

Effects of knowledge management strategy on organizational performance: A complementarity theory-based approach

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Abstract

The extant research investigating the relationship between knowledge management (KM) strategies and organizational performance has yielded inconclusive results. Our paper revisits this research problem by drawing on complementarity theory from Economics. The empirical segment of our work is based on data on KM strategies and organizational performance from a sample of 131 Korean firms. Our results suggest three types of relationship among KM strategies: non-complementarity, and non-critical symmetric complementarity, and asymmetric complementarity. Integrating explicit-oriented with tacit-oriented KM strategies showed non-complementarity, which suggests a drag on obtaining higher levels of organizational performance. Our analysis of KM strategies based on KM source shows that companies could benefit from KM by implementing external-oriented or internal-oriented strategy. Combining the tacit-internal-oriented and explicit-external-oriented KM strategies indicates a complementarity relationship, which implies synergistic effects of KM strategies on performance.

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1. Introduction

It is widely recognized that knowledge is an essential strategic resource for a firm to retain sustainable competitive advantage. As knowledge is created and disseminated throughout the firm, it has the potential to contribute to the firm's value by enhancing its capability to respond to new and unusual situations. There is growing evidence that firms are increasingly investing

in knowledge management (KM) initiatives and establishing KM systems in order to acquire and better exploit this resource [1].

The growing importance of knowledge as a critical resource has encouraged managers to pay greater attention to the firms' KM strategies. Appropriate KM strategies are important to ensure that the alignment of organizational process, culture, and the KM-related information technology (IT) deployment produce effective knowledge creation, sharing, and utilization [2]. KM strategies are no longer empty buzzwords but a fundamental concern for many firms [3,4].

A growing body of KM research has examined the range of KM strategies, and attempted to classify them. A synthesis of this research suggests that KM strategies can be primarily categorized based on two key

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dimensions: (i) KM focus and (ii) KM source. On the KM focus dimension, KM strategies can be categorized as explicit- and tacit-oriented. Explicit-oriented strategy attempts to increase organizational efficiencies by codifying and reusing knowledge mainly through advanced ITs [4]. Tacit-oriented strategy takes on the personalization approach where tacit knowledge is communicated through direct person-to-person contact and through socialization processes [5]. The second dimension to orient to KM strategy is based on the firm's primary source knowledge. KM strategies can be classified as internal- and external-orientation along this dimension [6,2]. External-oriented strategy attempts to bring knowledge from outside sources via either acquisition or imitation and then transferring the knowledge throughout organization [7]. Internal-oriented strategy focuses on generating and sharing knowledge within the boundary of the firm.

While researchers have sought to enhance organizational performance by providing guidelines for appropriate KM strategies, how different KM strategies affect organizational performance is not well understood. Even though several empirical studies have examined the relationship between KM strategies and organizational performance, the results to date have been mixed. Some researchers insist that KM strategies are better followed in isolation. Companies should mainly focus on a single strategy [4,8]. Other studies argue that organizations should pursue an integrated approach to KM which calls for the combining of KM strategies appropriately. *Complementarities* among such strategies are considered crucial from the perspective of their influence on organizational performance [6,9].

Previous research has contributed to our understanding of whether and how KM strategies help or hinder organizational performance. However, little consideration has been given to the underlying factors that can explain such results. We argue that the lack of adequate theoretical foundation has impeded research progress in this area.

This research aims to explore the synergistic relationship between KM strategies and their impact on organizational performance. This paper presents a framework of “complementarity” analysis as the theoretical basis for analyzing the impact of KM strategies on organizational performance. In particular, by drawing on the complementarity theory from the economics literature [10,11], this paper seeks to answer the question, which KM strategy or strategies work well together and what are the performance implications. This research will make the following contributions towards

advancing the literature by:

- (i) presenting how the use of association analysis can provide further insights into understanding the various types of complementary relationships.
- (ii) providing empirical analysis of complementarity among KM strategies and their effects on organizational performance.

The outline of this paper is as follows: we survey prior literature on the topic in Section 2. A description of our research methodology to investigate the relationships between KM strategies and organizational performance is provided in Section 3, followed by the data description, analysis, and results in Section 4. The limitations and implications of the study are discussed in Section 5. Section 6 concludes the paper.

2. Literature review

2.1. Complementarity

The original concept “complementarities” was first introduced by Edgeworth [12] in which he defined activities as complements, if doing (more of) any one of them increases the returns to doing (more of) the others. By drawing on lattice theory¹ and supermodularity,² Milgrom and Roberts [10,11] proposed that some organizational activities and practices are mutually complementary and so tend to be adopted together, with each enhancing the contribution of the other. Therefore, the impact of a system of complementary practices will be greater than the sum of its parts because of the synergistic effects of bundling practices together.

Many researchers have investigated the complementary relationship among various business practices. For example, Black and Lynch [13] argued that, until recently, there had been very little direct analysis of the impact of workplace practices on productivity. They found some synergies among various workplace practices but concluded that the important issue is not whether an organization adopts a particular work

¹ A lattice (X, \geq) is a set X with a partial order \geq with the property that for any x and y in X , X also contains a smallest element under the order that is larger than both x and y and a largest element that is smaller than x and y . If $x \vee y$ (read ‘ x join y ’) denotes the smallest element larger than x and y , and $x \wedge y$ (read ‘ x meet y ’) denotes the largest element smaller than x and y .

² Given a real-valued function f on a lattice X , we say that f is supermodular and its arguments are (Edgeworth) complements if and only if for any x and y in X , $f(x) - f(x \wedge y) \leq f(x \vee y) - f(y)$.

practice but rather how that work practice is implemented in conjunction with other complementary practices. Bresnahan et al. [14] surveyed approximately 400 large firms to obtain information on the aspects of organizational structure such as allocation of decision rights, workforce composition, and investments in human capital. They found that these work practices are correlated with each other, and argued that these practices are part of a complementary system.

The complementarity concept offers a useful perspective to understand the complex relationships among KM strategies and practices.³ In our work, complementarity indicates a condition of increasing returns in which adopting (doing more) of an activity (e.g. implementation of certain KM strategy) has a higher payoff when simultaneously adopting (doing more) of a complementary activity (e.g. implementation of another KM strategy).

2.2. KM strategies and complementarity

A relatively small number of studies have addressed the relationship between KM strategies and organizational performance because of the difficulty in measuring and quantifying the value of knowledge. These studies can be classified into two categories depending on how they implicitly define the relationship among KM strategies as being either complementary or non-complementary. Illustrative studies in each of these categories are listed in Table 1.

The studies under the first category suggest a complementary relationship among KM strategies. A central proposition is that adopting a full set of KM strategies is related to high performance while the adoption of individual KM strategies results in little or insignificant performance gain. Bierly and Chakrabarti [6] found that the complementary set of KM strategies (internal- and external-oriented strategy) tended to be more profitable in terms of ROS and ROA. Choi and Lee [9] showed that a complementary set of explicit- and tacit-oriented strategies resulted in higher performance. Zack

[2] argued that aggressive KM strategies (a complementary set of tacit-internal-oriented plus explicit-external-oriented strategy) lead to higher performance.

The second category deals with the non-complementary relationship among KM strategies. The gist of these studies is that using bundles of KM strategies does not guarantee increased organizational performance. Hansen et al. [4] proposed that companies should pursue either codification (explicit-oriented) or personalization (tacit-oriented) strategy but not both to utilize the organizational knowledge effectively. Keskin [19] argued that the impact on organizational performance is higher with explicit-oriented strategy than the tacit-oriented one. Pai [8] found that overall creationists (adopters of complementary set of external-oriented and internal-oriented strategies) achieved lower performance than internal exploiters. Schulz and Jobe [20] suggested that a focused strategy is superior to the other strategies. Swan et al. [21] posited that a community (tacit-oriented) strategy is better than cognitive (explicit-oriented) strategy.

By synthesizing previous studies, some interesting inferences can be made. First, KM strategies can be described along two dimensions reflecting their focus and source. For example, the codification strategy discussed in Hansen et al. [4] and the explicit-oriented strategy outlined by Keskin [19] are based on explicit knowledge, whereas the tacitness strategy of Schulz and Jobe [20] and the community approach outlined by Swan et al. [21] are based on tacit knowledge. In addition, the internal exploiter strategy of Pai [8] is based on internal knowledge, while the explorer strategy detailed by Bierly and Chakrabarti [6] is based on external knowledge. Typically, tacit and explicit dimensions reflect the focus and internal and external dimensions reflect the source of KM strategies. Regardless of the research approaches used, these two dimensions play a central role in classifying KM strategies and exploring their relationship with organizational performance.

Second, the importance of a complementary set of KM strategies and their performance impacts remain unclear. There appears to be an ongoing theoretical and empirical debate on the existence of synergies in bundles of KM strategies due to the complexity of the relationships among strategies. Some studies suggested a complementary set of KM strategies to improve organizational performance [6]. In contrast, others proposed that bundles of KM strategies have no effect on organizational performance, which implies non-complementarity relationship among KM strategies. Clarifying the relationships among KM strategies remains an important research issue.

³ Complementarity theory essentially follows contingency theory which considers performance as dependent on “fit”—generally investigated in terms of moderation—between organizational variables. However, it has pushed performance analysis beyond simple interactions between disaggregated one-to-one comparison [15]. Unlike the contingency theory, complementarity theory assumes that separate variables cannot be individually finetuned to achieve better performance [16]. That is, this theory takes a holistic view of organizational variables and their relationships to overcome the limitation of contingency theory (see Schoonhoven’s work [17] for more details on the limitations). Further, it provides more operational insights than fit theory into the nature of change involved [18].

Table 1
KM strategy and complementarity

Researcher	KM strategy categories	Categorization dimensions	Organizational performance	Suggested KM strategy	Research method	Findings
<i>Complementarity</i>						
Bierly and Chakrabarti [6]	Loner; exploiter; explorer; innovator	Focus (tacit-explicit) Source (internal-external)	Return on sales (ROS) Return on asset (ROA)	Innovator or explorer	Empirical	Complementarity set of KM strategies (innovator and explorer) are linked to higher profits.
Choi and Lee [9]	Passive; system-oriented; human-oriented; dynamic	Focus	(compared to key competitors) Overall success; market share; growth rate; profitability; innovativeness; business size	Dynamic	Empirical	Complementarity set (integrate human- and system-oriented strategies) results in higher performance.
Zack [2]	Conservative; aggressive	Focus Source	N/A	Aggressive	Conceptual	Complementarity set (aggressive KM strategies) leads higher performance.
<i>Non-complementarity</i>						
Hansen et al. [4]	Codification; personalization	Focus	N/A	80–20 split	Conceptual	Pursue either explicit-oriented or tacit-oriented in isolation to increase firms' performance.
Keskin [19]	Explicit-oriented; tacit-oriented	Focus	(compared to key competitors) Overall success; market share; growth rate; profitability; innovativeness; business size	Explicit	Empirical	The impact of explicit-oriented KM strategy is higher than the tacit-oriented one on firms' performance.
Pai [8]	Discoverer; discretionist; external learner; internal exploiter; overall creationist	Focus Source	Return on asset (ROA) Return on equity (ROE)	Internal exploiter	Empirical	Overall creationists (complementary set of external-oriented and internal-oriented strategy) are lower performer than internal exploiters.
Schulz and Jobe [20]	Codification; tacitness; focused; unfocused	Focus	(relative to overall performance) Subunit performance over the last 5 yr	Focused	Empirical	Focused strategies are superior to the other strategies.
Swan et al. [21]	Cognitive; community	Focus	N/A	Community	Conceptual	Community (tacit-oriented) strategy is expected to have higher performance than cognitive (explicit-oriented) strategy.

Third, although the relationship among KM strategies is sensitive to performance measure, little attention has been paid to this. In particular, previous studies that suggest non-complementary relationship among KM strategies used only financial performance measures like ROA and ROE [8]. Further investigations employing alternative performances measures like innovativeness are critical to providing useful, practical guidelines to managers.

3. Research methodology

In order to explore the relationships between KM strategies and organizational performance, this study was carried out in two stages. In the first stage, we classified the organizations in our sample based on their KM strategies. In the second stage, we analyzed the association among KM strategies to investigate their impact on performance. Fig. 1 illustrates the stages in our procedure.

3.1. Stage 1: KM strategy classification

In order to categorize organizations based on KM strategies, cluster analysis, which is the first stage in our proposed method, is used. Cluster analysis is a commonly used technique for empirically identifying patterns in complex sets of organizational variables in the KM research in particular [6,9,22] and more generally in the information systems literature [23–25]. This analysis allows us to group organizations so that each is similar to others within each cluster, thereby exhibiting high internal (within-cluster) homogeneity with respect to certain KM strategy characteristics (KM focus and KM source in this study) and high external (between-cluster) heterogeneity with respect to the same characteristics [26,27].

A major issue with clustering is how to decide the number of clusters. Membership of clusters is determined based on the three steps in our method. First,

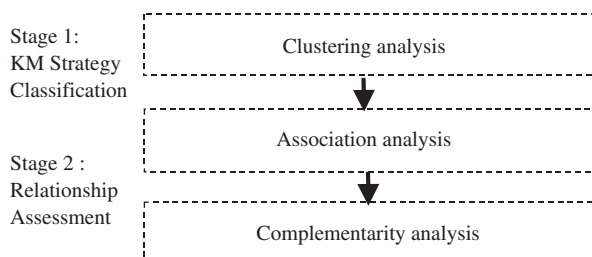


Fig. 1. Analysis procedure.

Ward's hierarchical technique is adopted using squared Euclidean distance, followed by an agglomeration schedule [6,26]. Cluster agglomeration is generally stopped when the increase between two adjacent steps becomes large. Second, K-means nonhierarchical analysis is performed for checking the validity. Finally, analysis of variance (ANOVA) is employed to validate the overall result.

3.2. Stage 2: relationship assessment

The concept of complementarity can be operationalized by the supermodularity function with respect to two or more complementary variables [28]. Supermodularity dictates that the sum of the increases in the value of a function when the levels of the complements are changed one at a time would be less than the increase in the function's value when the levels are changed simultaneously. In essence, if the synergistic condition holds, the gains from increasing every component are larger than the sum of the individual increases.

3.2.1. Association analysis

Association analysis is a widely employed technique in the field of knowledge discovery and data mining. This technique is particularly useful when the underlying theory is not well understood and when the study is exploratory in nature. An association analysis can provide a weak form of correlation measure between the variables based on probability measures. In particular, if there is an association between X which is an input variable and Y , the performance variable, i.e. $\prod(X_i)$, we say that $X \rightarrow Y$ provided

- The condition $X \rightarrow Y$ holds in the data set with support s , where s is the percentage of instances in the data set that contains $X \cup Y$ (i.e. both X and Y). This is taken to be the probability, support $(X \rightarrow Y) = P(X \cup Y)$.
- The condition $X \rightarrow Y$ has confidence c in the data set if c is the percentage of instances in data set with X that is also with Y . This is taken to be conditional probability, confidence $(X \rightarrow Y) = P(Y|X)$.

Support and confidence are the two key measures of the interestingness in association analysis [29]. High support implies that the condition is relatively frequent. Confidence indicates how often the condition is correct. High confidence indicates that Y is highly dependent on X . In this study, we derive a performance function that is supermodular with respect to pairs of KM

strategies being implemented simultaneously using association analysis.

3.2.2. Complementary analysis

Based on the concept of complementarity and its supermodularity functional representation, we need to consider performance data on some function that is supermodular. Suppose there are two KM strategies (X_1 and X_2). Each strategy can be adopted by the firm ($X_1 = 1$) or not adopted ($X_1 = 0$) and ($X_2 = 1$) or not adopted ($X_2 = 0$). The performance function $Y = f(X_1, X_2)$ is supermodular and X_1 and X_2 are complements if and only if:

$$f(1, 1) - f(0, 1) \geq f(1, 0) - f(0, 0) \quad (1)$$

i.e. adding a strategy while already executing the previous strategy has a higher incremental effect on performance than when using the first strategy in isolation. Even though the concept of complementarities offers a set of important implications for analyzing organizational performance, there is no well-established theory to conceptualize the association between X_1 and X_2 .

Note that the marginal benefit moving from (0, 0) to (1, 0) (or to (0, 1)) is less than the move from (1, 0) (or from (0, 1)) to the maximum (1, 1). Alternatively, Eq. (1) can be rewritten as:

$$f(1, 1) + f(0, 0) \geq f(1, 0) + f(0, 1). \quad (2)$$

Based on the concept discussed in the association analysis, we implement each of the performance functions in the form of conditional probability. We assume that the performance outcome consists of two discrete possibilities where 1 represents positive outcome and 0 represents non-positive outcome. Table 2 shows the

mapping of each positive performance outcome ($Y = 1$) into four different conditional probabilities.

Based on this mapping in Table 2, supermodularity function (Eq. (2)) can be modeled as:

$$\begin{aligned} &P(Y = 1|X_1 = 1 \wedge X_2 = 1) \\ &+ P(Y = 1|X_1 = 0 \wedge X_2 = 0) \\ &\geq P(Y = 1|X_1 = 1 \wedge X_2 = 0) \\ &+ P(Y = 1|X_1 = 0 \wedge X_2 = 1). \end{aligned} \quad (3)$$

Supermodularity condition (in Eq. (3)) holds that the probability of positive performance outcome with both KM strategies being implemented simultaneously is higher than the sum of probabilities when only either one KM strategy is implemented. Furthermore, we are able to provide more insightful interpretation of the relationships between X_1 and X_2 . We classify broadly the relationships into two sub-categories: (a) symmetry and (b) asymmetry.

3.2.2.1. Asymmetric complementarity condition Asymmetric complementarity describes a condition that only one KM strategy has positive incremental impact on performance when it is implemented independently. Positive incremental impact of X_1 and X_2 independently can be written based on Eqs. (1) and (2) as:

$$\begin{aligned} &\frac{P(Y = 1|X_1 = 1 \wedge X_2 = 0)}{P(Y = 1|X_1 = 0 \wedge X_2 = 0)} > 1 \quad \text{or} \\ &\frac{P(Y = 1|X_1 = 0 \wedge X_2 = 1)}{P(Y = 1|X_1 = 0 \wedge X_2 = 0)} > 1, \end{aligned}$$

respectively.

If only one of these two conditions holds, it implies that only the one KM strategy with such condition can impact performance independently, and the other KM strategy is playing an assisting role to further enhance the impact of X_1 on performance Y . Fig. 2 illustrates the

Table 2
Mapping conditional probability to performance function

	Performance function $f(X_1, X_2)$	Conditional probability $P(Y X_1 \wedge X_2)$	Descriptions
(i)	$f(1, 1)$	$P(Y = 1 X_1 = 1 \wedge X_2 = 1)$	Probability of positive performance outcome given that both KM strategies are implemented simultaneously
(ii)	$f(1, 0)$	$P(Y = 1 X_1 = 1 \wedge X_2 = 0)$	Probability of positive performance outcome given that only the one KM strategy is implemented
(iii)	$f(0, 1)$	$P(Y = 1 X_1 = 0 \wedge X_2 = 1)$	
(iv)	$f(0, 0)$	$P(Y = 1 X_1 = 0 \wedge X_2 = 0)$	Probability of positive performance outcome without either KM strategies being implemented

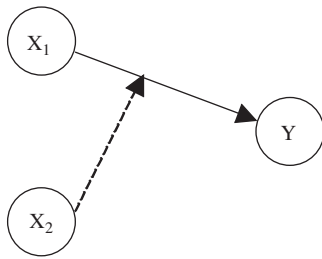


Fig. 2. Asymmetric complementarity.

asymmetric complementarity condition, when X_1 has direct impact on Y and X_2 is the moderator to enhance the performance impact of X_1 .

3.2.2.2. Symmetric complementarity condition Symmetric complementarity describes a condition in which both input variables behave in a similar manner in effecting the performance outcome. This condition can be further categorized as (a) critical symmetric complementarity and (b) non-critical symmetric complementarity.

The first case, critical symmetric complementarity, describes a condition in which there is incremental performance by implementing X_1 and X_2 simultaneously. Positive performance impact can only be achieved by the implementation of both input strategies, i.e.

$$\frac{P(Y=1|X_1=1 \wedge X_2=0)}{P(Y=1|X_1=0 \wedge X_2=0)} \leq 1 \quad \text{and} \quad \frac{P(Y=1|X_1=0 \wedge X_2=1)}{P(Y=1|X_1=0 \wedge X_2=0)} \leq 1,$$

respectively.

The second case, non-critical symmetric complementarity, describes a condition in which both input strategies have incremental performance impact even when they are implemented independently, i.e.

$$\frac{P(Y=1|X_1=1 \wedge X_2=0)}{P(Y=1|X_1=0 \wedge X_2=0)} > 1 \quad \text{and} \quad \frac{P(Y=1|X_1=0 \wedge X_2=1)}{P(Y=1|X_1=0 \wedge X_2=0)} > 1,$$

respectively.

Further positive performance can be achieved by implementing both input strategies simultaneously. Fig. 3(a) and (b) illustrates the two categorizations of symmetric complementarity conditions.

3.2.3. Complementarity index

One of the objectives in this paper is to develop a quantifiable measure of complementarity. We develop a

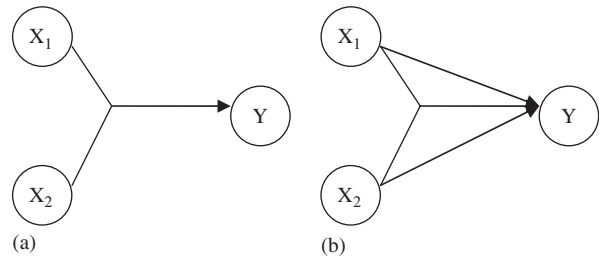


Fig. 3. Two types of complementarity: (a) critical symmetric; (b) non-critical symmetric.

measure of level of complementarity between X_1 and X_2 on performance Y , by rewriting Eq. (3) as:

$$CI = \frac{P(Y=1|X_1=1 \wedge X_2=1) + P(Y=1|X_1=0 \wedge X_2=0)}{P(Y=1|X_1=1 \wedge X_2=0) + P(Y=1|X_1=0 \wedge X_2=1)}. \quad (4)$$

The term complementarity index (CI) is developed to show level of joint performance impact by X_1 and X_2 simultaneously in addition to the performance impact by X_1 or X_2 independently. In order to be a valid CI, following two conditions should be satisfied. First, $P(Y=1|X_1=1 \wedge X_2=1)$ has to be larger than $P(Y=1|X_1=0 \wedge X_2=0)$, so that performance is improved by implementing both strategies simultaneously. Second, CI has to be greater than 1 in order to satisfy the basic complementarity condition. The larger the value of the CI, the higher the effect of the complementary relationship between X_1 and X_2 on performance, Y .

4. Analysis and results

4.1. Analysis

4.1.1. Data and measurement

The data for this study were gathered from 131 listed major companies in Korea. Annual Corporation Reports by Maeil Business Newspaper [30] served as the target population because it analyzed all listed companies in the Korea Stock Exchange. A questionnaire-based survey was conducted. Middle managers who are responsible for KM were surveyed because they played key roles in managing knowledge [31].

The questionnaire consisted of a number of relevant items and the responses were against six-point Likert scale ranging from 'very low' to 'very high'. Six-point Likert scales avoid a midpoint in order to prevent respondents from a neutral default option [32]. Research constructs were operationalized on the basis of related studies and pilot tests. The operational definitions of

instruments and their related references are summarized in Appendix A. Most of the research constructs have already been validated and used for other studies on KM. For example, items for assessing the explicit-oriented and tacit-oriented strategies have already been validated and used by Choi and Lee [9]. Questionnaire items for the internal-oriented and external-oriented strategy, which were used in this study, had been validated and used by Lee et al. [7]. To measure corporate performance, the constructs by Deshpande et al. [33] and Drew [34] were adopted. Variables for measuring KM strategies were transformed into binary measures (high versus low) from the actual values on the six-point Likert scale. This is not unlike several earlier studies such as [35] which have used binary measures (such as modeling the use versus non-use of IT) as a predictor of firm performance. The association analysis technique we adopt is facilitated by the availability of data in binary form.

4.1.2. Sample characteristics

In total, 131 questionnaires from 900 firms were returned (14.6% response rate). Sixteen responses were eliminated due to incomplete data. The remaining 115 responses were finally used. Table 3 summarizes the respondent characteristics in terms of industry type, total sales revenue, and number of total employees. The majority of these firms are in the manufacturing sector. Forty-eight firms have annual total sales revenue of 1 billion dollars or more, and 66 firms have 1000 or more employees.

4.1.3. Reliability and validity test

The content validity of the instruments is established by adopting the constructs that have already been validated by other researchers. The reliability is assessed by Cronbach's alpha [36]. Internal scale reliabilities (Cronbach's alpha) vary from 0.6763 to 0.8940. Table 4 outlines the results of reliability for survey items.

The validity was checked by a factor analysis with principal components analysis and varimax rotation. Convergent validity was checking loadings to see if items within the same construct correlate highly amongst themselves. Discriminant validity was assessed by examining the factor loadings to see if questions loaded more highly on their intended constructs than on their constructs [37]. Loadings of 0.45–0.54 are considered fair, 0.55–0.62 are good, 0.63–0.70 are very good, and above 0.71 are excellent [38]. Four components with eigenvalue above 1 were generated. These components corresponded to the KM focus and

Table 3
Respondent characteristics

Industry type (main)	Industry type (sub)	Frequency	Percent
(a) <i>Industry type</i>			
Manufacturing	Machinery	12	10.4
	Electronics	6	5.2
	Chemistry	11	9.6
	Pharmaceutical	5	4.3
	Clothing	6	5.2
	Food/beverage	9	7.8
	Others	1	0.9
Financing	Insurance	8	7.0
	Banking	9	7.8
	Security	10	8.7
Service	Construction	11	9.6
	Retailing	5	4.3
	Transportation	5	4.3
	IT/communication	16	13.9
	Others	1	0.9
Total		115	100.0
(b) <i>Total sales revenue</i>			
Range		Frequency	Percent
Less than \$100 million		9	7.8
\$100 million to below \$500 million		35	30.4
\$500 million to below \$1 billion		23	20.0
\$1 billion to below \$5 billion		39	33.9
\$5 billion to below \$10 billion		4	3.5
\$10 billion and above		5	4.3
Total		115	100.0
(c) <i>Number of total employees</i>			
Range		Frequency	Percent
100 to below 200		11	9.6
200 to below 500		17	14.8
500 to below 1000		21	18.3
1000 to below 3000		21	18.3
3000 to below 10,000		33	28.7
10,000 to below 30,000		5	4.3
30,000 and above		7	6.1
Total		115	100.0

Table 4
Reliability of constructs

Construct	Cronbach's alpha	Number of questions
KM focus		
Tacit-oriented (TA)	0.6763	4
Explicit-oriented (EX)	0.7809	4
KM source		
External-oriented (EO)	0.7021	5
Internal-oriented (IO)	0.8940	6
Corporate performance	0.8567	5

Table 5
Validity of items

Items	Factor 1	Factor 2	Factor 3	Factor 4
Tacit-oriented 1	0.193	0.811	0.106	0.194
Tacit-oriented 2	0.321	0.715	0.102	0.146
Tacit-oriented 3	0.284	0.577	0.416	0.209
Tacit-oriented 4	0.305	0.487	−0.046	0.263
Explicit-oriented 1	0.476	0.180	0.250	0.601
Explicit-oriented 2	0.448	0.208	0.127	0.611
Explicit-oriented 3	0.155	0.171	0.139	0.790
Explicit-oriented 4	0.331	0.394	0.104	0.469
Internal-oriented 1	0.565	0.500	0.312	−0.099
Internal-oriented 2	0.614	0.449	0.297	−0.057
Internal-oriented 3	0.811	0.086	0.105	0.222
Internal-oriented 4	0.783	0.183	0.037	0.285
Internal-oriented 5	0.829	0.146	0.090	0.069
Internal-oriented 6	0.664	0.487	0.236	0.069
External-oriented 1	0.269	0.182	0.650	−0.264
External-oriented 2	0.285	0.100	0.650	−0.264
External-oriented 3	−0.028	0.445	0.643	0.217
External-oriented 4	0.041	−0.419	0.708	0.058
External-oriented 5	0.028	0.300	0.654	0.220
Eigenvalue	4.410	3.140	2.760	1.860
Variance explained (%)	23.220	16.540	14.490	9.800
Cumulative variance (%)	23.220	39.760	54.250	64.050

KM source (see Table 5). All the measures used in this study are reported in Appendix B.

4.2. Results of stage 1: clusters of organizations on the basis of KM strategies

Our objective is not to generate a long list of possible KM strategy combinations but to propose an alternative method to identify the precise KM strategy relationships on the basis of complementarity theory. Therefore, this study highlights KM strategy relationships that have been considered as important to explain the relationship between KM strategies and organizational performance.

Cluster analyses were performed to derive high or low explicit-oriented strategy based on the degree of explicitness. The decision on the number of clusters was guided by an agglomeration schedule, which displays the squared Euclidean distances between each case or group of cases [6]. The agglomeration coefficient shows rather large increases from four to three clusters ($18.66 - 13.58 = 5.08$), three to two clusters ($26.25 - 18.66 = 7.59$), and two to one cluster ($46.53 - 26.25 = 20.27$). To help identify large relative increases in the cluster homogeneity, the percentage change in the clustering coefficient is calculated (see Table 6). Based on the percentage change in agglomeration coefficients, the appropriate number of clusters is determined to be two.

Table 6
Analysis of agglomeration coefficients

Number of clusters	Agglomeration coefficient	Differences in coefficient	Percentage change in coefficient in next level
10	1.85	1.07	0.37
9	2.92	1.07	0.27
8	3.99	1.67	0.30
7	5.65	1.91	0.25
6	7.56	2.32	0.23
5	9.89	3.70	0.27
4	13.58	5.08	0.27
3	18.66	7.59	0.29
2	26.25	20.27	0.44
1	46.53		

Similarly, firms were clustered by a K-means non-hierarchical technique. The result was similar to that of Ward's, except for the number of cases and group sequence. Both cluster analyses resulted in proof of reliability and validity. Either Ward's or the K-means method could be used. In this study, the result of Ward's technique was adopted.

Firms were categorized as high or low based on the degree of explicit-oriented strategy. Similarly, firms were categorized as high or low level of tacit-oriented, internal-oriented, and external-oriented degree by the use of Ward's hierarchical technique. Finally, firms were categorized along with high or low level of combination of KM focus and KM source (tacit-internal oriented and explicit-external oriented) degree that are widely adopted in previous research [6,2]. Table 7 summarizes the result of the cluster analysis by using Ward's hierarchical technique.

4.3. Results of stage 2

4.3.1. Association analysis

Based on the conditional probability measures, this study examined the relationships among KM strategies and their impacts on organizational performance. The results can help in developing guidelines for employing KM strategies (see Table 8).

Relating to KM focus, the results showed that only high explicit-oriented strategy would lead to greater probability in achieving improved performance (i.e. $0.645 > 0.505$). On the contrary, high tacit-oriented strategy resulted in low probability to achieve higher performance (i.e. $0.428 < 0.505$). Furthermore, organizations that have integrated explicit-oriented with tacit-oriented strategy would lead to even

Table 7
Result of cluster analysis

KM strategy	Group	High	Low	Mean	P-value
KM focus	Explicit-oriented	4.51	3.35	3.95	0.00
	Number of cases	59	56		
	Tacit-oriented	4.88	3.75	4.43	0.00
	Number of cases	69	46		
KM source	External-oriented	4.41	3.26	3.97	0.00
	Number of cases	71	44		
	Internal-oriented	5.24	3.97	4.33	0.00
	Number of cases	33	82		
Both (KM focus and KM source)	Tacit and internal-oriented	4.83 (tacit)	3.68 (tacit)	4.43 (tacit)	0.00
		4.66 (internal)	3.72 (internal)	4.33 (internal)	
	Number of cases	75	40		
		4.26 (explicit)	3.41 (explicit)	3.95 (explicit)	0.00
	Explicit and external-oriented	4.05 (external)	3.82 (external)	3.97 (external)	
		72	43		

Table 8
Relationships of KM strategies

	$P(Y=1 X_1=0 \wedge X_2=0)$	$P(Y=1 X_1=1 \wedge X_2=0)$	$P(Y=1 X_1=0 \wedge X_2=1)$	$P(Y=1 X_1=1 \wedge X_2=1)$	CI ^a	Remarks
KM focus	0.505	0.645	0.428	0.333	0.78	Non-complementarity
KM source	0.421	0.529	0.636	0.909	1.14	Non-critical symmetric complementarity
KM focus and KM source	0.565	0.476	0.750	1.000	1.28	Asymmetric complementarity

^aCI: Complementarity index.

lower probability in achieving high performance (i.e. $0.333 < 0.505$). This result suggested that organizations should consider explicit-oriented strategy in the context of KM focus.

Relating to KM source, the results proposed that external-oriented strategy would lead to a higher probability of achieving better performance ($0.529 > 0.421$). Similarly, internal-oriented strategy showed higher probability to achieve better performance ($0.636 > 0.421$). Furthermore, organizations that implemented both external-oriented and internal-oriented KM sources simultaneously obtained even higher probability in achieving high performance (i.e. $0.909 > 0.636 > 0.529 > 0.421$).

Considering KM focus and KM source together, we obtained some interesting results. Organizations that have high tacit-internal-oriented strategy show higher probability of achieving better performance

(i.e. $0.750 > 0.565$). On the other hand, organizations which employ high explicit-external-oriented strategy showed lower probability in achieving higher performance (i.e. $0.476 < 0.565$). The more interesting result is that the high explicit-external-oriented strategy is acting as a moderator in assisting the impact of tacit-internal-oriented strategy on performance. Despite the fact that high explicit-internal-oriented KM strategy by itself had lower probability to achieve high performance, companies can have high probability of achieving higher performance by combining high explicit-external-oriented strategy in conjunction with high tacit-internal-oriented strategy.

4.3.2. Analysis of complementarity

The results of complementarity test on the basis of CI measures are summarized in Table 8. Relating to KM focus, a non-complementarity relationship is found

based on the following three steps:

- (i) CI value of combination of explicit-oriented and tacit-oriented knowledge is 0.78, which is much less than one.
- (ii) Conditional probability measure for $P(Y = 1|X_1 = 1 \wedge X_2 = 1)$ is the lower than the two independently conditional probability measures (i.e. $P(Y = 1|X_1 = 1 \wedge X_2 = 0)$ and $P(Y = 1|X_1 = 0 \wedge X_2 = 1)$).
- (iii) Conditional probability measure for $P(Y = 1|X_1 = 1 \wedge X_2 = 1)$ is even lower than the conditional probability measure for $P(Y = 1|X_1 = 0 \wedge X_2 = 0)$.

These steps suggest that implementing explicit-oriented and tacit-oriented strategy together would decrease organizational performance.

For KM source, a non-critical symmetric complementarity is found on the basis of following two steps:

- (i) Conditional probability measures for $P(Y = 1|X_1 = 1 \wedge X_2 = 0)$ and $P(Y = 1|X_1 = 0 \wedge X_2 = 1)$ are higher than the conditional probability measure for $P(Y = 1|X_1 = 0 \wedge X_2 = 0)$. It represents non-critical symmetric condition.
- (ii) CI value is 1.14 (i.e. greater than 1), implying that supermodularity condition holds.

Relating to KM focus and KM source together, an asymmetric complementarity is found drawing on the following two steps:

- (i) Only conditional probability measures for $P(Y = 1|X_1 = 0 \wedge X_2 = 1)$ has higher conditional probability measure than $P(Y = 1|X_1 = 0 \wedge X_2 = 0)$.
- (ii) CI value is 1.28 (i.e. greater than 1), implying supermodularity condition holds.

4.4. Summary of results

Table 9 summarizes our analysis results and compares them with previous research. The findings relating to the KM focus dimension were different from previous studies that emphasized both explicit-oriented and tacit-oriented strategies together. In contrast, the result relating to KM focus is consistent with other studies that focused on either explicit-oriented or tacit-oriented strategy.

The analysis of KM strategies using knowledge source also showed interesting results. The results proposed that companies could gain benefits of KM by adopting either external-oriented or internal-oriented strategy. However, if companies implement both external-oriented and internal-oriented strategy together, they can achieve higher performance than if they adopted any one of them. That is, our results support a complementarity relationship between external-oriented and internal-oriented strategies.

The combination of KM focus and KM source showed a complementarity relationship. This finding confirms that companies can achieve strategic benefits of KM through focusing on both tacit-internal-oriented strategy and explicit-external-oriented strategy.

5. Discussion

5.1. Limitations

Although the findings of this study are interesting, they should be interpreted in the context of its inherent limitations. First, this study transforms continuous variables into binary variables. This may cause measurement errors and distort research results, though adopting binary constructs in early stages of research is

Table 9
Comparisons of research results

Researcher	Combination		
	Tacit-oriented and explicit-oriented	External-oriented and internal-oriented	Tacit-internal oriented and explicit-external oriented
Bierly and Chakrabarti [6]	N/A	Complementarity	Complementarity
Choi and Lee [9]	Complementarity	N/A	N/A
Zack [2]	Complementarity	Complementarity	Complementarity
Hansen et al. [4]	Non-complementarity	N/A	N/A
Keskin [19]	Non-complementarity (explicit-oriented)	N/A	N/A
Pai [8]	N/A	Non-complementarity	Non-complementarity
Schulz and Jobe [20]	Non-complementarity	N/A	N/A
Swan et al. [21]	Non-complementarity (tacit-oriented)	N/A	N/A
This study	Non-complementarity	Complementarity	Complementarity

not without merit. Second, our current sample was obtained from large and profitable companies; small or venture firms were not included. This bias may enable some KM strategies to perform above the norm. Including small or venture companies could lead to more robust results. Third, the validity of the results may be limited to Korean firms. The generalizability from Korean settings to other countries may be questionable. Finally, this study does not consider feedback effects because it presents a snapshot research. A longitudinal study to investigate the dynamic aspects of KM strategies would be of interest.

5.2. Implications

Our results have both theoretical and practical implications. First, our study proposes a new theoretical approach to identify interrelationships among KM strategies and their impacts on performance. In many areas, theory development has not yet advanced to a level that warrants elaborate explanations for KM factors including KM strategies and performance. This study explores the relationships between KM strategies and organizational performance by drawing on a novel theory which has not been used in previous empirical KM research. Although many studies have investigated the relationships, their findings are still inconclusive, which limits our understanding of the complex relationships between KM strategies and organizational performance. The complementarity theory-based approach enables a fresh perspective which can help address this limitation. In contrast with previous studies, the method proposed in this study enables us to examine the relationships with greater sophistication.

Second, this study explored relationships among KM strategies including the combination of tacit-internal-oriented and explicit-external-oriented strategy empirically. Due to the exploratory character of this study, the scales developed and used were necessarily limited. Thus, we regard our empirical analysis more as an illustration of our theoretical ideas than as a definitive test. Nevertheless, the results presented offer interesting insights into KM strategies and their relationships. Furthermore, this empirical study does not display any obvious symptoms of bias.

Third, our results show the danger of “stuck in the middle” strategy which emphasizes both explicit-oriented and tacit-oriented strategy [4]. Potential advantages and disadvantages of a combined KM strategy have been the focus of debate for some time. Many researchers and practitioners insist on an integrated approach which argues for the intermingling of both

strategies [39]. For example, 83% of respondents of Edwards et al.’s [40] study disagreed with the statement that an organization could not use both explicit-oriented and tacit-oriented strategies together. Our findings, however, show that explicit-oriented and tacit-oriented strategies are non-complementary with respect to organizational performance. The result may be due to the inherent contradictions between the two strategies.

Fourth, one of the challenges presented by the results of this study is to explain the counter-intuitive impact of tacit-oriented strategy on performance. Several researchers argue that tacit-oriented strategy occupies the central role in managing knowledge and for attaining sustainable competitive advantage. However, our results showed that tacit-oriented strategy does not contribute to better organizational performance. Furthermore, our results indicate that explicit-oriented strategy (0.645) is more critical than tacit-oriented strategy (0.428). This rather intriguing result may reflect the current Korean firms’ knowledge capability. Although several Korean firms like Samsung Electronics or Hyundai Motors have become leading players in the global market, most Korean firms are still in an imitation rather innovative mode [41]. Core knowledge seems to be transferred from foreign firms in developed countries. Therefore, explicit-oriented strategy plays key role in increasing performance because rapid transfer of explicit knowledge within the firm is critical to enabling the firms to stay ahead of their competitors [42].

Fifth, our study showed a non-critical symmetric complementarity relationship between external-oriented and internal-oriented strategies. Balancing between external-oriented and internal-oriented strategy increases the probability of attaining higher level of organizational performance. However, the result does not imply that it is necessary to employ both strategies together because adopting any one of them can also result in improved performance. Therefore, managers can focus on one of the KM strategies if the KM budget is not enough to implement two strategies simultaneously.

Finally, our study found that combining the tacit-internal-oriented and explicit-external-oriented KM strategies results in better performance than all other strategy combinations. Although further examination is needed to substantiate our findings due to some of the aforementioned limitations, this complementary relationship is interesting. Innovative organizations which integrate tacit and explicit knowledge without regard to organizational boundaries tend to outperform those competitors who pursue only one of them. In addition, our study indicates explicit-external-oriented strategy without tacit-internal-oriented strategy decreases

probability of improving organizational performance. This may be due, in part, to the knowledge obsolescence problem. Without tacit-internal-oriented strategy, explicit-external-oriented strategy may result in consuming without producing new knowledge [2].

6. Conclusion

This paper investigated the relationships between KM strategies and organizational performance by drawing on complementarity theory. The results suggest three types of relationships among the different KM strategies; non-complementarity, non-critical symmetric complementarity, and asymmetric complementarity. The KM focus strategy of integrating explicit-oriented with tacit-oriented strategies was found to be non-complementarity. This result is generally consistent with previous studies which suggest that internal organizational tensions (between tacit-oriented and explicit-oriented strategies in this study) are difficult to reconcile, leading to potential performance deficits [43,44].

KM sources revealed non-critical symmetric complementarity. Integrating external with internal knowledge source increased the probability of obtaining a higher level of organizational performance. This result is similar to the findings from a number of empirical studies investigating complementarity between internal and external sources in research and development [45] and in knowledge sourcing [2]. The non-critical symmetry that characterizes this complementarity found in this study implies that high levels of performance can also be achieved by any one of the two strategies in exclusion.

An interesting question raised by this study is why KM focus and KM source dimensions of KM strategy show different complementarity relationships. Prior research has contributed evidence to suggest that the two dimensions are relatively distinct. The tacit and explicit KM strategies that comprise the KM focus dimension require relatively different patterns of organizational design variables such as human resources, IT configuration, and internal business processes.

Complementarity may be difficult to achieve while integrating the two strategies because achieving the appropriate organizational design pattern that ensures high levels of performance can pose serious difficulties under these conditions. In contrast, comprehensiveness in knowledge acquisition is one of the most important considerations for KM strategy adoption from a KM source perspective [45]. Integrating internal and external-oriented strategies facilitates greater comprehensiveness resulting in higher levels of performance implying a complementary relationship between the two strategies.

Combining the tacit-internal and explicit-external-oriented KM strategies indicated asymmetric complementarity relationship. The results can benefit managers by offering insights that may help them enhance the organizational performance impact of their KM strategies. This initial exploration employing complementarity theory may be used as a stepping stone for further research.

On the basis of this research, the following future studies may be of interest. First, our proposed method supports only binary variables. It should be extended to deal with continuous variables. In addition, considering more than two strategies simultaneously will be of interest, which would give us a more holistic view of KM strategies. Second, this study uses composite performance measure. Since complementary relationship is very sensitive to performance measure, other types of performance measures may sharpen the results of our study. Such a future study will stimulate development of more elaborate scales and the collection of more comprehensive data. Third, the relationships between KM processes and KM strategies are a lynchpin in improving performance. KM strategies that firms take have a significant influence on KM processes [2]. Therefore, it is essential to identify complementarity relationship among KM factors including KM strategies and processes for attaining high levels of organizational performance.

Appendix A. Operational definitions and related literature

Variables	Operational definition	Related literature
Explicit-oriented	Degree of knowledge codification knowledge acquisition in codified forms documentation knowledge sharing through codified forms	Bierly and Chakrabarti [6] Hansen et al. [4] Jordan and Jones [46] Swan et al. [21] Zack [2]

Variables	Operational definition	Related literature
Tacit-oriented	Degree of knowledge acquisition from experts and co-workers face-to-face help by experts informal dialogues for knowledge sharing knowledge acquisition by one-to-one mentoring	Bierly and Chakrabarti [6] Hansen et al. [4] Jordan and Jones [46] Nonaka and Takeuchi [31] Zack [2]
External-oriented	Degree of knowledge from customers knowledge from analysis of competitors preference of knowledge through external consulting knowledge from collaboration or alliance scan for competitor's knowledge	Bierly and Chakrabarti [6] Grant [47] Nevis et al. [48] Zack [2]
Internal-oriented	Degree of perceived importance of internal knowledge to create new knowledge frequency of using internal knowledge for developing new knowledge trust for internal knowledge resource usefulness for internal knowledge resource quality and quality for internal knowledge resource preference of internal knowledge	Bierly and Chakrabarti [6] Cohen and Levinthal [49] Nevis et al. [48] Zack [2]
Corporate performance	Degree of overall success market share growth rate profitability innovativeness in comparison with major competitors	Deshpande et al. [33] Drew [34]

Appendix B. Questionnaire items

Knowledge definition provided to survey respondents

Here, *knowledge* means *the idea, know-how, technical skill, problem-solving methods, or something that is helpful in solving problems in the organization.*

(1) KM strategy

Explicit-oriented degree (Adopted from Choi and Lee [9])

Definition	The degree of codifying and storing organizational knowledge to access and use it. It measures knowledge codification, knowledge acquisition and sharing in codified forms, and documentation.
Instruction	Please check the number corresponding to the degree of explicit-oriented of your company in conjunction with each of following questions [scale ranges from one (lowest) to six (highest)].
Items (EX)	<ol style="list-style-type: none"> 1. Knowledge (idea, know-how, technical skill, problem solving methods, or etc.) is well codified in my company. 2. Knowledge can be acquired easily through formal documents and manuals in my company. 3. Results of projects and meetings should be documented in my company. 4. Knowledge is shared in codified forms like manuals or documents in my company.

Tacit-oriented degree (Adopted from Choi and Lee [9])

Definition	The degree of acquiring and sharing tacit knowledge through interpersonal interaction. The tacit-oriented degree measures the level of knowledge acquisition from experts and co-workers, face-to-face help by experts, informal dialogues for knowledge sharing, and knowledge acquisition through one-on-one mentoring.
Instruction	Please check the number corresponding to the degree of tacit-oriented of your company in conjunction with each of the following questions [scale ranges from one (lowest) to six (highest)].
Items (TA)	<ol style="list-style-type: none"> 1. Knowledge is easily acquired from experts and co-workers in my company. 2. It is easy to get face-to-face advice from experts in my company. 3. Informal dialogues and meetings are important methods for knowledge sharing in my company. 4. One-to-one mentoring is frequently used for knowledge acquisition in my company.

External-oriented (Adopted from Lee et al. [7])

Definition	The degree to which company seeks knowledge from outside the company in developing new knowledge (e.g., products or services). Common sources of external knowledge include publications, consultants, interorganizational alliances, competitors, customers, and knowledge brokers. External-oriented measures amount of knowledge from customers and collaborator, analysis of competitors and their knowledge, and preference of external knowledge.
Instruction	Please check the number corresponding to the degree of external-oriented of your company in conjunction with each of the following questions [scale ranges from one (lowest) to six (highest)].
Items (EX)	<ol style="list-style-type: none"> 1. A large portion of new knowledge in my company has been developed on the basis of customers' knowledge. 2. A large portion of new knowledge in my company has been developed through analysis of competitors' knowledge (e.g., products or services). 3. My company prefers external consulting companies' knowledge to internal departments' one in developing new knowledge. 4. A large portion of new knowledge in my company has been developed through collaboration and alliance with external institutions or organizations. 5. My company periodically checks competitors' strategy and products (services) to get new knowledge.

Internal-oriented degree (Adopted from Lee et al. [7])

Definition	The degree to which company depends on internal knowledge in developing new knowledge (e.g., products or services). Internal knowledge may be resident organizational members' brain, embedded in members' behaviors, software and equipment, and so on. It measures the perceived importance, trust, usefulness, superiority, and quality and quantity for internal knowledge and frequency of using internal knowledge.
Instruction	Please check the number corresponding to the degree of internal-oriented of your company in conjunction with each of the following questions [scale ranges from one (lowest) to six (highest)].
Items (TA)	<ol style="list-style-type: none"> 1. Internal knowledge is important resource to create new knowledge in my company. 2. Internal knowledge is frequently used for developing knowledge in my company. 3. Internal knowledge is trustable resource for developing new knowledge in my company. 4. Internal knowledge is core resource to create new knowledge in my company. 5. The quantity and quality of knowledge created internally are superior to those of competitors for developing new knowledge. 6. My company prefers internal knowledge to external one in developing new knowledge.

(2) **Corporate performance** (Adopted from Deshpande et al. [33], Drew [34])

Definition	The degree to which companies achieved its business objectives. Corporate performance measures overall success, market share, growth rate, profitability, and innovativeness compare with key competitors.
Instruction	Please check the number corresponding to the degree of explicit-oriented of your company in conjunction with each of following questions [scale ranges form one (lowest) to six (highest)].
Items (CP)	Compared with key competitors, my company 1. ... is more successful. 2. ... has greater market share. 3. ... is growing faster. 4. ... is more profitable. 5. ... is more innovative.

References

- [1] Sarvary M. Knowledge management and competition in the consulting industry. *California Management Review* 1999;41(2):95–107.
- [2] Zack MH. Developing a knowledge strategy. *California Management Review* 1999;41(3):125–45.
- [3] Earl M. Knowledge management strategies: toward a taxonomy. *Journal of Management Information Systems* 2001;18(1): 215–33.
- [4] Hansen M, Nohria N, Tierney T. What's your strategy for managing knowledge? *Harvard Business Review* 1999;77(2):106–16.
- [5] Zack MH. Managing codified knowledge. *Sloan Management Review* 1999;40(4):45–58.
- [6] Bierly P, Chakrabarti A. Generic knowledge strategies in the US Pharmaceutical industry. *Strategic Management Journal* 1996;17:123–35.
- [7] Lee H, Chang Y, Choi B. Analysis of effects of knowledge management strategies on corporate performance. *Korea Intelligent Information Journal* 1999;5(2):99–120.
- [8] Pai DC. Knowledge strategies in Taiwan's IC design firms. *Journal of American Academy of Business, Cambridge* 2005;7(2):73–7.
- [9] Choi B, Lee H. An empirical investigation of KM styles and their effect on corporate performance. *Information & Management* 2003;40:403–17.
- [10] Milgrom P, Roberts J. The economics of modern manufacturing: technology, strategy, and organization. *American Economic Review* 1990;80(3):511–28.
- [11] Milgrom P, Roberts J. Complementarities of fit: strategy, structure, and organizational change. *Journal of Accounting and Economics* 1995;19:179–208.
- [12] Edgeworth FY. *Mathematical psychics: an essay on the application of mathematics to the moral sciences*. London: Kegan Paul; 1881.
- [13] Black SE, Lynch LM. How to compete: the impact of workplace practices and information technology on productivity. *Review of Economics and Statistics* 2001;83(3):434–45.
- [14] Bresnahan T, Brynjolfsson E, Lorin MH. Information technology, workplace organization, and the demand for skilled labor: firm-level evidence. *Quarterly Journal of Economics* 2002;117(1):339–76.
- [15] Whittington R, Pettigrew A, Peck S, Fenton E, Conyon M. Change and complementarities in the new competitive landscape: a European panel study, 1992–1996. *Organization Science* 1999;10(5):583–600.
- [16] Huang X, Sinha KK, Dong Y. Complementarities between in-store and supply chain technologies in retail operations: an empirical analysis. Working Paper; 2004.
- [17] Schoonhoven CB. Problems with contingency theory: testing assumptions hidden within the language of contingency 'theory'. *Administrative Science Quarterly* 1981;26(3): 349–77.
- [18] Barua A, Kriebel CH, Mukhopadhyay T. Information technologies and business value: an analytic and empirical investigation. *Information Systems Research* 1995;6(1):3–23.
- [19] Keskin H. The relationships between explicit and tacit oriented KM strategy, and firm performance. *Journal of American Academy of Business, Cambridge* 2005;7(1):169–75.
- [20] Schulz M, Jobe LA. Codification and tacitness as knowledge management strategies: an empirical exploration. *Journal of High Technology Management Research* 2001;12(1):139–65.
- [21] Swan J, Newell S, Robertson M. Limits of IT-driven knowledge management for interactive innovation processes: towards a community-based approach. In: Schriver B, Sprague RH, editors. *Hawaii international conference on system sciences*. Los Alamitos, CA, Maui HI: IEEE Computer Society Press; 2000.
- [22] Lina C, Tseng S-M. Bridging the implementation gaps in the knowledge management system for enhancing corporate performance. *Expert Systems with Applications* 2005;29: 163–73.
- [23] Ferratt TW, Agarwal R, Brown CV, Moore JE. IT human resource management configurations and IT turnover: theoretical synthesis and empirical analysis. *Information Systems Research* 2005;16(3):237–55.
- [24] Premkumar G, Ramamurthy K, Saunders CS. Information processing view of organizations: an exploratory examination of fit in the context of interorganizational relationships. *Journal of Management Information Systems* 2005;22(1):257–94.
- [25] Segars AH, Grover V. The industry-level impact of information technology: an empirical analysis of three industries. *Decision Sciences* 1995;26(3):337–68.
- [26] Hair Jr JF, Anderson RE, Tatham RL, Black WC. *Multivariate data analysis with readings*. Englewood Cliffs, NJ: Prentice-Hall; 1995.

- [27] Jain H, Ramamurthy K, Ryu HS, Yiisai-Ardekani M. Success of data resource management in distributed environments: an empirical investigation. *MIS Quarterly* 1998;22(1):1–23.
- [28] Topkis DM. Minimizing a submodular function on a lattice. *Operations Research* 1978;26:305–21.
- [29] Han J, Kamber M. Data mining: concepts and techniques. San Francisco, CA: Morgan Kaufmann; 2001.
- [30] Maeil Business Newspaper. Annual corporation reports. Maeil Business Newspaper Co.; 2000.
- [31] Nonaka I, Takeuchi H. The knowledge creating company. New York: Oxford University Press; 1995.
- [32] Amabile T, Conti R, Coon H, Lazenby J, Herron M. Assessing the work environment for creativity. *Academy of Management Journal* 1996;39(5):1154–84.
- [33] Deshpande R, Jarley U, Webster F. Corporate culture, customer orientation, and innovativeness in Japanese firms: a quadrad analysis. *Journal of Marketing* 1993;57:23–37.
- [34] Drew S. From knowledge to action: the impact of benchmarking on organizational performance. *Long Range Planning* 1997;30(3):427–41.
- [35] Banker RD, Kauffman RJ, Morey RC. Measuring gains in operational efficiency from information technology: a study of the Positran deployment at Hardee's Inc. *Journal of Management Information Systems* 1990;7(2):29–54.
- [36] Kerlinger FN. Foundations of behavioral research. New York: Holt, Rinehart, and Winston; 1964.
- [37] Cook M, Campbell DT. Quasi-experimentation: design and analysis issues for field settings. Boston: Houghton Mifflin; 1979.
- [38] Comrey AL. A first course in factor analysis. New York: Academic Press; 1973.
- [39] Jasimuddin SM, Klein JH, Connell C. The paradox of using tacit and explicit knowledge: strategies to face dilemmas. *Management Decision* 2005;43(1):102–12.
- [40] Edwards JS, Handzic M, Carlsson S, Nissen M. Knowledge management research and practice: visions and directions. *Knowledge Management Research* 2003;1(1):49–60.
- [41] Kim L. The multifaceted evolution of Korean technological capabilities and its implications for contemporary policy. *Oxford Development Studies* 2004;32(3):341–63.
- [42] Bloodgood JM, Salisbury WD. Understanding the influence of organizational change strategies on information technology and knowledge management strategies. *Decision Support Systems* 2001;31:55–69.
- [43] Ebben JJ, Johnson AC. Efficiency, flexibility, or both? evidence linking strategy to performance in small firms. *Strategic Management Journal* 2005;26:1249–59.
- [44] Lewis MW. Exploring paradox: toward a more comprehensive guide. *Academy of Management Review* 2000;25:760–77.
- [45] Cassiman B, Veugelers R. In search of complementarity in the innovation strategy: internal R&D and external knowledge acquisition. *Management Science* 2006;52(1):68–82.
- [46] Jordan J, Jones P. Assessing your company's knowledge management style. *Long Range Planning* 1997;30(3):392–8.
- [47] Grant RM. Toward a knowledge-based theory of the firm. *Strategic Management Journal* 1996;17(Winter Special Issue):109–22.
- [48] Nevis EC, Anthony DJ, Gould JM. Understanding organizations as learning systems. *Sloan Management Review* 1995;Winter: 73–85.
- [49] Cohen WM, Levinthal DA. Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly* 1990;35:128–52.