



Information technology as a facilitator for enhancing dynamic capabilities through knowledge management

Peter J. Sher^{a,b,*}, Vivid C. Lee^{a,b}

^aNational Chung Hsing University, Taichung, Taiwan, PR China

^bPRINCO Corp., Hsin-Chu, Taiwan, PR China

Received 12 March 2002; received in revised form 1 January 2003; accepted 13 June 2003

Available online 27 November 2003

Abstract

Research on dynamic capabilities is an emerging field: it studies the activities of firms during turbulent administrative environments. Current management interests are also focused on knowledge management as a major determinant of business excellence and competitive advantage. Our motivation for this paper was to answer the research question: Does knowledge management (KM) contribute to the enhancement of dynamic capabilities and thus to the enhancement of business excellence and competitive advantage? Our effort examined the use of KM in enhancing dynamic capabilities. Based on results from a survey of major Taiwanese firms, we tested a set of hypotheses with regression models. Empirical findings suggest that management of both endogenous and exogenous knowledge through IT applications significantly enhances dynamic capabilities.

© 2003 Elsevier B.V. All rights reserved.

Keywords: Knowledge management; Dynamic capabilities; Information technology

1. Introduction

Today, the competitiveness of the firm relies less on traditional factors (capital, land, and labor) than was true in the past. Knowledge now appears to be replacing these traditional factors. Moreover, knowledge will become not just a source of competitive advantage** but the *only* source of it [13]. By 1996, there were at least six major conferences on knowledge management (KM) as well as three new journals focusing on it, and many major firms in the US and Europe had added positions with names such as: *chief knowledge officer*, *organizational learning officer*, and (in a few cases)

even *vice-presidents of intellectual capital* [44]. Within KM, maturity and the use of information technology (IT) development facilitates new methods and applications (such as groupware, on-line databases, intranets, etc.); it allows firms to deliver products and services better in quality and thus to achieve competitive advantage and profit [26,27,31,45].

Strategic management now requires a major stream of business administration dealing with the question of managing an organization in a dynamic and discontinuous environment. This has given rise to the dynamic capabilities school of strategic management [48,49]. This extends the resource-based view in stochastic environments. *Dynamic capabilities* refer to an organization's ways of responding in a rapidly changing environment. When the knowledge assets of a firm are exploited, the firm sees enhanced dynamic

* Corresponding author. Tel.: +886-4-2285-1811;
fax: +886-4-2285-1672.
E-mail address: sher@dragon.nchu.edu.tw (P.J. Sher).

capabilities and increased business value [25]. Likewise, good management of the integrative learning mechanisms of endogenous knowledge promotes dynamic capabilities and thus builds competitive advantage [17,33].

Recent studies in strategic management have increased attention to both theoretical and empirical convergences of KM with a dynamic capabilities perspective. IT is a fundamental dimension of this [32]. The role of software in supporting inter-functional cooperation and the coordination of knowledge and activities depends on the organization's ability to nurture integrating mechanisms which support two-directional translation flows between local (function-based) and global (computer-embedded) knowledge and activity levels [9]. These mechanisms also lie at the heart of the creation and maintenance of dynamic capabilities. Our research deals with the co-evolution of KM and dynamic capabilities for building competitive advantage and treats IT as an indispensable element in the current practices of KM. To what degree are a firm's dynamic capabilities enhanced by KM, as controlled by types of IT applications?—this is our guiding question.

2. Literature review and hypotheses

2.1. *Dynamic capabilities and sustained competitive advantage*

Sustained investment in creating dynamic capabilities is one of the three sources of successful competition in the 21st century [52]. Although dynamic capabilities may not be sufficient to guarantee performance enhancement, they are necessary for enhanced performance. They are of strategic importance for firms operating in a fast-changing environment where it is necessary for them to respond and adapt in a timely manner to change and environmental uncertainties. The strategic application of this principle must emphasize both “dynamic” and “capabilities” [46,47]. “Dynamic” refers to the concurrency of organizational renewal with environmental change. Firms need to be flexible and innovative when the timing of market entry and technological change demand highly responsive decisions and when future competition and market structures are difficult to

forecast. “Capabilities” needed in a volatile world include: adoption, integration, and reconfiguration of endogenous and exogenous organizational skills, resources, and functions to meet change.

In order to appreciate the role of dynamic capabilities, it is important to see how firm-specific dynamic capabilities relate to organizational or managerial processes, market positions and paths available to a firm. Organizational capabilities are embedded in processes, while the substance and opportunities of processes are affected by previous positions and paths. Although dynamic capabilities are idiosyncratic in their details and path dependent in their emergence, dynamic capabilities do have significant commonalities (“best practice”) across firms. Such knowledge is typically enclosed within business process management functions [23]. Business functions or process repositories contain knowledge for sales purposes involving products, markets, and customers, lessons learned in projects or product development efforts, knowledge around implementation of information systems, competitive intelligence for strategy and planning functions, and “learning histories,” or records of experience with a new corporate direction or approach. By and large, current capabilities and routines are conditioned by previous routines, resources, and capabilities. Therefore, cultivation of dynamic capabilities demands a path-dependent assumption [36], a double-loop learning practice [1], and routines to learn routines. These factors lay a solid foundation for incorporating KM into the strategic perspective of dynamic capabilities.

Empirical findings shed light on our understanding of dynamic capabilities in a variety of business dimensions. Firms that are flexible, for example, out-compete rivals, so strategic flexibility can be seen as a proxy of dynamic capabilities [7]. Empirical research on Japanese automobile supplier systems also suggests that dynamic capabilities enhance competition among a small number of suppliers and thus are a primary source of competitive advantage [18]. However, swift strategic realignment to market demand is often more difficult to achieve than it might appear to be. Deploying processes of business resources, a type of dynamic capability, as a source of competition requires intensive learning and adapting of processes of strategic planning and implementation [4,5,21]. Dynamic capabilities also enable firms to make timely decisions for developing

new products or new processes that respond to market change. Finally, power structures in international business relationships are affected by asset specificity, predictability, and market knowledge gaps [22].

In summary, dynamic capabilities should be laid at the core of strategic management processes, wherein dynamic capabilities are a set of specific and identifiable processes, such as product development, strategic decision-making, and alliances. Well-managed processes of breeding, accumulating and enhancing dynamic capabilities have been shown to improve KM for the delivery of business excellence and competitive advantage [50].

2.2. Management of endogenous knowledge and enhancement of dynamic capabilities

Bearing in mind the importance of dynamic capabilities in a turbulent environment, KM seeks ways to build competitive advantage in three dimensions: reduced operating costs, shortened lead-time, and product differentiation. First, KM reduces the operating costs of a firm and creates added value to customers by significantly increasing product quality [40]. Second, firms shorten time-to-market by analyzing current situations and allowing previous knowledge to be grafted into the problem-solving for current situations [14,42]. Finally, KM can be regarded as central to product and process innovation and improvement, executive decision-making, and organizational adaptation and renewal [16]. Effective and efficient knowledge flows within firms are critical to establishing and maintaining dynamic capabilities.

KM systems must enable knowledge to flow efficiently in order to enhance productivity, quality, innovation, and business excellence. In order to promote extensive and intensive knowledge flows in KM, IT application research is concerned primarily with three issues: comprehensiveness of IT construction within a firm, knowledge construction and maintenance, and facilitation of knowledge creation, search, and diffusion.

First, comprehensiveness of IT construction provides various objectives and leads to employment of various tools to meet the diversity of objectives [2,34,41]. A case study of successful KM has shown that popular tools include employee competence databases, on-line search systems, expert networks, case-based experience databases. [11]. Effective IT

infrastructures encompass communication infrastructures, groupware, e-mail, document management, data warehousing, workflow software, decision support systems, etc. [19]. IT is required for document management of project-relevant information, storage and search, as well as for procedures of project information renewal. Groupware contributes to knowledge sharing and management to improve organizational effectiveness [43].

Second, knowledge construction and maintenance requires that IT achieve at least two objectives: reduction of uncertainties of knowledge loss derived from variation in employee positions and reduction of dependence on specific personnel [8]. A considerable amount of knowledge may never be effectively exploited because of a lack of purposefully applied mechanisms. No matter how effective and efficient is the knowledge creation process of a firm, KM is useless for competitive ends unless communication and application systems are well developed to permeate every aspect of business operations.

Finally, knowledge creation, searching, and diffusion is improved by IT, which increases transmission and response speeds. In addition, IT facilitates storage and sharing of organizational knowledge [10,12,15,24,37,38]. Furthermore, since high IT utilization leads to a reduction of IT application costs, it tends to be a source of competitive advantage [6]. KM functions include the creation of new knowledge, storage of current knowledge, its diffusion, and its utilization.

Thus, with an effective IT infrastructure, KM can maximize the return on organizational knowledge through continuously creating, accumulating, and sharing it.

The first function of KM, knowledge creation, has traditionally been treated as a black box. However, more recently a knowledge spiral framework has been proposed as having more descriptive value in explaining the process of socialization, articulation, combination, and internalization. In this framework, knowledge creation incorporates organizational and managerial routines. It is closely related to innovation. For example, KM is regarded as central to: product and process innovation and improvement, the execution of decision-making, and organizational adaptation and renewal. In an environment of rapid change, KM can significantly reduce the response time for

experimenting with and implementing new techniques, especially as it can be aided by IT [28]. Thus, knowledge creation (or innovation) can enhance dynamic capabilities, rendering firms more flexible and responsive in an unpredictable environment.

The second function of KM, accumulating large amounts of knowledge, often results in increased dependence on the infrastructure. There are three patterns of knowledge flow:

- (1) collecting new knowledge; this intensifies its vertical flow;
- (2) codifying knowledge requiring both horizontal and vertical flows; and
- (3) combining new and old knowledge, mainly affecting horizontal flows.

In addition, uncertainties about the relevance of new knowledge are resolved via vertical flows, a process which rapidly exposes new knowledge to a wider range of remote and diverse knowledge and thereby facilitates faster, more comprehensive discovery of its relevance. It is impossible to manage the requirements for these knowledge flows unless IT infrastructure is supportive.

The third function of KM, knowledge sharing, allows for diffusion of endogenous skills, experience, and knowledge throughout the organization. Knowledge sharing provides employees encountering similar decisions short-cuts to solutions and thus enhances learning, enabling employees to respond to environmental change at an increased pace with less cost. Firms thus benefit from improved dynamic capabilities and competitiveness. Based on these findings, our first hypothesis, H1, is as follows.

H1a. Management of endogenous knowledge enhances dynamic capabilities.

H1b. The enhancement effect of the management of endogenous knowledge on dynamic capabilities is controlled by various IT applications.

2.3. Management of exogenous knowledge and enhancement of dynamic capabilities

Whether a firm adopts a “systematic KM strategy” or a “personal KM strategy,” IT is essential in acquiring

and accumulating core knowledge. Therefore, KM emphasizes the importance of integrating organizational core knowledge, both tacit and explicit, with adequate IT infrastructure. Besides accounting for management of endogenous knowledge, KM ought to take into consideration exogenous dimensions while constructing IT applications [51]. Incorporating exogenous knowledge into the KM system is a critical factor. KM must incorporate endogenous management functions with exogenous supply chain functions to attain systemic knowledge advantage. An empirical study of KM identified the following IT attributes [3]:

- congruence with corporate strategy;
- facilitation of processing marketing knowledge;
- facilitation of processing supply chain knowledge;
- facilitation of acquiring marketing knowledge; and
- facilitation of acquiring supply chain knowledge.

The research indicates three important issues of KM. First, IT is an indispensable enabler of KM. Second, KM plays a critical role in strategic management; such that all of its relevant activities must be congruent with corporate strategy. Finally, exogenous knowledge must be internalized and integrated within a firm’s knowledge base.

Dynamic capabilities can be enhanced through effective management of exogenous knowledge, including that of customers, suppliers, and competitors. First, in connection with customers, as market orientation acknowledges, surveillance of markets is highly relevant to competitive advantage. Competitive dynamics and market structures are determined by KM systems for market intelligence. Responsiveness to market change determines the firm’s effectiveness and effective incorporation of market knowledge reduces marketing surprises and thus leads to enhanced dynamic capability. Second, supply chain management has become a powerful competitive weapon and it serves as a threshold for cost and lead-time reduction. Furthermore, firms are increasingly involved in collaborative innovation with their suppliers in order to enrich innovative diversity. Knowledge acquired from suppliers facilitates adoption of new technologies and responsiveness to both evolutionary and revolutionary engineering change. Finally, competitors serve as sources of knowledge as more horizontally collaborative arrangements allow firms to tap into the routines of their competitors.

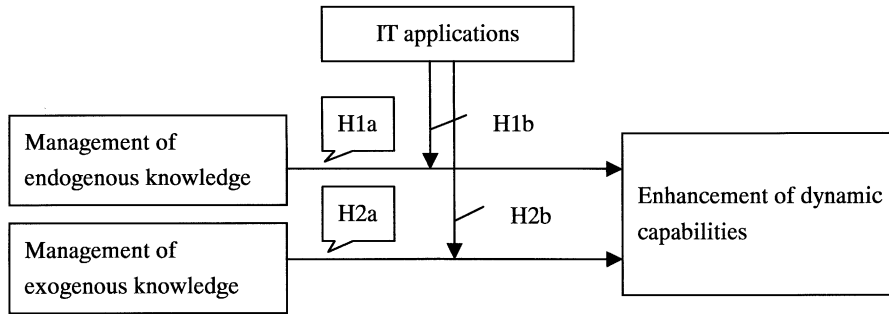


Fig. 1. Research framework.

Well-managed competitive knowledge is thus crucial to benchmarking and first-mover advantage. Based on this, our second hypothesis is as follows.

H2a. Management of exogenous knowledge enhances dynamic capabilities.

H2b. The enhancement effect of management of exogenous knowledge on dynamic capabilities is controlled by various types of IT applications.

3. Methodology

Our conceptual framework is illustrated in Fig. 1. The enhancement of dynamic capabilities is treated as the dependent variable, and KM is treated as the independent variable, while types of information technology application are tested as controlling variables. H1a and H2a predict a direct effect of knowledge management on dynamic capabilities, while H1b and H2b suggest the moderating effect of IT applications of KM on dynamic capabilities.

A survey questionnaire was the instrument used to collect data. Its elements are given in the tables. Measurements of the management of endogenous knowledge are listed in Table 1, measurements of exogenous knowledge in Table 2, and measurements of dynamic capabilities in Table 3. Relevant precedent research for each measure is also cited. The questionnaire was designed with the independent and dependent variables in mind. All measurements of the questionnaire are designed according to relevant literature and verified by a panel discussion of a group of five experts. All questions are expressed in plain Chinese and are easily understandable by informants. Therefore, both requirements of content and construct validities are fulfilled in this research design.

A survey of major Taiwanese firms was then conducted. Data was collected through a structured mailing. The sample was drawn from companies listed in the *Top 1000 Firms in Taiwan*, published by Commonwealth Ltd. in the year 2000. Of the firms sampled, 700 belonged to the manufacturing sector of the economy, 300 to the service sector, and 100 to the financial sector. One hundred and forty-two of the 1100 firms responded, representing a response rate of

Table 1
Measurements of management of endogenous knowledge

Measurement	Sources of previous research
IT reduces uncertainties of knowledge loss	[8,37]
IT reduces dependence on specific personnel	[8,37]
IT is comprehensively utilized by members in organization	[10,12,14,15,24,34,38]
IT is comprehensively constructed in organization	[10,19,31,41,43]
Top management is capable of applying IT	[10,42]
Members in organization apply IT to search and use current organizational knowledge	[10,12,14,15,24,34,38]
Members in organization apply IT to create new knowledge	[10,12,14,15,24,34,38]

Table 2
Measurements of management of exogenous knowledge

Measurements	Sources of previous research
IT facilitates acquisition of supply chain knowledge	[3,42]
IT facilitates acquisition of marketing knowledge	[3,42]
IT facilitates processing of supply chain knowledge	[3,42]
IT facilitates processing of marketing knowledge	[3,42]
IT infrastructure is congruent with corporate strategy	[10,51]

12.7%. Forty-eight of the respondents were from the finance or service sectors, and the other 94 firms were from the manufacturing sector.

A seven-point Likert scale was used to measure research variables. Cronbach's α for the 12 measurements of KM was 0.94, and the α for the 10 dynamic capabilities measurements was 0.96, demonstrating a high reliability for the measurements, taking a reliability value of 0.7 as the minimal standard [39]. The descriptive statistics on IT infrastructures are presented in Table 4.

A factor analysis using varimax rotation with principal components was applied to reduce the 12 measurements of management of endogenous and exogenous knowledge. Two factors of KM were extracted: management of endogenous knowledge (KMin) and management of exogenous knowledge (KMex) (see Table 5).

The first factor, KMin, encompasses: IT reduces uncertainties of knowledge loss, IT reduces dependence on specific personnel, IT is comprehensively

Table 3
Measurements of dynamic capability

Measurements	Sources of previous research
Enhanced learning effectiveness of new knowledge	[30,49]
Enhanced decision quality	[17,47]
Enhanced capabilities of communication and coordination	[7,49]
Enhanced responsiveness	[47,49]
Enhanced integration in new product development	[17,47,49]
Enhanced accumulation of knowledge	[49]
Enhanced capabilities of resource deployment	[7,30,49]
Enhanced customer relationships	[7,49]
Enhanced trust with vendors	[49]
Enhanced unimitability of strategic asset	[49]

Table 4
Descriptive statistics of IT applications

Typology of IT applications	Not constructed	Constructed
(1) Employee competence database	103 (72.5)	39 (27.5)
(2) Groupware for discussion	110 (77.5)	32 (22.5)
(3) Expert network	126 (88.7)	16 (11.3)
(4) Case-based experience database	100 (70.4)	42 (29.6)
(5) E-mail	49 (34.5)	93 (65.5)
(6) Documentation management	60 (42.3)	82 (57.7)
(7) On-line knowledge searching	77 (54.2)	65 (45.8)
(8) Data warehousing	87 (61.3)	55 (38.7)
(9) On-line learning	101 (71.1)	41 (28.9)
(10) Workflow	97 (68.3)	45 (31.7)
(11) Decision support system	97 (68.3)	45 (31.7)
(12) Enterprise portal site	65 (45.8)	77 (54.2)
(13) Teleconferencing	109 (76.8)	33 (23.2)
(14) Exogenous professional database	122 (85.9)	20 (14.1)
(15) Enterprise resource planning	85 (59.9)	57 (40.1)
(16) Supply chain management	115 (81)	27 (19)
(17) Customer relationship management	104 (73.2)	38 (26.8)

Note: Percentages are presented in parentheses along with corresponding observations.

utilized by members in organization, IT is comprehensively constructed in organization, top management is capable of applying IT, members in organization apply IT to search and use current organizational knowledge, and members in an organization apply IT to create new knowledge. The second factor, KMex, encompasses: IT facilitates acquisition of supply chain knowledge, IT facilitates acquisition of marketing knowledge, IT facilitates processing of supply chain knowledge, IT facilitates processing of marketing knowledge, and IT infrastructure is congruent with corporate strategy.

A factor analysis using varimax rotation with principal components was also applied to extract a factor of dynamic capabilities. Its 10 measurements were reduced to one factor (dynamic capabilities) accounting for nearly 70% of cumulative variance (see Table 6). The 10-component measurements included: enhanced learning effectiveness of new knowledge, enhanced quality of decisions, enhanced capabilities of communication and coordination, enhanced responsiveness, enhanced integration in new product development, enhanced accumulation of knowledge, enhanced capabilities of resource deployment, enhanced customer relationships, enhanced trust with vendors, and enhanced unimitability of strategic assets.

Table 5
Factor analysis of the application of IT in knowledge management

Measurements of knowledge management	Factor	
	Management of endogenous knowledge (KMin)	Management of exogenous knowledge (KMex)
IT reduces uncertainties of knowledge loss	0.808	0.808
IT reduces dependence on specific personnel	0.800	0.345
IT is comprehensively utilized by members in organization	0.795	0.292
IT is comprehensively constructed in organization	0.768	0.337
Top management is capable of applying IT	0.688	0.444
Members in organization apply IT to search and use current organizational knowledge	0.652	0.530
Members in organization apply IT to create new knowledge	0.623	0.465
IT facilitates acquisition of supply chain knowledge	0.313	0.850
IT facilitates acquisition of marketing knowledge	0.375	0.789
IT facilitates processing of supply chain knowledge	0.319	0.781
IT facilitates processing of marketing knowledge	0.205	0.755
IT infrastructure is congruent with corporate strategy	0.414	0.587
Eigenvalue	7.20	1.07
Variance	36.3%	32.6%
Cumulative variance	68.9%	36.3%

Linear regression was then applied to test the research hypotheses. Dynamic capabilities were analyzed with both management of endogenous knowledge (KMin) and management of exogenous knowledge (KMex), controlled by typology of IT applications (app) (see Table 7). We determined whether the following 17 types of IT application were in place or not: employee competence databases (Model 1), groupware for discussion (Model 2), expert networks (Model 3), case-based experience databases

(Model 4), e-mail (Model 5), document management (Model 6), on-line knowledge search (Model 7), data warehousing (Model 8), on-line learning (Model 9), workflow (Model 10), decision support systems (Model 11), enterprise portal sites (Model 12), teleconferencing (Model 13), exogenous professional databases (Model 14), enterprise resource planning (Model 15), supply chain management (Model 16), and customer relationship management (Model 17).

Table 6
Factor analysis of dynamic capabilities

Measurements of dynamic capabilities	Factor
Enhanced learning effectiveness of new knowledge	0.884
Enhanced quality of decisions	0.870
Enhanced capabilities of communication and coordination	0.863
Enhanced responsiveness	0.855
Enhanced integration in new product development	0.846
Enhanced accumulation of knowledge	0.827
Enhanced capabilities of resource deployment	0.827
Enhanced customer relationships	0.813
Enhanced trust with vendors	0.808
Enhanced unimitability of strategic assets	0.739
Eigenvalue	7.0
Cumulative variance	69.6%

4. Research findings

All of the regression models suggest that there is a significant influence of management of both endogenous knowledge and exogenous on dynamic capabilities enhancement (see the KMin and KMex). Thus, both hypotheses H1a and H2a were strongly supported by our empirical results. These findings are consistent with conventional wisdom on the importance of KM for business excellence and strategic advantage (e.g. [29]). Empirical results also lend support to the dynamic capabilities perspective, which suggests that paths and processes of knowledge accumulation through KM determine a firm's current position. Continuously tracking positions of a firm provides observations of its developing path as well as the

Table 7
Linear regression models

Model	Constant	Kmin	KMex	KMin* applications	KMex* applications	F	R ²
1	-0.333	0.44 (5.44 ^{***})	0.40 (5.29 ^{***})	0.04 (0.51)	0.06 (0.82)	23.25 ^{***}	0.404
2	-0.308	0.44 (5.95 ^{***})	0.42 (0.58 ^{***})	0.04 (0.58)	0.06 (0.84)	23.25 ^{***}	0.404
3	-0.247	0.45 (6.35 ^{***})	0.40 (5.77 ^{***})	0.01 (.18)	0.08 (1.07)	23.46 ^{***}	0.407
4	0.127	0.50 (6.43 ^{***})	0.42 (5.08 ^{***})	0.02 (0.24)	-0.07 (-0.84)	23.20 ^{***}	0.404
5	0.307	0.63 (5.70 ^{***})	0.55 (4.93 ^{***})	-0.21 (1.88 [*])	-0.14 (-1.28)	25.01 ^{***}	0.422
6	0.412	0.59 (5.95 ^{***})	0.41 (4.08 ^{***})	0.02 (0.19)	-0.17 (-1.70 [*])	24.11 ^{***}	0.413
7	0.477	0.60 (7.24 ^{***})	0.46 (5.47 ^{***})	-0.22 (2.66 ^{***})	-0.02 (-0.19)	25.85 ^{***}	0.430
8	-0.637	0.36 (4.19 ^{***})	0.37 (4.46 ^{***})	0.08 (0.99)	0.15 (1.73 [*])	24.63 ^{***}	0.418
9	-0.039	0.46 (5.69 ^{***})	0.43 (5.76 ^{***})	0.01 (0.16)	0.00 (0.01)	22.89 ^{***}	0.401
10	-0.087	0.49 (6.14 ^{***})	0.37 (4.48 ^{***})	0.09 (1.01)	-0.03 (-0.37)	23.47 ^{***}	0.407
11	-0.041	0.44 (5.38 ^{***})	0.46 (5.86 ^{***})	0.05 (0.57)	-0.05 (-0.57)	23.15 ^{***}	0.403
12	-0.117	0.44 (4.34 ^{***})	0.38 (3.88 ^{***})	0.07 (0.76)	0.03 (0.31)	23.16 ^{***}	0.403
13	-0.178	0.44 (6.07 ^{***})	0.42 (5.93 ^{***})	0.05 (0.72)	0.03 (0.41)	23.16 ^{***}	0.403
14	0.048	0.47 (6.84 ^{***})	0.42 (5.95 ^{***})	0.05 (0.68)	-0.05 (-0.66)	23.19 ^{***}	0.404
15	-0.237	0.35 (4.50 ^{***})	0.33 (3.80 ^{***})	0.19 (2.44 ^{**})	0.15 (1.78 [*])	26.76 ^{***}	0.439
16	0.064	0.47 (6.56 ^{***})	0.44 (6.05 ^{***})	-0.02 (-0.22)	-0.02 (-0.22)	22.92 ^{***}	0.401
17	-0.242	0.50 (6.07 ^{***})	0.42 (5.04 ^{***})	0.03 (0.30)	0.08 (0.92)	23.27 ^{***}	0.405

Note: *t*-values with significance levels are presented in parentheses along with knowledge management coefficients.

* $P < 0.1$.

** $P < 0.05$.

*** $P < 0.01$.

processes embodied as its position changes. Our findings are in accord with the evolutionary perspective [35], which argues that the path-dependent nature of KM is probably the central issue in tracking a firm's knowledge assets. By neutralizing volatility of personal knowledge through transmitting, preserving, and embedding personal knowledge within organizational knowledge, KM significantly reduces strategic astonishment and prepares firms with better KM to have better response to environmental turbulence. Furthermore, routines to learn routines, as dynamic capabilities, are manifested by KM in accumulating profound organizational reasoning and practices. This involves the notion of double loop learning.

Several control variables (IT applications) were seen significantly to affect the explanatory power of the independent variables (KMin and KMEx) on the dependent variable (dynamic capabilities). Among these IT applications, the most noteworthy was enterprise resource planning (ERP). It was found to amplify the explanatory power of the management of endogenous and exogenous knowledge on the enhancement of dynamic capabilities. Investment in ERP represents the attempt to integrate entire business resources, including backward linkage to suppliers and forward

linkage to customers, thus integrating supply chain management and customer relationship management. Therefore, ERP was seen to play a critical linking role in corporate KM investment and to strongly affect management of both endogenous and exogenous knowledge.

Besides ERP, four other IT applications were found to influence KM's impact on dynamic capabilities. First, e-mail reduced the explanatory power of management of endogenous knowledge on dynamic capabilities. E-mail is the most popular tool and the basis of most groupware; however, our findings indicated that KM did not find e-mail really effective. Thus, managers should be aware of possible discrepancies between expectations and reality when using e-mail systems.

Second, document management was found to reduce the value of managing exogenous knowledge on the enhancement of dynamic capabilities. Document sharing and synchronization with external entities generally involves a tremendous effort in communication and coordination, and the inherent costs of maintaining accuracy and timeliness are high. Document management across firms sometimes leads to interlocking effects and responsiveness

deterioration, two syndromes which undermine dynamic capabilities.

Third, on-line knowledge search was found to reduce the explanatory power of managing endogenous knowledge on the enhancement of dynamic capabilities. Powerful on-line search capabilities often encourage an overemphasis on knowledge availability that potentially reduces the critical abilities of employees making decisions, leading to absurd responses to changing conditions at specific decision points. Thus, the on-line search dimension of IT application may impede organizational renewal and potentially cause inertia.

Finally, data warehousing was found to amplify the explanatory power of managing exogenous knowledge on the enhancement of dynamic capabilities. Implementation of KM depends largely on powerful databases. Our findings suggest that more attention should be paid to the storage and retrieval of knowledge accessed from exogenous clients. Safety, accessibility and communication competences of entire systems are critical in managing exogenous knowledge. Summarizing these statistical results, we find that H1b and H2b are partially supported by IT applications.

5. Conclusion

The findings of this study show that management of both endogenous and exogenous knowledge significantly affect dynamic capabilities. Inasmuch as they represent a critical dimension of strategic management in a business world demanding higher levels of responsiveness, KM was shown to be a major source of quality improvement and business excellence. Such findings are consistent with other research on the contribution of KM to business excellence and strategic advantage. The implications are:

- firms ought to give particular attention to KM in order to enhance dynamic capabilities to the end of out-competing rivals in a turbulent environment; and
- development of Internet and database technology will facilitate more advanced IT applications in business administration and thus help to ensure excellence and competitiveness.

As a result, new frontiers of the business world will be expanded, and new business models will be launched to serve customers better. As trends of globalization, shorter life cycles, and stronger IT functions continue to occur, firms will operate in an arena of increasingly fierce competition. Our research supports literature which treats dynamic capabilities as an indispensable ingredient of strategic management in global competition [30]. Among other factors (e.g., organizational and behavioral dimensions of KM [20]), IT dimensions of KM have been shown to be important for enhancing dynamic capabilities. The influence of KM was also found to be controlled by specific IT applications.

Our findings are commensurate with precedent literature in terms of the managerial implications suggested by the function of KM in cultivating and developing dynamic capabilities to meet challenges of ever- and fast-changing business environments.

The limitations should also be noted. The findings should not be generalized; the low response rate (13%) and the selective sampling methodology (the top 1000 Taiwanese firms) act against this. Relative differences characterizing IT application levels also were not delineated. Furthermore, our research design focused primarily on KM infrastructures in terms of IT applications. Despite this narrower scope, the research design in no way denies nor undermines the potential significance of other organizational factors of KM.

Appendix A. Questionnaire

A.1. Introduction

This questionnaire is for a study on the influence of information technology and knowledge management on the enhancement of dynamic capabilities. Dynamic capability refers to the organizational capabilities of responding to environmental changes. The researchers are seeking to understand how the application of information technology and knowledge management enhances the responsiveness of a firm to external volatility. Data will be treated as confidential and used for academic purposes only. Thank you for your assistance!

Best wishes,
Peter J. Sher and Vivid C. Lee
Email: sher@nchu.edu.tw

Section 1. Profile of the firm

Name: _____

Revenue in the year of 2000: _____

Number of employees: _____

Section 2. Please indicate whether the following IT applications are installed in your firm:

Typology of IT Applications	Yes
(1) Employee competence database	
(2) Groupware for discussion	
(3) Expert network	
(4) Case-based experience database	
(5) E-mail	
(6) Documentation management	
(7) On-line knowledge searching	
(8) Data warehousing	
(9) On-line learning	
(10) Workflow	
(11) Decision support system	
(12) Enterprise portal site	
(13) Teleconferencing	
(14) Exogenous professional database	
(15) Enterprise resource planning	
(16) Supply chain management	
(17) Customer relationship management	

Section 3. Please indicate the degree to which you agree with the following statements on management of endogenous knowledge:

Management of Endogenous knowledge	E.D.						E.A.
IT reduces uncertainties of knowledge loss	1	2	3	4	5	6	7
IT reduces dependence on specific personnel	1	2	3	4	5	6	7
IT is comprehensively utilized by members in organization	1	2	3	4	5	6	7
IT is comprehensively constructed in organization	1	2	3	4	5	6	7
Top management is capable of applying IT	1	2	3	4	5	6	7
Members in organization apply IT to search and use current organizational knowledge	1	2	3	4	5	6	7
Members in organization apply IT to create new knowledge	1	2	3	4	5	6	7

E.D. stands for extremely disagree

E.A. stands for extremely agree

Section 4. Please indicate the degree to which you agree with the following statements on the management of exogenous knowledge:

Management of Exogenous Knowledge	E.D.						E.A.
IT facilitates acquisition of supply chain knowledge	1	2	3	4	5	6	7
IT facilitates acquisition of marketing knowledge	1	2	3	4	5	6	7
IT facilitates processing of supply chain knowledge	1	2	3	4	5	6	7
IT facilitates processing of marketing knowledge	1	2	3	4	5	6	7
IT infrastructure is congruent with corporate strategy	1	2	3	4	5	6	7

Section 5. Please indicate the degree to which you think enhancement of dynamic capabilities has been achieved through knowledge management

Enhancement of Dynamic Capabilities	Not Much						Very Much
Enhanced learning effectiveness of new knowledge	1	2	3	4	5	6	7
Enhanced decision quality	1	2	3	4	5	6	7
Enhanced capabilities of communication and coordination	1	2	3	4	5	6	7
Enhanced responsiveness	1	2	3	4	5	6	7
Enhanced integration in new product development	1	2	3	4	5	6	7
Enhanced accumulation of knowledge	1	2	3	4	5	6	7
Enhanced capabilities of resource deployment	1	2	3	4	5	6	7
Enhanced customer relationship	1	2	3	4	5	6	7
Enhanced trust with vendors	1	2	3	4	5	6	7
Enhanced unimitability of strategic asset	1	2	3	4	5	6	7

References

- [1] C. Argyris, Double loop learning in organizations, *Harvard Business Review* (September–October) (1977) 115–125.
- [2] H.J. Bajoria, Knowledge creation and management: inseparable twins, *Total Quality Management* 11 (4–6), 2000, pp. S562–S573.
- [3] R. Bennett, H. Gabriel, Organizational factors and knowledge management within large marketing departments: an empirical study, *Journal of Knowledge Management* 3 (3), 1999, pp. 212–225.
- [4] J. Bessant, D. Francis, S. Meredith, R. Kaplinsky, Developing manufacturing agility in SMEs, *International Journal of Manufacturing Technology and Management* 2 (1–7), 2000, pp. 730–756.
- [5] J. Bessant, D. Francis, S. Meredith, R. Kaplinsky, S. Brown, Developing manufacturing agility in SMEs, *International Journal of Technology Management* 22 (1–3), 2001, pp. 28–54.
- [6] A.S. Bharadwaj, A resource-based perspective on information technology capability and firm performance: an empirical investigation, *MIS Quarterly* 24 (1), 2000, pp. 169–196.
- [7] P.E. Bierly, A.K. Chakrabarti, Technological learning, strategic flexibility, and new product development in the pharmaceutical industry, *IEEE Transactions on Engineering Management* 43, 1996, pp. 368–380.
- [8] E.A. Bonora, O. Revang, A strategic framework for analyzing professional service firm—developing strategies for sustained performance, *Strategic Management Society Inter-organizational Conference*, Toronto, Canada, 1991.
- [9] L. D’Adderio, Crafting the virtual prototype: how firms integrate knowledge and capabilities across organizational boundaries, *Research Policy* 30 (9), 2001, pp. 1409–1424.
- [10] T.H. Davenport, D.W. De long, M.C. Beers, Successful knowledge management projects, *Sloan Management Review* (Winter) (1998) 43–57.
- [11] T.H. Davenport, L. Prusak, *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, 1998.

- [12] M. Demarest, Understanding knowledge management, *Long Range Planning* 30, 1997, pp. 374–384.
- [13] P.F. Drucker, *The Post-Capital Society*, Harper Collins, New York, 1993.
- [14] J. Duffy, Knowledge management: what every information professional should know, *Information Management Journal* 34 (1), 2000, pp. 10–16.
- [15] J. Duffy, The knowledge management technology infrastructure, *Information Management Journal* 34 (2), 2000, pp. 62–64.
- [16] M. Earl, Knowledge management strategies: toward a taxonomy, *Journal of Management Information Systems* 18 (1), 2001, pp. 215–233.
- [17] K.M. Eisenhardt, J.A. Martin, Dynamic capabilities: what are they? *Strategic Management Journal* 21 (10–11), 2000, pp. 1105–1121.
- [18] T. Fujimoto, The Japanese automobile supplier system: the triplet of effective inter-firm routines, *International Journal of Automobile Technology and Management* 1 (1), 2001, pp. 1–34.
- [19] W.H. Gates, *Business @ the Speed of Thought: Succeeding in the Digital Economy*, Warner Books Inc.
- [20] C. Gore, E. Gore, Knowledge management: the way forward, *Total Quality Management* 10 (4–5), 1999, pp. S554–S560.
- [21] R.M. Grant, Towards a knowledge based theory of the firm, *Strategic Management Journal* 17, 1996, pp. 109–122.
- [22] D.A. Griffith, M.G. Harvey, A resource perspective of global dynamic capabilities, *Journal of International Business Studies* 32 (3), 2001, pp. 597–606.
- [23] V. Grover, T.H. Davenport, General perspectives on knowledge management: fostering a research agenda, *Journal of Management Information Systems* 18 (1), 2001, pp. 5–21.
- [24] M.T. Hasen, N. Nohria, T. Tierney, What's Your Strategy for Managing Knowledge, *Harvard Business Review* (March–April) (1999) 106–116.
- [25] C.E. Helfat, Know-how and asset complementarity and dynamic capability accumulation: the case of R&D, *Strategic Management Journal* 18, 1997, pp. 339–360.
- [26] P.H.J. Hendriks, D.J. Vriens, Knowledge-based systems and knowledge management: friends or foes? *Information and Management* 35 (2), 1999, pp. 113–125.
- [27] C.W. Holsapple, K.D. Joshi, Knowledge manipulation activities: results of a Delphi study, *Information and Management* 39 (6), 2002, pp. 477–490.
- [28] E. Lesser, L. Prusak, Preserving knowledge in an uncertain world, *Sloan Management Review* (Fall) (2001) 101–102.
- [29] K.K. Lm, P.K. Ahmed, M. Zairi, Managing for quality through knowledge management, *Total Quality Management* 10 (4–5), 1999, pp. S615–S621.
- [30] Y. Luo, Dynamic capabilities in international expansion, *Journal of World Business* 35 (4), 2000, pp. 355–378.
- [31] G.S. Lynn, R.R. Reilly, A.E. Akgun, Knowledge management in new product teams: practices and outcomes, *IEEE Transactions on Engineering Management* 47 (2), 2000, pp. 221–231.
- [32] R. McDermott, Why information technology inspired but cannot deliver knowledge management, *California Management Review* 41 (4), 1999, pp. 103–117.
- [33] A. Madhok, T. Osegowitsch, The international biotechnology industry: a dynamic capabilities perspective, *Journal of International Business Studies* 31 (2), 2000, pp. 325–336.
- [34] P. Meso, R. Smith, A resource-based view of organizational knowledge management system, *Journal of Knowledge Management* 4 (13), 2000, pp. 224–234.
- [35] D. Mirchandani, R. Pakath, Four models for a decision support system, *Information and Management* 35 (1), 1999, pp. 31–42.
- [36] R.R. Nelson, S.G. Winter, *An Evolutionary Theory of Economic Change*, Harvard University Press, 1982.
- [37] I. Nonaka, H. Takeuchi, *The Knowledge-Creating Company*, Oxford University Press, New York, 1995.
- [38] I. Nonaka, K. Umemotoand, D. Senoo, From information processing to knowledge creation: a paradigm shift in business management, *Technology in Society* 18 (2), 1996, pp. 203–218.
- [39] J.C. Nunnally, *Psychometric Theory*, McGraw-Hill, New York, 1978.
- [40] E. Ofek, M. Sarvary, Leveraging the customer base: creating competitive advantage through knowledge management, *Management Science* (November) (2001) 1441–1456.
- [41] S. Offsey, Knowledge management: linking people to knowledge for bottom line results, *Journal of Knowledge Management* 1 (2), 1997, pp. 113–122.
- [42] S.L. Pan, H. Scarbrough, Knowledge management in practices: an exploratory case study, *Technology Analysis and Strategic Management* 11 (3), 1999, pp. 359–374.
- [43] J. Papows, *Enterprise.com*, Preseus Publishing, 1999.
- [44] L. Prusak, Why knowledge, why now? in: D.A. Klein (Ed.), *The Strategic Management of Intellectual Capital*, Butterworth-Heinemann, 1998.
- [45] J.B. Quinn, J.J. Baruch, K.A. Zein, *Innovation Explosion: Using Intellect and Software to Revolutionize Growth Strategies*, Free Press, New York, 1997.
- [46] M. Schulz, The uncertain relevance of newness: organizational learning and knowledge flows, *Academy of Management Journal* (August) (2001) 661–681.
- [47] D.J. Teece, Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets, *California Management Review* 40, 1998, pp. 55–79.
- [48] D.J. Teece, G. Pisano, The dynamic capabilities of firms: an introduction, *Industrial and Corporate Change* 3, 1994, pp. 537–556.
- [49] D.J. Teece, G. Pisano, A. Shuen, Dynamic capabilities and strategic management, *Strategic Management Journal* 18, 1997, pp. 509–533.
- [50] K.M. Wiig, Integrating intellectual capital and knowledge management, *Long Range Planning* 30 (3), 1997, pp. 399–405.
- [51] M.H. Zack, Developing a knowledge strategy, *California Management Review* 41 (3), 1999, pp. 125–145.
- [52] S.A. Zahra, The changing rules of global competitiveness in the 21st century, *Academy of Management Executive* 13 (1), 1999, pp. 36–42.

Peter J. Sher is a professor at Department of Business Administration, National Chung Hsing University, Taichung, Taiwan, ROC. Prior to joining the PhD program at University of Warwick, UK, in 1993, Dr. Sher worked as patent examiner in Taiwan for 6 years. He was also involved in international negotiation in the field of intellectual property while he was affiliated with Taiwanese Intellectual Property Office. Beside the professorship at Department of Business Administration, Dr. Sher is the director of Technology Licensing Office of National Chung Hsing University. His current research interests

include strategic management of technology and innovation, intellectual property management, technology commercialization and international technology transfer. His works has been published in *Industrial Marketing Management*, *International Journal of Innovation Management*, and several academic journals in Taiwan.

Vivid C. Lee got his MBA from Department of International Business Studies, National Chi Nan University and is currently expatriated by PRINCO Corp. in Panama.