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## **Emerald Article: Knowledge creation in a supply chain**

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### **Article information:**

To cite this document: Chuni Wu, (2008), "Knowledge creation in a supply chain", Supply Chain Management: An International Journal, Vol. 13 Iss: 3 pp. 241 - 250

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# Knowledge creation in a supply chain

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### Abstract

**Purpose** – This paper aims to analyze how organizational conditions, technology adoption, supplier relationship management and customer relationship management affect knowledge creation through socialization-externalization combination, internalization (SECI) modes, and various *ba*, as proposed by Nonaka and Konno, in a supply chain.

**Design/methodology/approach** – A qualitative inquiry with thematic analysis, which focuses on a thin film transistor-liquid crystal display (TFT-LCD) panel manufacturer and an integrated circuits (IC) packaging and testing manufacturer, is presented in order to identify how these key factors affect knowledge creation in a supply chain environment through the SECI modes and *ba*.

**Findings** – The results show that these critical factors facilitate different types of knowledge conversion process in order to achieve successful knowledge creation in a supply chain. Knowledge of the significant factors that were found in this study may be applicable to countries or areas such as Hong Kong, Korea, Singapore or other developing countries, whose dominant businesses are similar to the original equipment manufacturers (OEMs)/original design manufacturers (ODMs) in Taiwan.

**Research limitations/implications** – This paper considers the case study only as one empirical illustration of many other possible implementation processes. The study does not assume that these companies are a paradigm or that the specific situation is applicable to all other business enterprises. Future researchers interested in this field are therefore encouraged to triangulate its findings by examining variables generated from this study.

**Originality/value** – This study employs a quantitative approach to investigate critical knowledge creation factors for supply chain performance. Through empirical study, a better understanding of the dynamics of knowledge creation in a supply chain can be gained.

**Keywords** Knowledge creation, Supply chain management, Organizational porocesses, Technology led strategy, Customer relations, Taiwan

**Paper type** Case study

## 1. Introduction

Creating value through supply chain integration has become a potentially valuable way of securing competitive advantage and improving organizational performance, since competition is no longer between organizations, but among supply chains (Li *et al.*, 2006). The integration of a supply chain not only focuses on tangible resources and assets, but also on intangibles such as knowledge. Knowledge is becoming the only resource capable of offering competitive advantage and continued growth and prosperity for supply chain partners. Thus, the effective creation of knowledge has become a top priority in a supply chain. The tangible consequences of knowledge creation include improved employee and customer satisfaction, an enhanced image, and an increased share valuation (Coulson-Thomas, 2004). Knowledge creation acquires expertise from outside the company. In order to create new knowledge, supply chain partners are engaging in interlinked processes that enable rich information sharing, and building information technology infrastructures that

allow them to process information obtained from their partners (Malhotra *et al.*, 2005). In the past few years, many key factors have been examined concerning knowledge creation in a supply chain. Lin and Wu (2005) suggested that collaborative relationships with customers as well as suppliers are the key to enhancing knowledge creation in a supply chain. Weck (2006) focused on the importance of customer relationship management (CRM), which affects knowledge creation in a supply chain. He examined the management of collaborative R&D projects with customers and the results showed that the creation of a genuine “win-win” situation, clear roles and responsibilities, a customer-oriented approach and the exchange of complementary specialist knowledge are found to be key critical success factors in the process of inter-firm knowledge creation. With regard to supplier relationship management (SRM), through an analysis of quality improvement projects conducted in one factory over a decade, Lapre and Wassenhove (2003) suggested that a stable relationship with raw materials suppliers enhances knowledge creation.

Technology adoption and organizational conditions are also critical factors that affect knowledge creation in a supply chain. Cassivi (2006) analyzed how e-collaboration tools

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Supply Chain Management: An International Journal  
13/3 (2008) 241–250  
© Emerald Group Publishing Limited [ISSN 1359-8546]  
[DOI 10.1108/13598540810871280]

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This study was supported by a grant from the National Science Council, Taiwan, Republic of China (NSC 96-2416-H-432-002-MY2). Thanks are also due to Professor Mark Goh and the anonymous referees for their helpful comments and suggestions for improving this article.

affect different partners along the supply chain, and suggested that they play an important role in facilitating access to information, which affects knowledge creation capabilities, and assisting in the design of flexible supply chains. Kodama (2005) examined the dynamism of the knowledge creation process at Fujitsu Ltd. The results show that new product development in a high-tech field requires the merging and integration of different technologies to network strategic communities inside and outside the company in order to share and transfer and thus create knowledge. Based on a survey of 105 R&D partnerships in the global telecommunications industry, Feller *et al.* (2006) suggest that a higher overall use of knowledge transfer mechanisms among supply chain partners leads to better learning results, and in turn, knowledge creation. Regarding the organizational conditions, Phan and Peridis (2000) noted cultural conflicts as another factor which affects knowledge creation in a supply chain. They suggested that knowledge creation often occurs in turbulent and discontinuous environments associated with the tension between alliance partners of different cultural origins. Although the literature has identified many critical factors that affect knowledge creation in a supply chain, the essential features that lead to achieving it have not been fully explored.

Taiwan is the world's largest manufacturer for dozens of information technology-related products, such as notebook computers, palm scanners, motherboards, and thin film transistor-liquid crystal display (TFT-LCD). In terms of production value, it ranks third in the world for computer manufacturing and fourth for semiconductors (MOEA, 2005). Taiwan's electronics sector has grown from a humble beginning in the 1970s to its current status as a supplier of half the world's computer hardware. Taiwan's computer firms have also been developing higher-margin services such as design (Young, 2000). The computer and electronics industries continue to flourish in Taiwan through upstream suppliers and downstream customers (Lin *et al.*, 2002; Hsu, 1999). In addition, Taiwan is also home to one of Asia's most open and well-developed internet communities (Trappey and Trappey, 2000). In June 1999, Taiwan launched a national industrial automation and electronic business (IAEB) plan to build up the business-to-business (B2B) infrastructure. The five-and-a-half-year plan increased B2B e-business to 50,000 enterprises (comprising 200 supply chains) through its objective of increasing global competitiveness for manufacturing and distribution. In 2000, internet nodes were completed for the whole island of Taiwan and its four outlying islands. Taiwan is thus a leading internet and computer technology provider, not only for Asia, but also for the world. The above are all reasons why Taiwan's computer and electronics industries are a suitable sample for exploring issues concerned with knowledge creation in a supply chain.

This paper aims to analyze the role of several key factors, including organizational conditions, technology adoption, SRM and CRM with regard to knowledge creation in a supply chain. First, research constructs are defined and operationalized according to a review of the literature. Second, the socialization, externalization combination and internalization (SECI) modes, and various *ba*, as proposed by Nonaka and Konno (1998), are introduced. Third, a qualitative inquiry with the thematic analysis, which focuses on a TFT-LCD panel manufacturer and an integrated circuits (IC) packaging and testing manufacturer, is presented in order to identify how these key factors affect knowledge

creation in a supply chain environment through the SECI modes and *ba*.

## 2. Research background

Today's global marketplace offers significant opportunities to conduct supply chain management (SCM). Ogulin (2003) suggests that supply chain firms need to develop organizational, procedural, technical, and strategic capabilities to respond to four emerging requirements in the twenty-first century: customer and end consumer focus, technology adoption, relationships management, and styles of leadership. In addition, knowing that the firm's capabilities are limited in time and effort, management will need to choose the level of partnership appropriate for each particular supply chain member (Lambert and Cooper, 2000). This requires breaking down the traditional organizational boundaries and moving beyond mere communication and cooperation. Thus, the effective management of organizational conditions, technology adoption, SRM and CRM is the key to remaining competitive in the long run for firms in today's global environment. In order to explore what role of these key factors play in knowledge creation in a supply chain, which previous studies have not addressed, the four research constructs of this paper are defined and operationalized according to a review of the literature in this section.

### 2.1. Organizational conditions

Organizational conditions are one type of environmental influence which impacts the way employees think, perform tasks, and communicate/interact with each other. They have a significant impact on the supply chain partnership (Yap *et al.*, 2006). Different people and different organizational forms have different styles and cultures. Sometimes, those heterogeneous cultures do not easily work together and it is necessary for organizations to use specific organizational mechanisms to facilitate ongoing dialogue among the participants. Cooper *et al.* (1998) stressed that there are certain organizational mechanisms, such as business goals, organizational structure and culture, that are common across all business processes and members of the supply chain, and these common management components are critical and fundamental for implementing SCM. A business goal, such as knowledge management objectives that permeate the organization, can provide personnel with a needed sense of purpose that transcends everyday activities. It may also define key domains and core knowledge, including value-enhancing processes (Ndlela and Toit, 2001). In addition, a process-oriented organizational structure entails a sequence of discrete value-added stages designed to deliver a product and service to external and internal customers, since it makes direct connections between the organizational knowledge assets – both explicit and tacit (Mentzas *et al.*, 2001). Meanwhile, the organizational culture is the carrier of tacit knowledge in an organization, and cultures with a quality of “care” facilitate organizational members' communication and sharing of knowledge (Von Krogh, 1998).

### 2.2. Technology adoption

To facilitate the development of supply chain strategies and new sources of competitive advantage, an important input factor for supply chain firms today is their technology

strategies and infrastructure. The focus of enterprise systems is shifting from an internal to an external orientation. Liu *et al.* (2005) claimed that collaborative SCM systems can be supported by enhanced information sharing and collaborative planning among partners, and are supported primarily through mechanisms such as information integration and process coordination. In the digital era, an integrated system of information such as enterprise resource planning (ERP) that treats the functional and different business units of a firm as a cohesive whole would definitely help businesses to excel in achieving the competitive priorities set by supply chain firms. Madu and Kuei (2004) also noted the development of ERP II – a web-enabled application of ERP. ERP II enables supply chain enterprises to operate with cleaned-up data rather than a haphazard collection of data, thereby improving their business processes. In addition, Rosenbaum (2001) also noted that information communication technology (ICT) such as the internet, which connects different actors along the supply chain, and three-dimensional computer-aided design (3D CAD) for interacting with customers and suppliers, have an enormous impact on how companies manage their supply chains. Meanwhile, an enterprise information portal (EIP) is viewed as a knowledge community (Ryu *et al.*, 2005), and Kakumanu and Mezzacca (2005) stressed that EIP provide delivery mechanisms that overcome information barriers between technical, functional, and cultural silos that limit the internal creation and development of competitive advantages within organizations.

### 2.3. SRM

As firms are increasingly becoming outsourcing-oriented, effective SRM should be viewed as a firm's core competency and a source of competitive advantage (Wu and Shen, 2006). Firms need to understand which suppliers make significant contributions to the supply chain performance and which do not. Thus, supplier selection has become a major strategic decision for original equipment manufacturers and original design manufacturers (OEMs/ODMs) (Huang and Keskar, 2007). Effective supplier selection will provide insights into the process situation of suppliers who can then become technological innovation partners (Chen *et al.*, 2005). In addition, purchasing of raw material, parts, and services is an important and costly process in most organizations (Parikh and Joshi, 2005). The objective of the purchasing process must be the harmonization of the internal processes of an organization and its suppliers in order to avoid a waste of resources within the supply chain. Thus, organizations shall ensure that the product purchased conforms to specified purchase requirements. Purchasing information describes the product to be purchased and ensures the adequacy of specified purchase requirements prior to their communication to the supplier (ISO, 2000). Meanwhile, in order to maintain a network of competent suppliers to improve purchasing performance, an organization must have a supplier development program (McGovern and Hicks, 2006). Supplier development can be referred to as a capability-enhancing activity that an organization undertakes to improve its suppliers' performance (Sako, 2004). The implementation of supplier development practices contributes significantly to the prediction of purchasing performance (Sánchez-Rodríguez *et al.*, 2005).

### 2.4. CRM

The success of an organization depends on its ability to satisfy customers. CRM attempts to manage the relationship with customers to understand, target, and attract them, with the objective of satisfying and retaining them (Chen and Su, 2006). The basis for a tight relationship is agreement on communication and exchange of valuable product information, enquiries, contracts or order handling, including amendments and customer feedback, such as customer complaints (ISO, 2000). In addition, the contract review process may be used purposefully to increase mutual understanding and learning, and to build up trust between an organization and its customers (Blomqvist *et al.*, 2005). This review will be conducted prior to the organization's commitment to supply a product to the customer, and ensures that product requirements are defined and that the organization has the ability to meet them (ISO, 2000). Meanwhile, managing customer perceptions is the real key for long-term organizational success. Management implies an active rather than a passive role, while perception involves acquiring, interpreting, selecting and organizing sensory information (Hoots, 2005). Thus, the organization monitors information relating to customer perceptions as to whether the organization has met customer requirements (ISO, 2000).

## 3. Typologies of knowledge and knowledge creation

Among the studies relating to knowledge typologies, the distinction between explicit and tacit knowledge is the dominant concept in the literature (Polanyi, 1966; Nonaka and Takeuchi, 1995; Senker, 1995). The assumption in the literature is that articulated knowledge is easily shared because it can be codified. According to Nonaka and Takeuchi (1995), tacit knowledge is personal, context specific, and therefore hard to formalize and communicate, while explicit knowledge can be described as knowledge that is transmittable by informal or systematic language. Tacit knowledge is in general more difficult to transmit than codified knowledge; and it travels particularly poorly between organizations (Kogut and Zander, 1993). Johnson (1998) believed that explicit knowledge is stored in document databases, while tacit knowledge is in the human head and database tracks.

Knowledge creation relates to knowledge addition and/or the correction of existing knowledge (Shin *et al.*, 2001). Nonaka and Konno (1998) proposed a SECI model that describes a dynamic process in which explicit and tacit knowledge are exchanged and transformed. Four modes of knowledge creation have been identified in the SECI model. The socialization mode (from tacit to tacit) involves sharing tacit knowledge between individuals. The externalization mode (from tacit to explicit) relies on analogies, metaphors, hypotheses, and models expressed through articulated language. The combination mode (from explicit to explicit) involves converting explicit knowledge into more complex sets of explicit knowledge. Finally, the internalization mode (from explicit to tacit) conveys explicit knowledge into tacit knowledge.

In addition, it will be beneficial to consider the conditions and environments that facilitate knowledge creation. Nonaka and Konno (1998) employed the Japanese word *ba* to define a common place or space for knowledge creation. *Ba* is a place



where information is interpreted to become knowledge. It is the context shared by those who interact with each other, and through such interactions those who participate in *ba*, and the context itself, evolve through self-transcendence to create knowledge. There are four types of *ba* corresponding to the four modes of knowledge creation. Originating *ba* is a place where individuals share experiences primarily through face-to-face interactions. It mainly offers a context for socialization. Interacting *ba* entails the externalization mode of knowledge creation. It is a place where tacit knowledge is converted to explicit knowledge and is shared among individuals through the process of dialogue and collaboration. Cyber *ba* is defined by collective and virtual interactions. Cyber *ba* is associated with the combination mode of knowledge creation and refers to a virtual space of interaction. Finally, exercising *ba* refers to a space for active and continuous individual learning and corresponds to the internalization mode of knowledge creation.

## 4. Research method and results

### 4.1 Profile of case companies

Most Asian industries consist of medium/small firms that do not have enough independent knowledge resources of their own. Thus they need to source knowledge from foreign companies, cultivate their knowledge under others' guidance, or conduct cross-national knowledge activities such as cooperative R&D, joint knowledge alliances, and even mutually utilizing foreign patents (Jih *et al.*, 2005). Thus, the connections between firms are close, tight, inseparable, and sophisticated. Even though the R&D infrastructure is weak, the firms can still utilize their knowledge or patents mutually via interaction. By doing so, they are able to create technological advantages.

Taiwan's critical high-tech industries depend on appropriate government support so that they can develop vigorously. An important policy is to establish government-sponsored research organizations and institutes, and to support the development of science-based industrial parks. Taking semiconductor and TFT-LCD manufacturers in Taiwan as the example, they are two of the most important high-tech industries that have been actively promoted by Taiwan's government to compete in the global market. Since the capital of the firms in these industries cannot compare to their counterparts in the USA and Europe, every independent manufacturer might fall behind in technology or knowledge capability. To raise the technological capability of these firms, the Industry Technology Research Institute (ITRI) in Taiwan has attracted a lot of IC-related experts coming from the USA and Europe to produce new technology and patents, and then transferred and diffused the technologies to other firms within the industry. The structure of high-tech industries in Taiwan consists of upstream, midstream, and downstream segments. Most of them set up their factories in science-based industrial parks in order to work together cooperatively in a consolidated chain. Such efforts have made the high-tech industries very competitive globally. Thus, this paper chooses a TFT-LCD panel manufacturer company called Chi Mei Optoelectronics (CMO) and an IC packaging and testing manufacturer called ASE Group in order to identify how these above-mentioned key factors affect knowledge creation in a supply chain through the SECI modes and *ba*.

The main products of CMO are LCD TV panels and LCD panel displays for desktop and notebook computers, delivered to IT and home electronics vendors worldwide. The production facilities of CMO are based in Southern Taiwan Science Park and it is considered one of the high-tech leaders in Taiwan. In the past few years CMO has been developing "Tree Valley", an industrial zone on 250 hectares adjacent to the Southern Taiwan Science Park. CMO has invited LCD TV upstream suppliers of glass, backlights, polarizer, lamps, and driver ICs to build facilities in Tree Valley, in this way forming an optoelectronics cluster that will dramatically improve LCD TV supply chain performance in Taiwan ([www.cmo.com.tw/](http://www.cmo.com.tw/)). ASE Group mainly offers IC packaging and testing and is the world's largest provider of independent semiconductor manufacturing services in assembly and testing. ASE Group is a global company with manufacturing bases strategically located in key centers for semiconductor manufacturing. This enables its customers to take advantage of the seamless logistic management of all stages of semiconductor production and delivery ([www.aseglobal.com/](http://www.aseglobal.com/)).

### 4.2. In-depth interview

The case study involves qualitative research and data collected from in-depth interviews. Interviews are one of the most extensively used methods of data collection (Bryman and Burgess, 1999). The individual in-depth interviews which the author conducted were face-to-face and semi-structured in nature (Atmarow *et al.*, 1998; Linberg and Rosenqvist, 2003), which is one of the most common approaches to interviewing in qualitative research (Bryman and Burgess, 1999). The author conducted several in-depth interviews with various department managers of the two case companies, including R&D, sales, purchasing, manufacturing and shipping. A total of 15 managers were invited to take part in the interviews. Eight managers were from CMO, the others were from ASE Group. The work experience of these managers ranged from five to ten years. Each interview lasted about one-and-a-half hours. The contents of the interviews were audiotaped and transcribed verbatim. Observations and informal conversations also constituted an important part of the data collection process. After the data were completely collected, content analysis was employed for the transcripts.

### 4.3. Data analysis

Content analysis has been extensively employed in analyzing qualitative data. It is an objective coding scheme applied to various types of unobtrusive data, such as interviews and field notes, which are often not amenable to analysis until the information they convey has been condensed and made systematically comparable. Seven major elements in written messages can be counted in content analysis: words or terms, themes, characters, paragraphs, items, concepts and semantics (Berg, 2000). The most frequent and useful unit to count is the theme. By using thematic analysis, the interview data was parsed into information-rich quotations that were ultimately placed into thematic categories (Anderson and Felsenfeld, 2003). By categorizing the data, important concepts pertaining to themes emerged. Essential themes were pre-determined by a review of the literature. Analysis identified five core themes: knowledge creation mode and *ba*, organizational conditions, technology adoption, supplier relationship management and customer relationship

management. The sub-themes within knowledge creation mode and *ba* include socialization mode and originating *ba*, externalization mode and interacting *ba*, combination mode and cyber *ba*, internalization mode and exercising *ba*. The sub-themes within organizational conditions are establishing business goal, establishing culture with care and identifying processes needed for SCM. The sub-themes within technology adoption are ICT, information system (IS) and EIP. The sub-themes within supplier relationship management are evaluation of suppliers, purchasing documents review and supplier development. The sub-themes within customer relationship management are communication with customers, contract review and obtaining and analyzing customer perception.

Preparation and analysis of the interview data generally follow guidelines outlined by Boyatzis (1998) and Miles and Huberman (1994). Each interview was transcribed verbatim from the audiotape using a standard word processing program. The author read each transcript multiple times and highlighted all the statements that appeared to be information-rich. Statements that appeared to have relevant themes embedded in the text were sorted together, and potential statements were those that were judged to pertain directly to the themes being probed. An iterative process was then used to further refine themes and categories until both coders agreed upon a satisfactory set of categories that adequately accounted for the variety of statements (Anderson and Felsenfeld, 2003). By analyzing all of the interview data in this way we have assessed how frequently specific issues were mentioned and how they were addressed. A total of 297 events were coded, of which 277 were judged unambiguous and 20 were judged as slightly ambiguous but codable from common knowledge and/or other information provided (Kracker and Pollio, 2003). Crosscoder reliability was 95.8 percent, using the formula given in Hosti (1969), well above the level suggested by Krippendorff (1980) as an acceptable level of crosscoder agreement.

#### 4.4 Results of the case study

The results from Tables I and II show that: regarding the organizational condition, 75 percent of the interviewed managers of the two case companies believed that establishing the business goal is part of the exercising *ba*. In this *ba*, management disseminates measurable knowledge creation objectives down the organizational hierarchy and across its suppliers in order to make sure all employees and suppliers are committed to meeting key domain knowledge as well as the customer requirements of the supply chain. In addition, over 78 percent of the interviewed managers considered that establishing culture with care is part of the originating *ba*. In this *ba*, members of the supply chain partners can interact with each other to acquire tacit knowledge in order to assess areas for improving the SCM system. Meanwhile, 90 percent of the interviewed managers felt that identifying the processes needed for SCM is categorized as interacting *ba*. Within the *ba*, tacit knowledge about validation of processes for production under a supply chain is made explicit. These documents describe criteria for approval of the processes, suitable equipment and qualification of personnel, and use of specific methods and procedures. With regard to the technology adoption, 75 percent and 76.7 percent of the interviewed managers thought the ICT and IS are a cyber *ba*, respectively, which edits and

processes synthetic knowledge of various departmental and organizational information, including logistics, cost accounting, human resources and other features in written reports relevant to supply chain systems. In addition, 68.7 percent of the interviewed managers felt that they can use the EIP as exercising *ba*, and in this *ba* employees, suppliers and customers can enter a single gateway for the personalized information needed to augment their tacit knowledge base in order to make more informed decisions.

Concerning the SRM, 85 percent and 77.7 percent of the interviewed managers in evaluation of suppliers and review of purchasing documents, respectively, believed that these activities work as interacting *ba*. In this *ba*, tacit knowledge about potential suppliers and purchasers' specific requirements is recorded and documented. Furthermore, 80 percent of the interviewed managers considered supplier development an exercising *ba*, because it provides vital explicit knowledge of technical or process know-how to enhance potential suppliers' ability to deliver raw materials effectively. As regards the CRM, 84 percent of the interviewed managers felt that communication with customers is part of originating *ba*, where its sales representatives can acquire tacit knowledge about customer product preferences. Additionally, 76.7 percent of the interviewed managers thought that the contracts review is interacting *ba*. Such activity facilitates an essentially creative dialogue as to customer product requirements. At this juncture, tacit knowledge about requirements specified by the customer is made explicit in the form of contract review records, including a definition of product. Furthermore, 77.8 percent of the interviewed managers said that company sales representatives obtaining and analyzing customer perceptions is an interacting *ba*. Tacit knowledge about customer expectations and perceptions is documented in customer feedback surveys of product uniformity, delivery, and after-sale service.

## 5. Discussion

The following discussion refers to four types of knowledge conversion process, which show how managers can leverage the proposed constructs in knowledge creation in a supply chain. In addition, the interactions between the knowledge creation process and SCM will be discussed.

### 5.1. Socialization conversion process

Socialization mode involves building fields of interaction in which individuals share experiences and tacit knowledge. Different people and different organizational forms have different styles and cultures. Sometimes, those heterogeneous cultures do not easily work together. Notably, when supply chain opportunities involve other functional areas beyond the product-flow function within the same firm, managerial control becomes more complicated. Enterprises in Taiwan tend to place a greater emphasis on "soft human-oriented" rather than "hard technology-oriented" organizational culture. They tend to be organic in nature and use informal approaches such as personal relations in sharing knowledge, and are better able to cope with uncertainty. In addition, most firms in Taiwan, which are OEMs and ODMs, constantly face the uncertainties of order cancellation or change in quantity from their overseas customers. As firms in Taiwan are almost all small and medium-sized enterprises (SMEs), sometimes it is not easy for them to break through social boundaries and

Table I Results of the thematic analysis of knowledge creation mode and *ba*

Main themes	Main themes Sub-themes	Knowledge creation mode and <i>ba</i>									
		Socialization and originating <i>ba</i>		Externalization and interacting <i>ba</i>		Combination and cyber <i>ba</i>		Internalization and exercising <i>ba</i>		Total	%
		<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)		
Organizational conditions	Establish business goal	5	20.8	1	4.2	0	0	18	75	24	100
	Establish culture with care	25	78.1	2	6.2	1	3.1	4	12.5	32	100
	Identify process-needed for SCM	1	5	18	90	0	0	1	5	20	100
Technology adoption	ICT	0	0	2	7.1	21	75	5	17.9	28	100
	IS	2	6.7	1	3.3	23	76.7	4	13.3	30	100
	EIP	0	0	1	6.3	4	25	11	68.7	16	100
Supplier relationship management	Evaluation of suppliers	3	15	17	85	0	0	0	0	20	100
	Purchasing process	1	5.6	14	77.7	2	11.1	1	5.6	18	100
	Supplier development	1	5.6	1	5.6	2	11.1	14	77.7	18	100
Customer relationship management	Communication with customers	21	84	2	8	0	0	2	8	25	100
	Contract review	2	6.7	23	76.7	1	3.3	4	13.3	30	100
	Obtain and analyze customer perception	2	5.6	28	77.8	5	13.9	1	2.7	36	100
Total		63	21.2	110	37	59	19.9	65	21.9	297	100

Table II Results of knowledge creation in a supply chain

Constructs	Knowledge before being converted	Knowledge conversion mode	<i>ba</i>	Type of the <i>ba</i>	Knowledge after being converted
Organizational conditions	Customer requirements	Internalization	Establish business goal	Exercising <i>ba</i>	Key domains knowledge
	Intra-organizational based knowledge	Socialization	Establish culture with care	Originating <i>ba</i>	Inter-organizational based knowledge
	Validation of process for production	Externalization	Identify process-needed for SCM	Interacting <i>ba</i>	Process control documents
Technology adoption	Product information and enquiries	Combination	ICT	Cyber <i>ba</i>	Characteristics of products
	Characteristics and trends of processes and products	Combination	IS	Cyber <i>ba</i>	Corrective and preventive action for SCM
	Documented key domains knowledge	Internalization	EIP	Exercising <i>ba</i>	Ability to make more informed decisions
Supplier relationship management	Suppliers' ability	Externalization	Evaluation of suppliers	Interacting <i>ba</i>	Criteria for selection and evaluation
	Specified requirements	Externalization	Purchasing documents Review	Interacting <i>ba</i>	Criteria for purchasing
	Documented technical or process know-how	Internalization	Supplier development	Exercising <i>ba</i>	Suppliers' ability
Customer relationship management	Customer focus	Socialization	Communication with Customers	Originating <i>ba</i>	Product preferences
	Customer requirements	Externalization	Contract review	Interacting <i>ba</i>	Define product requirements
	Customer perception	Externalization	Obtain and analyze Customer perception	Interacting <i>ba</i>	Customer satisfaction Index

consolidate network relationships (Beck *et al.* 2005). They are therefore more proactive in initiating closer collaboration heuristically compared with their counterpart buyers. Collaborative relationships require more communication for long-term cooperation, along with a willingness to share knowledge. Thus, greater cultural understanding of relational partners will increase communication interactions and lead to the rapid assimilation of tacit knowledge.

### 5.2. Externalization conversion process

When we attempt to conceptualize an image, we express its essence mostly in language. The way writing is an act of converting tacit knowledge into articulated knowledge is illustrative of this (Emig, 1983). The competitive strategy of Taiwanese manufacturers is based on the core operations capability and widely employs outsourcing to have flexible and responsive operation capabilities to deal with emergencies. These outsourcing systems are closely cooperative networks that link various specialized and mutually supplemental enterprises. This is the crucial reason why the 1997 Asian financial crisis did not significantly impact on Taiwan's economy. The decision making on core operations capability and outsourced processes is considered teamwork, and a cross-functional company team reviews each customer contract, plans core operations processes and outsourced processes, evaluates and selects suppliers, reviews purchasing documents and obtains and analyzes customer perceptions. The results are recorded and documented, analyzed and structured, and this is a key manifestation of knowledge and provides a way for successful

distribution of it (Enting *et al.*, 1999; Heng, 2001). A cross-functional team, including participants with the right mix of specific knowledge, thus serves to speed the externalization conversion process.

### 5.3. Combination conversion process

Combination mode involves many channels of communication, such as face-to-face talking (socialization), communication networks (internet, information system), and use of writing (having aspects of externalization), such as written media (3D CAD, information analysis reports). It is knowledge transmittable in formal, systematic language. Such configurations are a codification strategy in which knowledge is codified and stored in databases where it can be easily accessed and used by anyone in the supply chain (Turban *et al.*, 2001). More and more Taiwanese companies have begun the adoption of ICT and IS because of government policy on global logistics. The primary objective of ICT and IS is supporting management decisions, such as the continuing suitability of SCM, by collecting and analyzing information, such as customer satisfaction, information relating to suppliers, characteristics and trends of processes and products, shipment, package and delivery. In addition, the ERP system and 3D CAD have gained considerable attention in Taiwanese firms. The ERP system allows companies to integrate various departmental information such as logistics, cost accounting, human resources and other features relevant to production systems. It can facilitate the learning process, the creation of a learning infrastructure, and innovation and improvement loops (Soliman and Youssef,



2001). The 3D CAD allows companies to design, manage the bill of materials and to integrate with computer-aided manufacturing (CAM). An organization with a high technology adoption capability will enhance the combination conversion process by editing and processing synthetic knowledge in written reports.

#### 5.4. Internalization conversion process

Quinn (1998) found that a lack of sufficient commitment, including business goals and support from top management, often resulted in the failure of SCM projects. Measurable business goals will trigger the organizational learning process (Lin and Wu, 2007). Organizational learning is a process by which a firm acquires information, knowledge, understanding, know-how, techniques, and practices that lead to changes in its routines (Argyris and Schon, 1996). An EIP can undergo three distinct types of learning processes: learning-by-investment, learning-by-doing, and learning-from-others. Through these three types of learning processes, each supply chain member achieves specialized knowledge that is related to his or her own task (Ryu *et al.*, 2005). In addition, as mentioned above, by involving suppliers, a firm would provide the requisite flexibility for a supply chain to become more responsive to changing customer preferences. However, supplier evaluation cannot guarantee successful collaboration. The main reason for unsuccessful collaboration is not a lack of technology or hardware, but of inter-organization trust. Supplier development may be used purposefully to increase mutual understanding and learning and to build up trust. Through internalization facilitated by business goals, EIP and supply development, the explicit knowledge created is shared throughout a supply chain and converted into tacit knowledge by individuals.

#### 5.5. Interactions between knowledge creation process and supply chain management

Leveraging the knowledge creation process in a supply chain will form knowledge networks for companies with their suppliers and customers. Knowledge networks allow their participants to create, share, and use strategic knowledge to improve coordination and decision making, as well as planning, and further sharing of resources and competencies, and in turn, enhance operational and strategic efficiency and effectiveness in a network structure. Thus, progressive supply chain management needs more intensive and interactive relationships with a firm's partners, collaborating in new product development, integrating key business processes and cross-functional information sharing on a range of issues in order to achieve mutually beneficial objectives. The nature of information exchange between supply chain partners has evolved from limited information sharing environments to sharing of rich knowledge between partners (Warkentin *et al.*, 2001). By sharing strategic knowledge that enables the analysis and management of all supply chain activities, a new cycle of the knowledge creation process will be triggered, expanding horizontally and vertically within a supply chain.

### 6. Conclusions

In recent years, more and more manufacturers from Taiwan have set up their production facilities in China, resulting in

lower costs and cheaper prices, but also more competitors and more intense competition. Thus, a comprehensively implemented SCM strategy for Taiwan's manufacturers is the best means to react to such harsh competition and to provide the highest value of products and services to customers. In addition, innovation is widely recognized to be vital for the survival and growth of an organization within a supply chain. An innovation process involves using existing knowledge, but also often requires generating and acquiring new knowledge (Howells and Roberts, 2000). This study employs a quantitative approach to investigate critical knowledge creation factors for supply chain performance. Through empirical study, we have a better understanding of the dynamics of knowledge creation in a supply chain. The results show how these critical factors facilitate different types of knowledge conversion process in order to have successful knowledge creation in a supply chain. Knowledge of these significant factors could help multinational enterprises, small businesses, and firms in both traditional and high-tech industries to achieve and sustain supply chain excellence through the effective deployment of knowledge creation processes. Moreover, using the right strategy for partner selection and management is critical for companies looking at setting up in Taiwan or doing business with Taiwanese firms. The selection of partner in terms of organizational conditions, technology adoption, SRM and CRM helps address the need for knowledge creation with regard to innovation when engaging in SCM with local firms in Taiwan.

Even though this research yields quite valuable empirical results, this study nonetheless has several limitations. First, because the data were collected only in Taiwan, the distribution of the scale and type of the firms surveyed may be quite distinct from those in other countries. Because of this, the results obtained cannot be easily generalized. However, they may be applicable to countries or areas such as Hong Kong, Korea, Singapore or other developing countries, whose dominant businesses are similar to the OEMs/ODMs in Taiwan. Second, this paper considers the case study only as one empirical illustration of many other possible implementation processes. The author does not assume that these companies are a paradigm or that the specific situation is applicable to all other business enterprises. Future researchers interested in this field are therefore encouraged to triangulate its findings by examining variables generated from this study.

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