business Review*, Vol. 71, No. 5, pp. 108-119.

Pine II, J., Peppers, D. and Rogers, M. (1995), 'Do you want to keep your customers forever?', *Harvard Business Review*, Vol. 73, No. 2, pp. 103-114.

Rai, A., Patnayakuni, R. and Seth, N. (2006), 'Firm performance impacts of digitally enabled supply chain integration capabilities', *MIS Quarterly*, Vol. 30, No. 2, pp. 225-246.

Sahin, F. (2000), 'Manufacturing competitiveness: Different systems to achieve the same results', *Production and Inventory Management Journal*, Vol. 41, No. 1, pp. 56-65.

Sambamurthy, V., Bharadwaj, A. and Grover, V. (2003), 'Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms', *MIS Quarterly*, Vol. 27, No. 2, pp. 237-263.

Schoenherr, T., Griffith, D.A. and Chandra, A. (2014), 'Knowledge management in supply chains: The role of explicit and tacit knowledge', *Journal of Business Logistics*, Vol. 35, No. 2, pp. 121-135. .

Schroeder, R.G., Bates, K.A. and Junttila, M.A. (2002), 'A resource-based view of manufacturing strategy and the relationship to manufacturing performance', Strategic Management Journal, Vol. 23, No. 2, pp. 105-117.

Sharifi, H. and Zhang, Z. (2001), 'Agile manufacturing in practice: application of a methodology', *International Journal of Operations & Production Management*, Vol. 21, No. 5/6, pp. 772-794.

Tallon, P.P. and Pinsonneault, A. (2011), 'Competing perspectives on the link between strategic information technology alignment and organizational agility: insights from a mediation model', *MIS Quarterly*, Vol. 35, No. 2, pp. 463-486.

Tsai, M.T. and Li, Y.H. (2007), 'Knowledge creation process in new venture strategy and performance', *Journal of Business Research*, Vol. 60, No. 4, pp. 371-381.

Tu, Q., Vonderembse, M.A. and Ragu-Nathan, T.S. (2001), 'The impact of time-based manufacturing practices on mass customization and value to customer', *Journal of Operations Management*, Vol. 19, No. 2, pp. 201-217.

Tu, Q., Vonderembse, M.A. and Ragu-Nathan, T.S. (2004b), 'Manufacturing practices: antecedents to mass customization', *Production Planning & Control*, Vol. 15, No. 4, pp. 373-380.

Tu, Q., Vonderembse, M.A., Ragu-Nathan, T.S. and Ragu-Nathan, B. (2004a), 'Measuring modularity-based manufacturing practices and their impact on mass

customization capability: a customer-driven perspective', *Decision Sciences*, Vol. 35, No. 2, pp. 147-168.

Urbach, N. and Ahlemann, F. (2010), 'Structural equation modeling in information systems: research using partial least squares', *Journal of Information Technology Theory and Application*, Vol. 11, No. 2, pp. 5-40.

Von Hippel, E. (1988), *The Sources of Innovation*, Oxford University Press, New York.

Weill, P., Subramani, M. and Broadbent, M. (2002), 'Building IT infrastructure for strategic agility', *Sloan Management Review*, Vol. 44, No. 1, pp. 57-65.

Wowak, K.D., Craighead, C.W., Ketchen, D.J.Jr. and Hult, G.T.M. (2013), 'Supply chain knowledge and performance: A meta-analysis', *Decision Sciences*, Vol. 44, No. 5, pp. 843-875.

Zahra, S.A. and Nielsen, A.P. (2002), 'Sources of capabilities, integration and technology commercialization', *Strategic Management Journal*, Vol. 23, No. 5, pp. 377-398.

Appendix 1

Measurement Scales

A. External learning (EL)	
EL1	We have strived to establish long-term relationships with partners.
EL2	We have maintained close communication with partners about quality considerations and design changes.
EL3	Our customers have given us feedback on quality and delivery performance.
EL4	Our customers have actively involved in the product design process.
B. Internal learning (IL)	
IL1	Our employees are cross-trained so that they can fill in for others if necessary.
IL2	Our employees have received training to perform multiple tasks.
IL3	Management has taken all product and process improvement suggestions seriously.
IL4	We have implemented many useful suggestions.
C. Customer agility (CA)	
We have……	
CA1	cooperated with customers in the exploration and exploitation of opportunities for innovation and competitive action moves.
CA2	leveraged the voice of the customer for gaining market intelligence opportunities.
CA3	leveraged the voice of the customer for detecting competitive action opportunities.
D. Partnering agility (PA)	
We have……	
PA1	leveraged the assets, knowledge, and competencies of partners through collaboration.
PA2	exploited opportunities through efficient sourcing and staging of manufacturing, logistics, or customer support assets and resources.

PA3	built a network of strategic, extended, or virtual partnerships to explore opportunities for innovation and competitive action.
E. Operational agility (OA)	
We have……	
OA1	accomplished speed, accuracy, and cost economy in the exploitation of opportunities for innovation and competitive action.
OA2	redesigned existing processes and created new processes for exploiting dynamic marketplace conditions rapidly.
OA3	reduced information asymmetries between buyers and sellers through rapid and up-to-date supply of comprehensive information.
F. Customization capability (CC)	
We can……	
CC1	respond to customer's customization requirements quickly.
CC2	translate customer requirements into technical designs quickly.
CC3	customize products on a large scale.
CC4	customize products while maintaining a large volume.