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Knowledge sharing, absorptive capacity, and innovation capability: an empirical study of Taiwan's knowledge-intensive industries

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Received 6 February 2006
Revised 26 June 2006

Abstract.

This research investigates the relationships between knowledge sharing, absorptive capacity, and innovation capability in Taiwan's knowledge-intensive industries. We propose statistical hypotheses and a LISREL model to study these based on the data sampled from 170 Taiwanese firms, including electronic, financial insurance and medical industries, yielding 355 valid returned research samples. By testing three hypotheses, this study finds that absorptive capacity is the intervening factor between knowledge sharing and innovation capability. It also shows that knowledge sharing has a positive effect on absorptive capacity, and that a completely mediating model exhibits both model generalization and extension characteristics through multiple model comparison in different industry population samples. Finally, managerial implications are discussed and a brief conclusion is presented.

Keywords: knowledge management; knowledge sharing; absorptive capacity; innovation capability; LISREL

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1. Introduction

Innovation is an area receiving a great deal of attention from companies in the current fast-changing business environment. Realizing that most competitors within an industry have acquired the same level of competence in areas of management, such as operations, human resources, marketing and strategy, many firms have begun to look to innovation as a key differentiating factor for competitive advantage [1]. As a result, knowledge is a very important resource for preserving valuable heritage, learning new techniques, solving problems, creating core competences, and initiating new situations. Knowledge sharing may encourage knowledge exchange and creation in the organization in order to develop competitive advantages, such as intellectual capital. In addition, since knowledge is a key in achieving continuous innovation, innovation and knowledge are closely related. Therefore, knowledge management has become an important activity for businesses. Knowledge management covers a wide range of topics, and knowledge sharing has been identified as a major focus area for knowledge management [2]. In addition, the knowledge life cycle, knowledge capture, knowledge development, knowledge sharing, and knowledge utilization have all become strategic necessities for organizations to integrate with their information technology capabilities [3].

Several previous studies of innovation claim that the firm's absorptive capacity has a significant influence on the ability to innovate [4, 5]. For example, Quinn et al. [6] state that the foundation of a company's competitive advantage is to make use of its absorptive capacity to develop unique competitive abilities. However, they make no suggestions on how to achieve this. In addition, other related studies present little discussion on how to improve or develop absorptive capacity. In this study, we define absorptive capacity as the employees' ability and motivation to obtain external knowledge and the willingness to use this knowledge in the firm's innovation capability. Absorptive capacity emphasizes the ability to obtain knowledge and the level of effort used to transform it for use. Therefore, a close relationship exists between knowledge and the level of absorptive capacity. Overall, knowledge includes a relationship between knowledge sharing, absorptive capacity and innovation capability. However, it is still unclear whether or not knowledge sharing influences either absorptive capacity or innovation capability.

This study investigates the relationships between knowledge sharing, absorptive capability, and innovation capability in Taiwan's knowledge intensive industries. We use LISREL to model the relationships among knowledge sharing, absorptive capacity and innovation capability based on the data sampled from 170 Taiwanese firms. These firms include electronic, financial insurance and medical industries from which 355 valid samples were received. The rest of the paper is organized as follows. Section 2 reviews the literature and Section 3 proposes the research framework and hypotheses. Section 4 describes the research methodology followed. Section 5 describes the data analysis and the results. Section 6 examines model generalization and extension characteristics for the completely mediating model through multiple model comparison in different population samples. Section 7 discusses managerial implications and Section 8 presents a brief conclusion.

2. Literature review

2.1. Knowledge sharing

In knowledge management, a basic concept is that knowledge can be shared [7]. Performance in various parts of the organization is enhanced when people communicate information, effective practices, insights, experiences, preferences, lessons learned, as well as common and uncommon sense. Knowledge sharing implies that individuals mutually adjust their beliefs and actions through more or less intense interactions [8]. In the 'resource-based' view of the firm, knowledge is considered to be the most strategically important resource [9]. The important question is how these important assets are transformed into value for the organization and then turned into competitive advantage. Liebowitz [10] proposes that knowledge management is the process of creating value from an organization's intangible assets. To determine the core or the focus of knowledge management, Hendriks

[2] suggests that knowledge management activities should focus on knowledge sharing. Knowledge sharing is an important process in modern organizations since successful knowledge sharing can result in shared intellectual capital, an increasingly important resource. Only when individual and group knowledge are translated into organizational knowledge can the organization begin to manage this resource effectively [11].

There are some definitions describing the term 'knowledge sharing'. In organizations, 'communities of communities' are the source of homogeneity of view in both intra-organizational groups and inter-organizational groups. Communities of practice are 'groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.' They operate as 'social learning systems' where practitioners connect to solve problems, share ideas, set standards, build tools, and develop relationships with peers and stakeholders. Organizations and researchers use a variety of terms to describe similar phenomena, such as 'knowledge communities', 'competency networks', 'thematic groups', and 'learning networks'. A community of practice is a particular type of network that features peer-to-peer collaborative activities to build member skills and steward the knowledge assets of organizations and society [12]. Mei et al. [13] propose a communication strategy, which facilitates effective communication between senior managers and staff so that effective knowledge sharing takes place. The strategy provides proactive and reactive communication to achieve acceptance of and commitment to knowledge management in the organization. In addition, it is believed that investing in social values based on mutuality, trust and respect yields long-term benefits such as corporate well being and innovativeness. The benefits arise from knowledge sharing, lower transaction costs due to a communicative spirit, and a greater coherence of action. However, the concept of social capital in the field of information behavior in organizations requires a more theoretical framework. Therefore, Widén-Wulff and Ginman [14] investigate how social and informative aspects are related in order to explore the mechanisms behind knowledge sharing.

Based on previous research, this study considers that whether or not knowledge sharing is a behavior or process, the activities of knowledge sharing include different methods to obtain knowledge. The method of knowledge sharing may turn into the organization's unique characteristic, culture, or system, which influences the firm's performance. In addition, this research considers whether an individual's active knowledge sharing behavior is the basis for successful knowledge sharing in the group or firm. Active knowledge sharing by the employee begins when other people 'voluntarily' donate their knowledge and 'eagerly' collect from others the knowledge needed, thus creating a knowledge sharing cycle in the organization. Only through motivation will an individual willingly and truthfully donate his or her knowledge to another person, and only through motivation will the person in need of the knowledge be truly willing to learn it. Knowledge sharing can be a process, activity or behavior. Van den Hooff and Van Weenen [11] make a distinction between two different forms of knowledge sharing: knowledge donating and knowledge collecting. We employ the definitions of Van den Hooff and Van Weenen [11] stating that organizational knowledge sharing between employees includes both knowledge donating and knowledge collecting, and that knowledge needed is obtained using these two methods: *knowledge donating*, communication to others what one's personal intellectual capital is; and *knowledge collecting*, consulting colleagues in order to get them to share their intellectual capital. Both processes are active processes – either actively communicating to others what one knows, or actively consulting others in order to learn what they know. Thus, in this study, our further analysis of knowledge sharing, we propose that knowledge sharing is an antecedent variable of absorptive capacity and innovation capability.

2.2. Absorptive capacity

Providing a fundamental concept for this factor, Cohen and Levinthal [4] defined absorptive capacity as: 'the ability to recognize the value of new information, to assimilate it, and apply it to commercial ends'. They assumed that a firm's absorptive capacity tends to develop cumulatively, is path dependent and builds on existing knowledge: 'absorptive capacity is more likely to be developed and maintained as a by-product of routine activity when the new knowledge domain that the firm

wishes to exploit is closely related to its current knowledge base' (p. 150). In addition, Lane and Lubatkin [15] further re-conceptualized the concept and proposed that absorptive capacity is a dyad-level construct – denoted relative absorptive capacity – rather than a firm-level construct. Lane and Lubatkin [15] and later research [16] found support for the concept of relative absorptive. In fact, Lane and Lubatkin [15] tested the traditional measure of absorptive capacity of research and development (R&D) as a share of sales (e.g. applied by Cohen and Levinthal [4]) against their own measures of relative absorptive capacity (three bibliometry-based measures of knowledge and five knowledge-processing-similarity variables). They found that the traditional measure of R&D spending explained only 4% of the variance in inter-organizational learning, while the knowledge similarity variables explained another 17% and the five knowledge-processing-similarity variables explained an additional 55%. Thus, a significant finding can be drawn from [15]. First, absorptive capacity should be understood in its context indicating that in some instances absorptive capacity should be treated as a dyad-level construct rather than as a firm-level construct. Second, traditional measures of absorptive capacity (e.g. R&D spending) may be inappropriate as they only partly capture the dyadic construct. Therefore, relative absorptive capacity is 'more important to inter-organizational learning than the commonly used measure of absolute absorptive capacity' (p. 473).

In recent years, studies relating to absorptive capacity can be divided into three main areas:

(1) the re-conceptualization of absorptive capacity [17, 18];

(2) the development of absorptive capacity [17, 19]; and

(3) the relationship between absorptive capacity and other topics [4, 15, 20].

Zahra and George [18] suggest that absorptive capacity should be considered as 'potential' absorptive capacity (acquisition, assimilation) and 'realized' absorptive capacity (transformation, exploitation). Furthermore, from the re-conceptualization viewpoint, Minbaeva et al. [17] examine the firm's capacity to utilize and exploit previously acquired knowledge. They identify employees' ability and motivation as the key aspects of the firm's absorptive capacity. The empirical study by Minbaeva et al. [17] shows that specific human resources management activities have a positive effect on the development of absorptive capacity. The exploratory study on the development of absorptive capacity, by Lenox and King [19], finds that managers can directly affect a firm's absorptive capacity by providing information to potential adopters in the organization.

In addition, Santangelo [21] investigates the role of corporate technological specialization factors in the inclusion of strategic technological partnerships in the European ICT industry by carrying out a dynamic analysis considering absorptive capacity. Eriksson and Chetty [22] develop and empirically test a model of how depth and diversity of experience affect absorptive capacity, and how absorptive capacity affects the way trust foreign market knowledge may be perceived as an obstacle in carrying out ongoing business activity. Chen [23] examines the effects of knowledge attributes, alliance characteristics, and a firm's absorptive capacity on the performance of knowledge transfer. His findings suggest that knowledge transfer performance is positively affected by the explicitness of knowledge and the firm's absorptive capacity. Moreover, equity-based alliances transfer tacit knowledge more effectively, whereas contract-base alliances are more effective in the transfer of explicit knowledge. Harrington and Guimaraes [24] examine the role of absorptive capacity in IT implementation success. Their research provides support for the proposed dimensions of absorptive capacity and its role as an antecedent of corporate culture that acts to influence the implementation of new technologies. Rothaermel and Thursby [25] find that incubator firms' absorptive capacity is an important factor when transforming university knowledge into firm-level competitive advantage. Giuliani and Bell [26] examine the influence of individual firms' absorptive capacities on both the functioning of the intra-cluster knowledge system and its interconnection with extra-cluster knowledge. They apply social network analysis to identify different cognitive roles played by cluster firms and the overall structure of the knowledge system of wine industries in Chile. The results show that knowledge is not diffused evenly 'in the air', but flows within a core group of firms characterized by advanced absorptive capacities. Their research findings explore the relationship between meso and micro within the cluster. Instead of an emphasis on ways in which the meso-level characteristics of

clusters influence micro behavior, Giuliani and Bell point out the importance of the opposite direction of influence. It was the capacities of individual firms to absorb, diffuse and creatively exploit knowledge that shaped the learning dynamics of the cluster as a whole. Thus, we can consider that both intra-cluster and extra-cluster knowledge might have a two-way direction of influence on absorptive capacity within the different social networks.

Moreover, Zahra and George [18] criticized the inappropriate use of figures such as R&D expenditures or the number of R&D technical personnel in the department to measure a firm's absorptive capacity, since this data neglects the roles of the department's members. Since employees are the actual users of knowledge, the utilization of the organization's knowledge is important to employees. As proposed by Zahra and George [18], firms can acquire and assimilate knowledge but might not have the capacity to transform and exploit the knowledge to generate profits. Most studies prior to Zahra and George emphasized the 'capability' part of absorptive capacity, overstressing the abilities that employees should have and neglecting to examine whether employees have the motivation to be committed to their jobs. Commitment is the key to whether the company can succeed.

In sum, this study uses Minbaeva et al. [17] definitions as the basis for the measurement of absorptive capacity. They propose that absorptive capacity has two elements: prior knowledge (employees' ability) and intensity of effort (employees' motivation). The prior knowledge base refers to existing individual units of knowledge available within the organization. Thus, the definition of employees' ability is their educational background, and acquired job-related skills may represent the prior related knowledge, which the organization needs to assimilate and use. In this study, the first construct of absorptive capacity is the employees' ability, which captures their potential and ability. On the other hand, in addition to the prior related knowledge, there should be a certain level of organizational aspiration, which is characterized by the organization's innovation efforts [4]. As proposed by Kim [27], intensity of effort refers to the amount of energy expended by organizational members to solve problems.

Employees' intensity of effort is well studied in cognitive process theories such as the expectancy-valence theory of work motivation [28]. Motivated employees want to contribute to organizational effectiveness. Even though the organization may consist of individuals with high learning abilities, its ability to utilize the absorbed knowledge will be low if employees' motivation is low or absent [29]. Thus, the definition of employees' motivation is the ability/can do factor, usually denoting a potential for performing some task influenced by the individual's drive. The prior knowledge base (employees' ability) and intensity of effort made by the organization (employees' motivation) are related to the concept of potential and realized absorptive capacity, since potential absorptive capacity is expected to have a high content of employees' ability while realized absorptive capacity is expected to have a high content of employees' motivation. Therefore, the second construct of absorptive capacity is the employees' motivation.

2.3. Innovation capability

Innovation is often described in terms of changes in what a firm offers the world (product/service innovation) and the ways it creates and delivers those offerings (process innovation) [30]. While there are many ways a firm can achieve a competitive advantage, two of the most important in dynamic markets are innovation and strategic flexibility [31]. Innovation is a critical activity for companies and firms that do not innovate risk being eliminated from the market. Reviewing the classifications of innovative capability in previous studies, this study categorizes it into:

(1) the technical aspects of innovation; and

(2) the management aspects of innovation.

In the technical aspects of innovation, Marquis [32] indicates that innovation can be divided into:

(1) radical innovation;

(2) incremental innovation; and

(3) systems innovation.

Betz [33] adds another type of innovation called next-generation technology innovation. Furthermore, Samson [34] classifies innovation into three categories:

(1) product innovation;

(2) process innovation; and

(3) managerial and systems innovation.

Zander [35] proposes a taxonomy of innovation networks in the multinational corporation, differentiating between international duplication and international diversification of advanced technological capabilities. Galende and Fuente [36] investigate the determining factors in the organization of a firm's innovative activities, confirming the existence of relations between internal factors and the innovative process. Yam et al. [37] introduce a framework for innovation auditing and examine the relevance of seven technological innovation capabilities (TICs), discussing their impact on a firm's competitive performance. Their findings verify that R&D and resource allocation capabilities are the two most important TICs. A strong R&D capability sustains innovation rate and product competitiveness in large and medium-sized firms, whereas a resource allocation capability enhances sales growth in small firms.

Based on Samson's concept of innovation categories, Tasi et al. define a firm's innovation capability as including product innovation, process innovation, and managerial innovation [38]. The first definition, product innovation, is that a firm can provide differentiated or new products/services in the market and obtain satisfaction from customers. In this definition, product improvement and new product development which can satisfy customers is the basis of product innovation. This product innovation may include three categories: radical innovation, incremental innovation and system innovation in the new product development process. On the other hand, process innovation is a process in which a firm can provide a better manufacture or service process than current operation in order to achieve better performance. Tasi et al. [38] describe how a method of generating modification or a new process in a current operational step or procedure can offer a capability for innovative process. By doing so, a new process may reduce operational costs or generate more production for a firm. In the same vein, process innovation belongs to the area of technical innovation. Management innovation is a capability that improves a firm's performance by implementing new managerial regulations, systems, and methods etc. Therefore, knowing how to increase a firm's managerial functions and mechanisms in terms of improving managerial efficiency becomes an innovative capability. In this regard, management innovation is the management aspect of innovation.

To investigate whether knowledge sharing and absorptive capacity can improve innovation capability and shape competitive advantage, this study proposes that the technical aspects and the management aspects are complementary. Hence, we implement measurement tools from Tasi et al. [38] and divide innovation into product, procedure and management innovations. Then we combine this with suggestions made by actual businesses to develop a multi-dimensional presentation of an enterprise's innovative capability. The conceptual structure is shown in Figure 1.

3. Research framework and hypotheses

This research examines an enterprise's innovation capability and the factors that affect its improvement. The research hypotheses test the relationships among knowledge sharing, absorptive capacity, and innovation capability.

3.1. Knowledge sharing and innovation capability

Quinn et al. [6] propose that knowledge and intellect grow exponentially when shared. If two people exchange knowledge with each other, both gain information and experience linear growth. However, if both then share their new knowledge with others and receive feedback questions, amplifications, and modifications, the benefits become exponential. Once a company gains a knowledge-based competitive

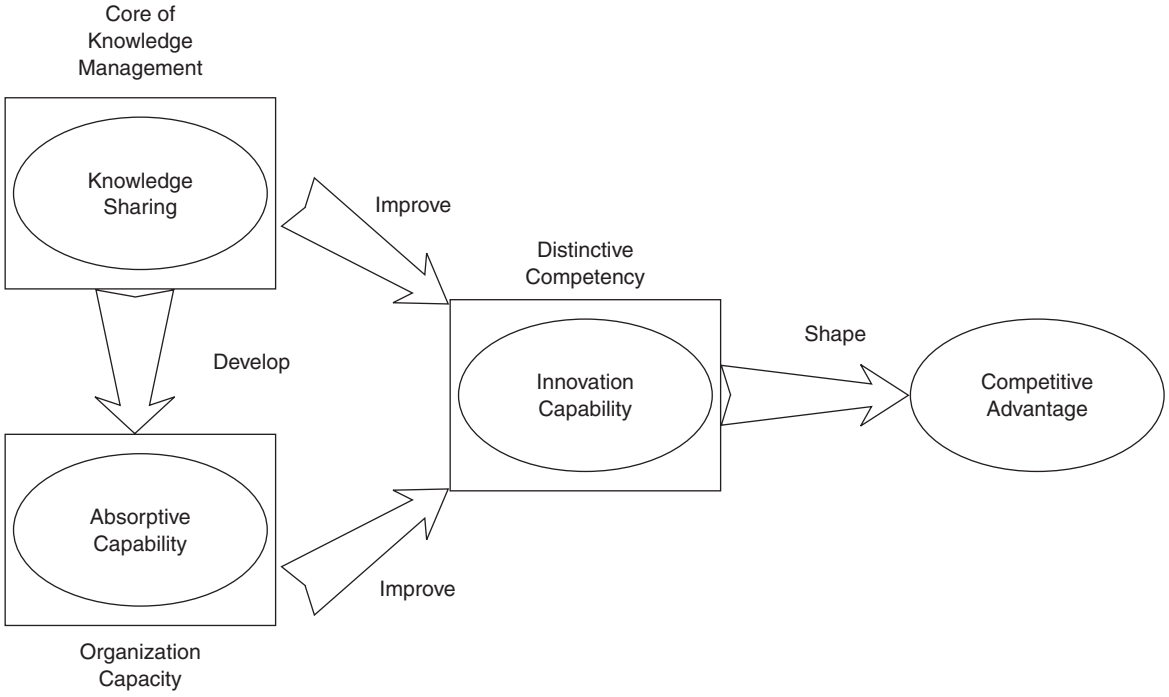

Fig. 1. Conceptual framework.

edge, it becomes easier to maintain the lead. In an empirical study on knowledge sharing behavior and the outsourcing of an organization's information system, Lee [39] showed that knowledge sharing is a major indicator of whether or not the outsourcing activity succeeds. This study confirms that knowledge sharing is one of the major predictors for outsourcing success, that organizational capability to learn or acquire the needed knowledge from other organizations is a key source of successful knowledge sharing, and that partnership quality is a significant intervening factor between knowledge sharing and IS outsourcing success. Accordingly, a positive impact of knowledge sharing, organizational capability, and partnership quality on IS outsourcing success could develop an organization's competitive advantage. Hong et al. [40] discovered in their empirical study that knowledge sharing and new product development have a significant positive relationship.

In addition, Van den Hooff and Van Weenen [11] propose that future research should focus on investigating whether knowledge sharing has effects on organizational performance that are more directly related to the knowledge process and organizational competence. In summary, through knowledge sharing an organization can develop competitive advantage. This type of competitive advantage may consist of technologies or management abilities that motivate the organization to improve on its innovations. Therefore, the following is hypothesized:

Hypothesis 1: knowledge sharing has a positive influence on innovation capability.

3.2. Absorptive capacity and innovation capability

Cohen and Levinthal [4] propose that the utilization of external knowledge gathered by the organization is a major determinant of innovation capability. Zahra and George [18] review previous studies related to absorptive capacity, finding a significant positive relationship between absorptive capacity and innovation since these factors work together to establish the organization's competitive advantage. The empirical study by Knudsen and Roman [5] also suggests that absorptive capacity is an important factor in predicting an organization's innovation capability. On the other hand, Caloghirou et al. [41] investigate the extent to which the existing internal capabilities of firms and

their interaction with external sources of knowledge affect their level of innovativeness. Their research findings show that some capabilities result from a prolonged process of investment and knowledge accumulation within firms and form what has been addressed as the absorptive capacity of firms. Also, the results show that both internal capabilities and openness towards knowledge sharing are important for upgrading innovative performance. In addition, Nieto and Quevedo [42] analyze the influence of three variables related with industrial structure (absorptive capacity, technological opportunity, and knowledge spillovers) on the innovative efforts developed by firms. These relationships are investigated in a total of 406 Spanish manufacturing companies with an established degree of innovative capabilities. Their research findings show that the absorptive capacity variable determines innovative effort to a greater extent than the two structure variables. It is also shown that absorptive capacity has a moderating effect on the relationship between technological opportunity and innovative effort. Further, Minbaeva et al. [17] suggest that absorptive capacity is needed to facilitate the transfer of knowledge from ability and motivation to investigate its influence on organizational performance.

Based on this prior research, our study posits that the extent of the employees' ability and motivation to work hard determines the firm's performance in developing both technical and managerial innovation capabilities. Therefore, the following is hypothesized:

Hypothesis 2: absorptive capacity has a positive influence on innovation capability.

3.3. Knowledge sharing and absorptive capacity

Employees' overall subjective perceptions of an organization are based on factors such as degree of risk tolerance, team emphasis, and personal support. This overall perception becomes, in effect, the organization's culture or personality. It is favorable or unfavorable perceptions that affect employee performance and satisfaction [43]. Thus, if the company's employees establish a knowledge sharing culture or characteristics that differ from other firms, then those employees are likely to be affected. Through the process of interacting with others employees can acquire new knowledge that increases their learning abilities. At the same time, employees understand the firm's support for knowledge sharing and may be inspired by the learning atmosphere with their colleagues. Consequently, when employees understand the firm's position on knowledge sharing and experience learning between colleagues, they may be more motivated to participate in learning. Therefore, the following is hypothesized:

Hypothesis 3: knowledge sharing has a positive influence on absorptive capability.

The research framework is shown in Figure 2.

4. Research methodology

4.1. Measurement

A five-point Likert scale (1 = totally disagree, 5 = totally agree) was used to measure the constructs. In this research framework, knowledge sharing is an independent variable that is described as the employees' interaction with their own knowledge, and with that of other employees in the company. This study employs the concepts of Van den Hooff and Van Weenen [11], who use knowledge donating and knowledge collecting to measure the degree of knowledge sharing between employees in a firm. Knowledge donating is the motivation of employees to pass on their own intellectual capital to others. Knowledge collecting refers to employees asking for advice from each other in order to obtain intellectual capital. Since the current research objective and aim differ from the original studies, some of the questions from the original measurements were modified to more effectively measure knowledge sharing. Each knowledge sharing construct has five questions (items 1–5 for knowledge donating; items 6–10 for knowledge collecting) as shown in the Appendix.

On the other hand, many previous studies have measured absorptive capacity in organizations [4, 17]. This study employs the constructs by Minbaeva et al. [17] that use both employees' ability and

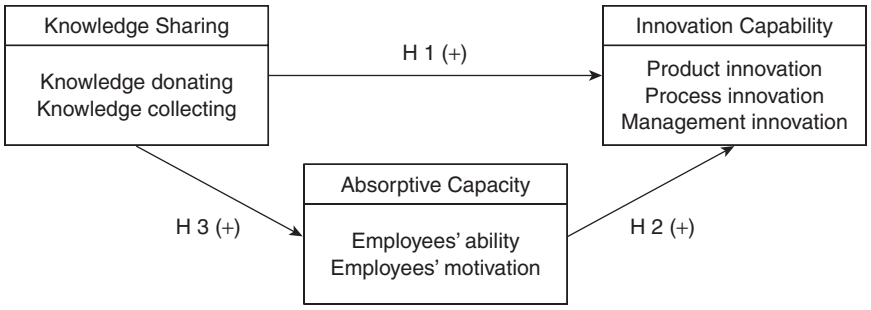

Fig. 2. Research framework.

motivation to measure the firm's absorptive capacity. In the section on employees' ability, the questions (items 11–15) are designed according to the employee's own professional knowledge, the comparison of the employee's level of technical standard and levels of skill and education, and the employee's ability to utilize knowledge. It is not a measure of an individual ability, but a measure of the overall ability of the firm's employees. In the section on the employees' motivation (items 16–22), this research uses the influence of the firm's encouragement, and the effort level of the employee (employees' drive). In the same vein, this is a measure of the overall motivation of a firm's employees and not individual motivation.

In our framework, innovation capability is the dependent variable defined as the performance of the enterprise going through various types of innovation and achieving an overall improvement of its innovation capability. There are few empirical studies on innovation capability, and most concentrate on discussing technical types of innovation. Thus, this study employs three constructs by Tasi et al. [38] combining product, process, and management innovation aspects. There are 18 items relating to these constructs, six of which refer to product innovation (items 23–28), five of which refer to process innovation (items 29–33), and seven of which refer to management innovation (items 34–40).

4.2. Sample design

According to the OECD's definition, there are two types of knowledge-intensive industries: the first type is high-tech industrial companies in the manufacturing sector, which include the electronic, aerospace, and biotechnology industries. The second type is knowledge-intensive services, which include education, communications, and information service industries. Since the medical profession has a high level of knowledge it is also regarded as a service industry. According to data from the Ministry of Economic Affairs, the percentage of value added to the GDP created by Taiwan's domestic knowledge-intensive services increased from 37.7 percent in 1991 to 43 percent in 2001. Clearly, Taiwan's domestic industry structure is rapidly shifting towards a more knowledge-intensive approach. This paper uses the cross-industry data collection method to verify the relationship structure among knowledge sharing, knowledge absorptive capability, and innovation capability. Prior cross-industry researchers have generally categorized industries into the manufacturing, financial, and services sectors. However, opinions differ as to which types of businesses should be included in each of the industry sectors.

The industries can be categorized according to the OECD classifications, and a convenient sampling method is used to select 17 sample companies from the electronic, banking, and medical industries of Taiwan. The data collection proceeded in three stages. The first stage was to select randomly two employees from each company in one of the three industries to pre-test the questionnaire. The second stage was a pilot test, administered in September 2004, which randomly selected one company from each of the three industries, and sent a total of 150 questionnaires to the firm's employees. A total of 74 valid responses were received with six incomplete questionnaires. Tests indicated sufficient reliability and validity. The third stage was to distribute the questionnaires during November 2004. A total of 565 questionnaires were sent out and 397 were returned. Excluding 42 invalid questionnaires, a total of 355 valid responses were received for an effective response rate of 62%. (See Table 1.)

Table 1
Sample group statistics

Sample	Firm	Sampling no.	Response no.	Invalid no.	Valid no.	Response rate
	Electronics Industry					
1	Advanced Semiconductor Engineering Inc.	70	40	2	38	54%
2	Chi Mei Optoelectronics	40	35	8	27	67%
3	Macronix Corporation	30	30	0	30	100%
4	Appro Optoelectronics	20	20	0	20	100%
5	New Age Optoelectronics	20	20	5	15	75%
6	Hun-Whu Technology Corporation	20	19	0	19	95%
7	Nanya Technology Corporation	25	16	1	15	60%
	Medical Industry					
8	Pingtung Christian Hospital	50	25	2	23	46%
9	Taiwan University Hospital	30	25	0	25	83%
10	Taipei Jen-Ai Hospital	30	26	3	23	76%
11	Kaoshiung Chang Gung Memorial Hospital	50	34	9	25	50%
	Banking Industry					
12	Chang Hwa Bank	30	20	2	18	60%
13	Citibank, Taipei Branch	30	22	3	19	63%
14	ING Antai, Taipei Branch	30	17	2	15	50%
15	Makodo Bank	30	15	2	13	43%
16	Taitung Business Bank	30	16	2	14	46%
17	Land Bank	30	17	1	16	53%
Total		**565**	**397**	**42**	**355**	**62%**

4.3. Reliability and validity

After the questionnaires were returned, confirmatory factor analysis was performed to investigate reliability and validity. The results are shown in Table 2.

In the reliability analysis, the Cronbach's α are all greater than 0.7 and the composite reliability (CR) values are all larger than 0.6, meeting the benchmark of Bagozzi and Yi [44] that CR values should be greater than 0.6. The goodness-of-fit index (GFI) values are between 0.92–0.95 and 0.85~0.90. Although the root mean square error of approximation (RMSEA) results are somewhat greater than 0.05, the questionnaire measurements still show consistency. In the validity analysis, the *t*-values of all the questions are between 11.59 and 21.02 indicating excellent convergent validity. Whether or not the items will be combined depends on the $\Delta\chi^2$. The results show that a multidimensional model is better than a single-aspect model. Since the $\Delta\chi^2$ is greater than 3.84, this is good evidence for the scale's convergent and discriminant validities.

5. Data analysis and results

Table 3 displays the means, standard deviation and correlation coefficients of the research variables. The results from Table 2 indicate that the correlations between factors are all significant.

The aim of this research is to confirm the relationship among knowledge sharing, absorptive capacity, and innovation capability. A structural equation model is used to estimate the direct and indirect effects. According to the confirmatory factor analysis results, the path of the LISREL second-stage model is as shown in Figure 3. A data set may have many feasible fit models, just as more than one theory may explain a phenomenon that occurs in society. However, it is not always certain which explanation is the best. Thus, we use model competition to choose the best among comparative models. Two competitive models, the completely mediating model (model B) and the direct

Table 2
Reliability and validity of the questionnaires

Variate	Factor	Cronbach's α	GFI	RMSEA	CR	*t*-Value	Multiple factors χ^2	Multiple factors d.f.	Unifactor χ^2	Unifactor d.f.	$\Delta\chi^2$
Knowledge sharing	Knowledge donating	0.87	0.96	0.08	0.66	13.73–18.88	292	34	436	35	144*
	Knowledge collecting	0.88			0.62	13.21–18.72					
Absorptive capability	Employees' ability	0.89	0.95	0.05	0.74	15.27–18.42	253	53	650	54	397*
	Employees' motivation	0.91			0.87	11.59–19.02					
Innovation capability	Product innovation	0.93	0.92	0.06	0.87	16.89–19.90	458	132	(1) + (2) 712	133	254*
	Process innovation	0.90			0.78	16.34–19.63			(1) + (3) 1079	133	621*
	Management innovation	0.92			0.87	14.35–21.02			(2) + (3) 823	133	365*

*$\Delta\chi$2 significant, multiple factors are better than reduced factors model.
(1) Product innovation; (2) process innovation; (3) management innovation.

Table 3
Means, standard deviations and correlations

Factor	Mean	s.d.	1	2	3	4	5	6	7
1. Knowledge donating	3.92	0.56	1.00						
2. Knowledge collecting	3.98	0.49	0.74*	1.00					
3. Employees' learning ability	3.62	0.63	0.39*	0.33*	1.00				
4. Employees' learning motivation	3.48	0.71	0.32*	0.28*	0.62*	1.00			
5. Product innovation	3.39	0.75	0.36*	0.27*	0.59*	0.52*	1.00		
6. Process innovation	3.58	0.68	0.34*	0.29*	0.53*	0.49*	0.74*	1.00	
7. Management innovation	3.31	0.73	0.33*	0.28*	0.58*	0.60*	0.66*	0.70*	1.00

n = 355. *Significant at $p < 0.05$.

effect model (model C), are compared with the hypothetical model (model A), which is the partially mediating model. The results are shown in Table 4.

For the completely mediating model (model B) and hypothetical model (model A), all the fitted indices of GFI, NFI (normed fit index), CFI (comparative fit index), and RMSEA are consistent, and the $\Delta\chi^2$ is insignificant. According to the parsimonious principle, it can be concluded that the completely mediating model (model B) is the best choice. The estimated path coefficients of the completely mediating model are shown in Figure 4.

From the measurement model's perspective, Bagozzi [44] suggests that the standardized coefficient λ should be between 0.5 and 0.955. The results from Table 4 show that the standardized coefficients of the measurement model are between 0.74 and 0.93 and meet the requirements. For knowledge sharing, the coefficient of knowledge donating is much larger than that of knowledge collecting (0.93 vs 0.79), indicating that knowledge sharing behavior occurs mainly through the donation of knowledge by those who possess it. In the formation of absorptive capacity, employees' ability is slightly higher than employees' motivation, indicating that employees are inclined to use the technical aspects rather than the motivation aspect in their evaluations of absorptive capacity. The three

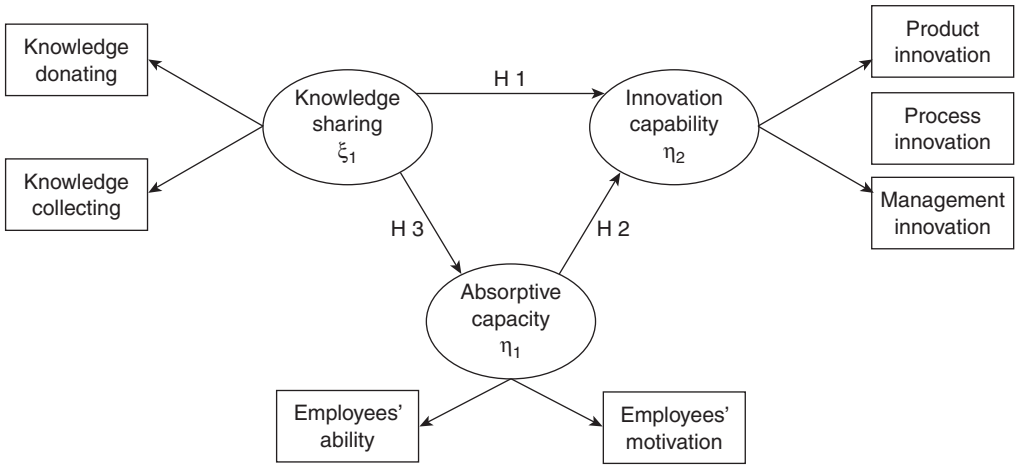

Fig. 3. Second-order structure.

Table 4
Model competition results

Model	χ^2	d.f.	$\Delta\chi^2$	Δd.f.	GFI	NFI	CFI	RMSEA
Model A[a]	33.07	11	—	—	0.97	0.97	0.98	0.04
Model B[b]	32.06	12	1.01	1	0.97	0.97	0.98	0.04
Model C[c]	95.08	12	62.01	1	0.93	0.92	0.93	0.10

[a]Partially mediating model. [b]Completely mediating model. [c]Direct model.

aspects of innovation capability have similar effects on forming innovation capability. These results suggest that businesses recognize that, apart from product innovations, more effort should be put into changes in the procedures and services, especially as product life cycles are becoming shorter. However, the effect of management innovations is not as obvious as other types of innovations. Since the management innovation scope encountered is very broad, any new managerial change requires proper planning and consideration of the consequences. Thus, instances of management innovation are not as frequent as those of product innovations and procedure innovations. After testing the measurement model, we proceeded to examine the hypothetical relationships. The results in Table 5 show that the model fit is good: the ratio of χ^2 to degrees of freedom is 2.67, GFI = 0.97, CFI = 0.98; and all estimates of the hypothesized path results are significant. The path coefficient from the absorptive capacity to innovation capability is 0.85 ($p < 0.01$). This supports Hypothesis 2, that absorptive capacity significantly affects innovation capability. The path coefficient from knowledge sharing to absorptive capacity is 0.49 ($p < 0.01$), supporting Hypothesis 3, that knowledge sharing significantly influences absorptive capacity. These results suggest that the influence of knowledge sharing on innovation capability is achieved through absorptive capacity and the research model with the best fit is the completely mediating structure. Thus, Hypothesis 1 is rejected.

6. Model generalization and extension

Most research uses cross-industries as the objective and examines the relationships among variables discussing only the path coefficient difference between industries. However, in addition to this we also consider whether the overall best-fit model is suitable for use in other industries and whether the path coefficients of each industry are the same. Diamantopoulos and Siguaw [45] suggest using model generalization and extension concepts. Model generalization employs different competitive

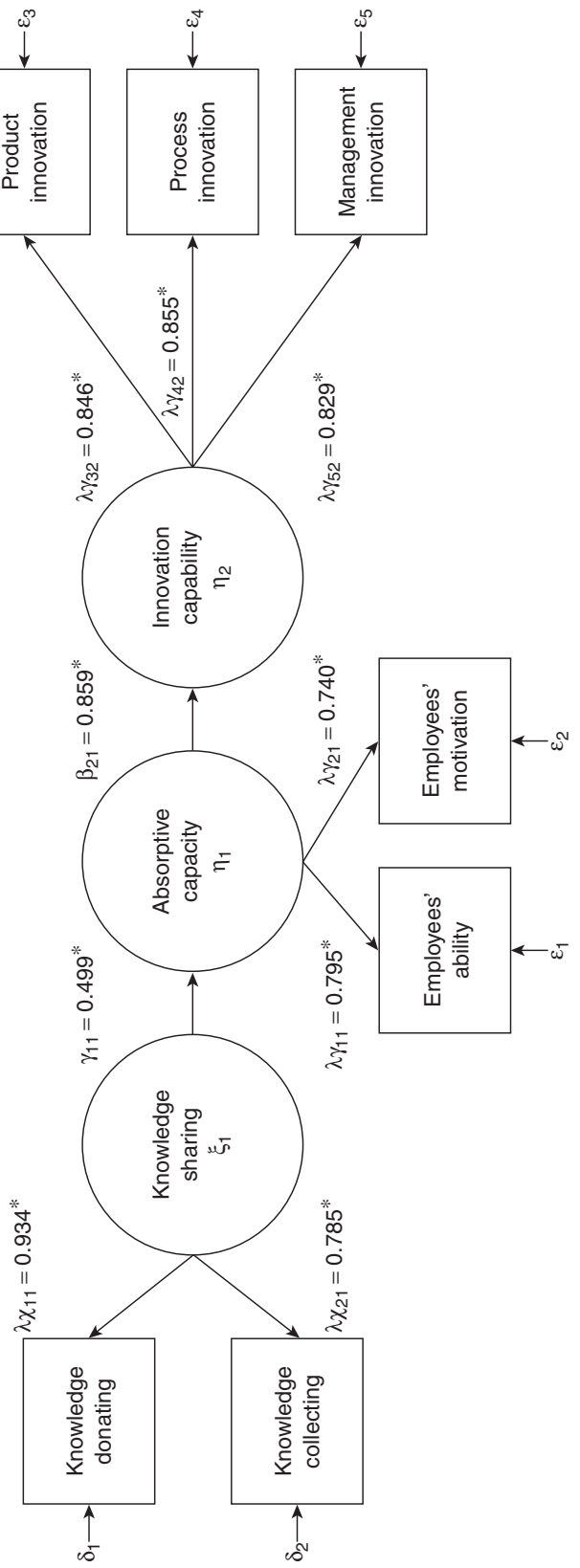

Fig. 4. Result of completely mediating model.

Table 5
Measurement model and structure model

	Variate	Factor	Standardized structure coefficient	Parameter	*t*-Value
Measurement model	Knowledge sharing	Knowledge donating	λx_{11}	0.93*	15.95
		Knowledge collecting	λx_{21}	0.78*	13.70
	Absorptive capacity	Employees' ability	λy_{11}	0.79*	16.68
		Employees' motivation	λy_{21}	0.74*	15.20
	Innovation capability	Product innovation	λy_{32}	0.84*	18.85
		Process innovation	λy_{42}	0.85*	19.06
		Management innovation	λy_{52}	0.82*	18.04
Structure model	Parameter and relationship			Parameter estimate	
	Knowledge sharing → Absorptive capability (β_{21})			0.499*	
	Absorptive capability → Innovation capability (γ_{11})			0.859*	

*Significant at $p < 0.05$.
Goodness of fit: $\chi^2 = 32.06$, d.f. = 12, GFI = 0.97, CFI = 0.98, RMSEA = 0.04.

models on each sample set and compares the results with a particular best model. Model extension develops a good best-fit model from one sample and tests another population set to determine whether the model still exhibits good fit. If so, then the model can be extended into the second population. Model generalization and extension tests results are shown in Table 6.

The completely mediating model (model B) is the best choice for each of the three industries, indicating good model generalization characteristics. In model extension Table 6 shows that for all of the industries the completely mediating model exhibits a good fit. This indicates that the completely mediating model may be developed and extended to different industries. These results are consistent with previous research in that the completely mediating model is used for both model generalization and extension.

7. Discussion and implications

This study develops a framework for examining knowledge sharing, absorptive capacity, and innovation capability using research participants from financial, medical and electronic firms' employees in Taiwan.

First, we focus on the absorptive capacity concepts of researchers such as Cohen and Levinthal [4], Zahra and George [18], and Minbaeva et al. [17]. Our study suggests that absorptive capacity has a significant positive effect on innovation capability, indicating that absorptive capacity plays an important

Table 6
Model generalization and extension results

Industry	MODEL	χ^2	d.f.	$\Delta\chi^2$	Δd.f.	GFI	NFI	CFI	RMSEA
Financial	Model A	34.13	11	–	–	0.90	0.91	0.94	0.0908
	Model B	35.57	12	1.44	1	0.90	0.91	0.94	0.0930
	Model C	42.22	12	8.09	1	0.89	0.89	0.92	0.0985
Medical	Model A	39.31	11	–	–	0.90	0.90	0.92	0.1023
	Model B	39.32	12	0.01	1	0.90	0.90	0.92	0.0938
	Model C	58.19	12	18.88	1	0.87	0.85	0.87	0.1294
Electronics	Model A	28.72	11	–	–	0.95	0.95	0.97	0.0470
	Model B	30.84	12	2.12	1	0.95	0.95	0.96	0.0468
	Model C	66.06	12	37.34	1	0.90	0.89	0.92	0.1182

The comparison basis is the partially mediating model.
A: partially mediating model; B: completely mediating model; C: direct effect model.

role in the development of a firm's innovation capability. Thus, a higher absorptive capacity may increase a firm's innovation capability. The empirical results are consistent with Cohen and Levinthal [4] that absorptive capacity is beneficial in the implementation of innovation. The role of absorptive capacity in the empirical study by Knudsen and Roman [5] suggests that absorptive capacity is also important for the forecasting of an organization's innovation capability, and according to Nieto and Quevedo [42], absorptive capacity determines the performance of a business's striving for innovation.

The research results also reveal that knowledge sharing has a significant positive effect on absorptive capacity. This finding is consistent with the expected hypotheses of the research. This is an important finding since it varies from prior studies that regard absorptive capacity as an exogenous variable. Our study finds that knowledge sharing can both develop and increase a firm's absorptive capacity. Absorptive capacity can benefit an organization by integrating external knowledge and then transforming it into the firm's competence. This ability is part of a learning oriented organization culture and is the basis of the firm creating sustainable competitive advantages.

The research results show that absorptive capacity is the mediating variable of knowledge sharing and innovation capability, acting as a bridge between the two. This means that if absorptive capacity is inadequate, then the knowledge sharing in a firm will have less direct benefit for a firm's innovation capability. This result contradicts the expected hypothesis that knowledge sharing has a direct positive effect on innovation capability. Logically speaking, frequent knowledge sharing behavior between employees should be directly beneficial to a firm's innovation capability. However, it may be that the knowledge shared between employees needs to be reprocessed. That is to say, the knowledge exchanged between employees might be only a concept or thought, and not a real concrete matter. Thus, unspecified knowledge may not have direct benefits in each of the innovative aspects in the firm. However, if the knowledge shared by these employees can be integrated or transformed through absorptive capacity, it may have a significant effect on firm innovation. Van den Hooff and Van Weenen [11] confirm that when the individual's and group's knowledge is transformed into the organization's knowledge, then the organization can start to manage its resources efficiently. This research infers that knowledge shared between employees must be absorbed and then transformed by employees with the relevant knowledge capabilities in order to benefit the firm and influence a firm's innovation capability.

Through the development of the second-order structural equation model, we discover that employees' knowledge sharing is largely due to employees eagerly donating knowledge to other colleagues rather than by employees eagerly collecting knowledge from others. Moreover, employees believe that apart from their own abilities, a firm's level of absorptive capacity depends on the employee's motivation to work hard willingly. This result is consistent with the criticisms by Zahra and George [18] that prior studies on absorptive capacity disregard the roles played by the employees. Innovation capability research suggests that all employees believe that a firm's innovation capability should simultaneously exhibit product, procedure and management innovations, which sufficiently reflects the thoughts of both the academic and the business world. The completely mediating model indicates that, even though the three industries exhibit great diversity, absorptive capacity is a key factor in improving a firm's innovation capability strategy. Businesses should recognize that knowledge sharing improves their innovation capability and they should not neglect its importance.

On the other hand, with regard to common method variance, the authors employed Harman's one-factor test to check for the presence of common method variance that threatens validity, as suggested by Podsakoff and Organ [46]. We entered all the manifest variables in the study into a factor analysis, and then examined the results of the unrotated factor analysis. The basic assumption of this procedure is that if a substantial amount of common method variance in the data exists, either a single factor will emerge or one factor will account for the majority of the covariance among the manifest variables. Harman's one-factor test for common method variance in this study yielded six factors with eigenvalues greater than one, and the explained variance is 68.1%. There is 39.2% variance accounted for by the first factor. Also, a worse fit for the one-factor model would suggest that common method variance does not pose a serious threat to this study. The one-factor model yields a $\Delta\chi^2 = 5465.3$ with d.f. = 740 compared with the $\Delta\chi^2 = 1820.7$ and d.f. = 719 for the seven-factor measurement model. Thus, the fit is considerably worse ($p < 0.001$) for the uni-dimensional model than for the measurement model of this

study. The results of both tests indicate that the common method variance does not pose a serious threat to the data analysis. However, possible common method variance problems should be avoided at the beginning of research design for future research [47].

Finally, as in any empirical study, this study has limitations. We use a convenience sampling method to select respondents for this research, thus the results may not reflect the real situation. Also, since Taiwan's financial, medical and electronic industries are the research subjects, the results may not apply to other regions or industries due to differences in culture, internal industry environment and other characteristics. In addition, some other factors in relation to knowledge sharing, absorptive capacity and innovation capability are not considered in this study. This means that other variables, factors, and constructs omitted by this study could be developed in new research frameworks in future work.

8. Conclusions

This research demonstrates the importance of knowledge sharing and its relationship with absorptive capacity and innovation capability. Future research should investigate how to successfully achieve employee knowledge sharing in the firm. If knowledge sharing is the input, then absorptive capacity may be the output of successful knowledge sharing activities. Further studies should examine what factors affect knowledge sharing, and then verify the antecedent variables to develop a more complete research framework. For instance, some scholars propose that the success of knowledge sharing in an organization is not only due to technological means, but is also related to behavioral factors [48]. Liao et al. [49] found that when the relationship between employees and the firm is good, then those employees are more apt to share working knowledge and experience with colleagues voluntarily and unconditionally. In addition, Bock et al. [50] propose a theoretical framework based on the theory of reasoned action, and examine it using extrinsic motivators, social–psychological forces and organizational climate factors that appear to influence individuals' knowledge sharing intentions. In addition, Chou [51] develops a framework that delineates the interrelationships among 'absorptive capacity', 'the roles of individuals as well as organizations,' 'the IT capabilities of knowledge storage/retrieval,' and 'knowledge creation.' Thus, there are many avenues for future studies to incorporate different variables into the research framework.

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Appendix: the questionnaire questions

The choice of response to each of questions 1–40 was:
Totally agree; Agree; Neutral; Disagree; Totally Disagree.

I. Knowledge sharing

1. I often share with my colleagues the new working skills that I learn.
2. My colleagues often share with me the new working skills that they learn.
3. I often share with my colleagues the new information I acquire.
4. My colleagues often share with me the new information they acquire.
5. Sharing knowledge with my colleagues is regarded as something normal in my company.

6. My colleagues often share with me the working skills they know when I ask them.
7. I often share with my colleagues the working skills I know when they ask me.
8. My colleagues often share with me the information they know when I ask them.
9. I often share with my colleagues the information I know when they ask me.
10. Our company staff often exchanges knowledge of working skills and information.

II. Knowledge absorptive capacity

11. Our company staff is equipped with excellent professional knowledge.
12. Our company staff can acquire quickly and thoroughly new knowledge required by the work.
13. Our company staff has better working skills than the staff of our competitors.
14. Our company staff has higher educational qualifications than the staff of our competitors.
15. Our company staff has the ability to use and organize the acquired knowledge.

16. Our company staff strives to acquire working skills and job licenses in order to obtain pay rise, promotions and job offers.

17. The knowledge acquisition behavior of our company staff has positive impact on the working efficiency.
18. Our company determines pay rise, promotions and job offers according to the working skills and license possessed by the staff.
19. Our company assigns further learning or training opportunities according to the working skills and license possessed by the staff.
20. The rewards offered by our company can effectively encourage the staff to acquire working skills and job licenses.
21. Our company staff obtains fair rewards for their progress in learning compared with the staff of our competitors.
22. The reward system of our company for encouraging staff to acquire working skills and job licenses is better than that of our competitors.

III. Innovation capability

23. Our company often develops new products and services well accepted by the market.
24. A great majority of our company's profits are generated by the new products and services developed.
25. The new products or services developed by our company always arouse imitation from competitors.
26. Our company can often launch new products or services faster than our competitors.
27. Our company has better capability in R&D of new products or services than our competitors.
28. Our company always develops novel skills for transforming old products into new ones for market.

29. Our company often tries different operation procedures to hasten the realization of the company's goals.
30. Our company always acquires new skills or equipment to improve the manufacturing operation or service process.
31. Our company can develop more efficient manufacturing process or operation procedure.
32. Our company can flexibly provide products and services according to the demands of the customers.
33. The new manufacturing process or operation procedure employed by our company always arouses imitation from competitors.

34. Our company will change the division of work among different departments according to the needs of market management.
35. Our company's department heads will adopt new leadership approaches to lead all staff towards task completion.
36. The new staff welfare system adopted by our company can effectively provide incentives to our staff.
37. The new financial management system adopted by our company can effectively monitor the actual discrepancy between our performance and our goals.
38. Our company emphasizes innovative and creative capability when recruiting staff.
39. The new staff recruitment system adopted by our company is efficient and effective.
40. The new performance assessment method adopted by our company can enable department heads to gain a better picture of how far the staff has achieved the company goal.

Company and Personal information

A: Company information

41. Your company is engaged in
    □ Manufacturing □ Service industry □ Finance
    □ Others (Please specify) _____
42. Number of years since its establishment: _____
43. Number of employees: _____

B: Personal information

44. Sex: □ Male □ Female
45. Marital status: □ Married □ Single
46. Education level: _____
47. In your company, you are engaged in department related to:
    □ Management □ Professional □ Administration
    □ Operations □ Other (Please specify) _____
48. Age: _____
49. Number of years working in your company: _____