

Beyond ERP implementation: The moderating effect of knowledge management on business performance

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The implementation of an enterprise resource planning (ERP) system is known to be time consuming and resource demanding. The success rate of implementation has been notoriously low. This may be attributed to the contextual factors of the implementing organisation. Previous studies of the success factors of ERP system implementation often overlook the contextual factors of post-implementation maintenance and knowledge management. This study intends to examine the extent to which these two contextual factors affect the performance of a business. In this study, we classify post-implementation into system maintenance and data maintenance. A sample of 600 large firms in Taiwan was surveyed and 110 usable questionnaires were collected. Using regression analysis to test the hypotheses, we found that post-implementation maintenance of an ERP system has significant influence on the performance of a business. Furthermore, system maintenance has a significant direct effect on business performance and the moderating effect of knowledge management strengthens the relationship between data maintenance and business performance.

Keywords: ERP implementation; post-implementation maintenance; system maintenance; data maintenance; knowledge management; business performance

1. Introduction

Since its advent in the early 1990s, the enterprise resource planning (ERP) system has become the nerve centre of today's businesses. An ERP system consists of many different components which access and process data across business functions and physical boundaries. The complexity of the system is beyond human comprehension and requires a team of knowledge workers to maintain the system beyond its implementation. A successful ERP system is one that supports the goals and strategies of a business and provides sustainable benefits to business (Keen, 1991; Neumann, 1994). It is well known that successful implementation of an ERP system may bring immediate benefits to a business; however this effect may not last long. As time goes by, changes in the environment, turnover of members, and variations of customer demands may significantly impact the existing processes and operations of a business. If the ERP is unable to adapt to and cope with these changes, its effectiveness is likely to disappear (Sheu, Yen, & Krumwiede, 2003), and this in turn diminishes business performance. Robbins-Gioia (2002) surveyed 100 enterprises and discovered that 46% enjoyed the benefits of ERP at the beginning of

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post-implementation but were unable to maintain business performance in the long run. A survey of 117 executives conducted by the Conference Board in 2001 revealed that 40% of ERP projects failed to achieve their business case after one year of going live. Additionally, 75% of the firms felt a moderate to severe productivity dip after implementing ERP (Peterson, Gelman, & Cooke, 2001). Therefore, successful implementation of an ERP system does not guarantee the long-term performance of a business. There are other factors that help an enterprise sustain the positive effect of an ERP system.

Previous studies of factors affecting ERP implementation have identified several key success factors (KSF), such as support of top management, software integration, cost of implementing ERP, employee training, user participation, and effective project team (Bingi, Sharma, & Godla, 1999; Laughlin, 1999; Mandal & Gunasekaran, 2003; Marlene, 1999; Oliver, 1999; Willcocks, 2000). Besides these implementation factors, what are the organisational and systemic conditions on which the long-term effect of an ERP system depends? We surveyed the related literature to find possible factors that sustain information system effectiveness and in turn the business performance. One plausible factor we found is proper maintenance after a system implementation, as recommended by Shelly, Cashman and Rosenblatt (2001). This factor, according to Forger (2000), should include data maintenance and system maintenance.

Moreover, the complexity of an ERP system calls for intensive interactions among ERP team members and with system users. All these interactions involve constant knowledge creating, sharing, extraction, preservation, and learning among members. It is therefore necessary to use a well-structured knowledge management mechanism to support these interactions and reduce the impact of the 'brain drain' caused by the exit of team members (Becerra-Fernandez & Sabherwal, 2001; Davenport & Klahr, 1998; Hendriks, 1999). With an effective knowledge management mechanism an enterprise would have a better chance of operating its ERP system and sustaining its business performance effectively.

Following the previous discussion, the purpose of this study is two-fold: (1) to explore whether post-implementation maintenance of an ERP system has a positive and significant impact on business performance; and (2) to examine whether a knowledge management mechanism can foster the effect of post-implementation maintenance of an ERP system on business performance.

2. Literature review and hypotheses

2.1. Enterprise resource planning (ERP)

Enterprise resource planning (ERP) was first introduced by the Gartner Group in the early 1990s. It is an outgrowth of material requirement planning (MRP) and manufacturing resource planning (MRP II). According to the American Production and Inventory Control Society (APICS), ERP is a financial accounting oriented information application system, which can effectively integrate and plan for the resources (including resources for purchasing, production, distribution, and logistic operations) required to satisfy customer orders so as to increase the overall business performance (Mraz, 2000).

2.2. Post-implementation maintenance

ERP is essentially a management information system with online transaction processing capability that generates voluminous data. It differs from a decision support system in its real-time operations and level of integration and flexibility. Through ERP systems,

enterprises can integrate information flows generated from individual departments, unify internal information processing processes, and allow real-time access to databases distributed in various locations. Once generated, all the business information can be reused and shared in the system, creating the need for efficient data storage and production of information. This need calls for effective post-implementation maintenance.

During post-implementation maintenance, users are first required to add, delete, or update data entries according to corporate standards for the other users to access. These data entries, along with automated transaction processing data, are stored in, retrieved from, and updated to an integrated database system. These voluminous data are further analysed through logic analysis, statistical calculation, and aggregation to assist enterprises in developing business strategies. When setting up the maintenance after ERP implementation, one must have sufficient data sources, otherwise information cannot be instantly delivered through the system maintenance and data maintenance to enterprises for decision-making activities. After the system has been implemented, user proposals for modifications or additions according to user on-site operations, experience, and knowledge serve as feedback that improves system performance (Shelly et al., 2001). Therefore, the ability and effectiveness of system maintenance to produce real-time integrated information and the validity and integrity of data maintenance both contribute to the effectiveness of ERP performance. This study thus defines the construct of post-implementation maintenance of an ERP system as the quality of system maintenance and data maintenance, following the approach of Forger (2000). The former factor refers to data input and output, system modification and enhancement, and system infrastructure. The latter refers to data processing functions, database integration, and data quality management.

2.3. Performance of business

An ERP system brings numerous competitive advantages to enterprises, including the reduction of business cost, quick response to customers, and the acceleration of corporate connections, among others (Cronin et al., 1994; Koushik & Pete, 2000). It helps simplify work processes, hasten corporate responses, increase validity and timeliness of data, and reduce secretarial work processes (Bingi et al., 1999). It can also improve output sales value and lower inventory turnover rate (Dykeman, 1997). When the value chain of the Internet is applied to marketing and product-related research, an ERP system may effectively increase an enterprise's market share, reduce marginal cost, and boost customer satisfaction (Cronin et al., 1994). All these effects contribute to the performance of a business and can be classified into two categories: internal process performance and financial performance. In essence, internal process performance refers to the simplification of work processes, improvement of data validity and instantaneity, and the growth of internal communication efficiency. Financial performance refers to the increase of output sales value, reduction of inventory turnover, increase of receivables turnover, and growth of profit margin. Based on the preceding discussion, we propose Hypothesis 1:

Hypothesis 1: Post-implementation maintenance of an ERP system has a positive and significant impact on business performance.

2.4. Knowledge management

The benefits of knowledge management for the performance of an organisation have been empirically investigated and verified by many researchers in recent years

(Becerra-Fernandez & Sabherwal, 2001; Jayachandran, Sharma, Kaufman, & Raman, 2005). Through effective creation, storage, learning, dissemination, and sharing of knowledge, the performance of a business can be improved (Gold, Malhotra, & Segars, 2001; Lee, Chae & Suh, 2004; Mutiran & Mohamed, 2003). An effective ERP system requires system users to follow its prescribed processes and routinely enter structured data. The data are later stored into an integrated data warehouse and shared by all users. This data warehouse is a major source of explicit knowledge in the knowledge management system. Conversely, post-implementation maintenance of an ERP system requires tacit knowledge to achieve target quality. From a more proactive perspective, a knowledge management mechanism permits ERP users to systematically absorb and accumulate related knowledge, rectify and update their knowledge, and further improve the effect of post-implementation maintenance on business performance. Based on the above discussion, the following hypothesis is postulated:

Hypothesis 2: The interaction between post-implementation maintenance and knowledge management mechanism has a positive influence on the performance of business.

3. Research model

Based on the two hypotheses postulated in the last section, we propose a research model as exhibited in Figure 1. In this model, we first investigate the role of post-implementation maintenance and its impact on the performance of business. Furthermore, we examine the role of knowledge management and its interaction with post-implementation maintenance to determine whether it significantly affects the performance of business after ERP implementation. The operationalisation of the three constructs is as follows. Based on the concepts from Forger (2000) and Shelly et al. (2001), we define the construct of post-implementation maintenance as consisting of two variables: system maintenance and data maintenance. According to the perspective of Gold et al. (2001), the construct

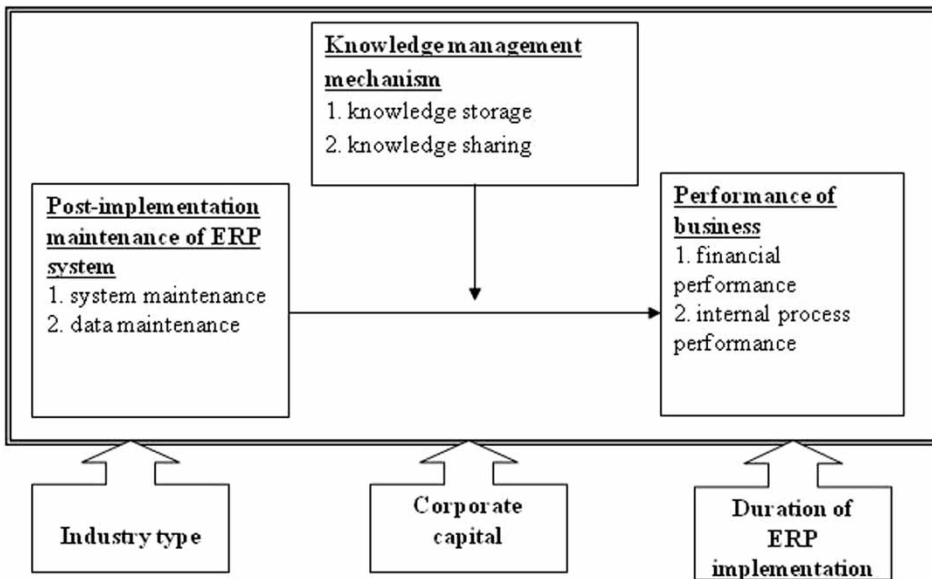


Figure 1. The research model.

of the knowledge management mechanism is defined as composed of the knowledge storage mechanism and the knowledge sharing mechanism. Moreover, we define the construct of business performance as comprising financial performance and internal process performance, following Cronin et al. (1994), Dykeman (1997), Bingi et al. (1999), and Koushik and Pete (2000). Finally, three control variables are included in the model: industry type, corporate capital, and duration of ERP implementation. These variables are known to affect the performance of a business (Bradford & Florin, 2003; Fichman, 2000; Fichman & Kemerer, 1997).

4. Research method

4.1. Measures of constructs

4.1.1. Post-implementation maintenance

The measurement items for this construct are all evaluated on a seven-point Likert scale, a total of 15 items are included in this construct. For a detailed list of these items and their sources, please refer to Table 1. In this table, the first nine items measure system maintenance while the latter six items measure data maintenance.

4.1.2. Knowledge management mechanism

Likewise, the measurement items of this construct are all evaluated on a seven-point Likert scale, and a total of 10 items are included in this construct. Table 2 contains a detailed list of these items and their sources. While the first four items measure knowledge sharing, the latter six items measure knowledge storage.

4.1.3. Performance of business

Finally, a total of 10 items, as listed in the Table 3, measure the construct of business performance. The first six items measure internal-process performance while the latter four items measure financial performance. All items are evaluated on a seven-point Likert scale.

4.1.4. Basic data of the companies

In addition to the data for measuring the constructs, we also collected some demographical data from the sample, such as the title of the respondent, industry that the company belongs to, capital value of the company, how many years the ERP system has been implemented in the company, and the name of the ERP system.

4.2. Sampling design and survey subjects

In this study, sampling was conducted on enterprises that have implemented ERP systems. To ensure the generalisation of the survey results, cross-industry samples were used. Firms were sampled from manufacturing and service companies listed in *The Directory of Corporations in Taiwan*, published by China Credit Information Service (Anonymous, 2008). The sample contains the top 500 firms in the manufacturing industry and the top 100 firms in the service industry. ERP implementation was confirmed with each selected firm by telephone, and the questionnaires were later delivered via electronic mail to those who implemented ERP. Recipients of the questionnaire were users of the ERP systems.

Table 1. Measures of post-implementation maintenance.

System maintenance	Sources
1. New data generated after ERP implementation provide efficient and extensive information to employees	Swanson and Beath (1989); IEEE Std 1219 (1993);
2. The ERP system is capable of modifying information systems and providing suggestions	Krogstie (1995); Pressman (1997);
3. The ERP system is capable of initiating new constructions to cope with specific demands of customers in various locations	Brehm, Heinzl and Markus (2001); Shelly et al. (2001); This study
4. The ERP system architecture can be adjusted according to the administrative and operational processes of your company	
5. Old data converted after ERP implementation provide efficient and extensive information to employees	
6. New functions can be added according to the organizational goals and strategies	
7. Each department is required to follow a clear guideline when performing data input	
8. The operation interface on the ERP system is designed according to the planning process from bottom to top and is compliant with the practical operations of the system development	
9. A good data warehouse is available to facilitate inquiries and provide reference for decision-making	
Data maintenance	Sources
10. The report generation and data response speed is fast	Ives, Olson and Baroudi (1983);
11. Incorrect data input can be instantly discovered by ERP	Bailey and Pearson (1983); Hoven (1998);
12. Any update of record will be recorded for future inspection	Inmon, Rudin, Buss and Sousa (1999); Chen, Soliman, Mao and Frolick (2000);
13. The data warehouse has effectively integrated the data about upstream and downstream firms on the supply chain through conversion rather than manual key-in	Forger (2000); Watson, Annino, Wixom, Avery and Rutherford (2001);
14. In addition to the required columns, ERP users in your company will also fill out the note column in detail for future inspection	Vassiliadis, Quix, Vassiliou and Jarke (2001);
15. The ERP system ensures high instantaneity and precision of data	Shelly et al. (2001); This study

They were asked in person over the phone to confirm whether they received the questionnaire and urged to return their responses so as to increase the final response rate. A total of 384 questionnaires were distributed to the qualified firms, and 116 copies were collected. Excluding six invalid questionnaires, 110 were valid and usable, giving a valid response rate of 29%. Table 4 presents the profile of the valid samples.

5. Data analysis and discussion

5.1. Reliability and validity analyses

5.1.1. Reliability analysis

For reliability analysis, Cronbach's alpha was computed to verify the reliability of each factor. The standardised alpha values of system maintenance and data maintenance

Table 2. Measures of knowledge management construct.

Knowledge sharing	Sources
1. Proper measures have been set up to promote cross-department knowledge sharing	Nelson and Coopriider(1996); Jarvenpaa and Staples (2000);
2. Experienced users or experts of the ERP system are frequently invited to share their knowledge	Bock and Kim (2002); Bock, Zmud, Kim and Lee (2005)
3. When your colleagues learn to use the ERP system, system users will exchange opinions and discuss with each other to more effectively learn how to operate the system	This study
4. The knowledge required for the work can be easily acquired from experts or coworkers	
Knowledge storage	Sources
5. The SOP data are securely stored and convenient for inquiries after ERP implementation	Leonard-Barton (1995); Nonaka and Takeuchi (1995);
6. In your company, knowledge is shared in the forms of user manual, document or other graphic or text-based media	Davenport and Klahr (1998); Shin, Holden and Schmidt (2000); Tiwana (2001)
7. All kinds of ERP reference documents are properly provided in your company	This study
8. The ERP system used in your company can record the experience and knowledge of users as a reference for others	
9. The ERP system users in your company will spontaneously save their experiences and share with colleagues	
10. Your company has applied information technologies for employees to instantly consult and learn knowledge from	

Table 3. Measures of business performance construct.

Internal processes performance	Sources
1. The ERP system will process the daily business data to enhance correctness and instantaneity of information	DeLone and McLean (1992);
2. A unified language is used to reduce the cost of internal communication	Cronin et al. (1994); Dykeman (1997);
3. Processes are improved to make all departments use consistent forms and processes	Bingi et al. (1999); This study
4. The ERP system can rapidly signal abnormal problems and enforce the internal cost control	
5. The visibility of information is enhanced for enterprises in various locations to transmit information smoothly	
6. The reports provided by the ERP system can reduce the waste of human resources and time	
Financial performance	Sources
7. Increase of inventory turnover	Gatian (1994);
8. Increase of receivable turnover	Cronin (1995);
9. Decrease of cost of human resources and increase of productivity	Koushik and Pete (2000);
10. Increase of profit margin	This study

Table 4. The profile of valid samples.

		Total	
		Number of firms	Percentage
Industry type	Manufacturing	90	77.5%
	Service	20	23.5%
Capital	<\$200 million	18	16.4%
	\$200 million ~ \$1 billion	34	30.9%
	\$1 ~ 5 billion	16	14.5%
	\$5 ~ 10 billion	9	8.2%
	>\$10 billion	33	30.0%
Duration of ERP implementation	<1 year	5	4.5%
	1 ~ 2 years	7	6.4%
	2 ~ 3 years	18	16.4%
	3 ~ 5 years	34	30.9%
	>5 years	46	41.8%

were respectively 0.858 and 0.838. Those of knowledge sharing and knowledge storage were respectively 0.793 and 0.815. Finally, those of financial performance and internal processes performance were respectively 0.7672 and 0.8171. All these values were greater than 0.7, indicating acceptable internal reliability (Nunnally, 1978).

5.1.2. *Validity analysis*

To test the construct validity of the questionnaire, factor analysis was performed on each construct. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy test (Kaiser, 1974) and Bartlett's (1950) sphericity test were carried out to evaluate the adequacy of each item. According to Kaiser (1974), a KMO value less than 0.5 indicates that the item is inadequate for factor analysis. The results showed that all the items had a measure above 0.8, indicating the partial correlation among items was low and a high degree of collinearity was absent. Bartlett's test also showed that all the measures reached the level of significance ($p < 0.000$), indicating that a common factor was present. Therefore, the designed scale was appropriate for factor analysis.

The method of principal component analysis was applied to extract the principal factor of each construct. Kaiser's (1958) rule of an eigenvalue greater than 1 and factor loading greater than 0.5 was adopted. The resulting factor analysis revealed that all the items had a factor loading greater than 0.5 and complied with the criterion of lowest absolute value greater than 0.5. In addition, the item-total correlation of all the items is greater than 0.5, which also met the criterion suggested by Kerlinger (1986). The operational definitions for each construct satisfied the requirement of construct validity.

5.2. *Test of hypotheses*

Before testing the hypotheses, we divided the 110 companies into two groups: a group of 64 companies with ERP implemented within five years and another group of 46 companies with ERP implemented over five years ago. After testing the mean values of all the variables between these two groups, no significant difference was found. The age of ERP implementation obviously does not affect the responses of participants. Therefore, all 110 samples were treated as one group in the subsequent statistical analysis.

5.2.1. *Hypothesis 1: Post-implementation maintenance of an ERP system has a positive and significant impact on the performance of business*

In this section, the impact of the post-implementation maintenance on the performance of business is explored. The result of regression analysis shows that system maintenance ($\beta = .387, p < 0.001$) and data maintenance ($\beta = .359, p < 0.001$) have significant influence on the internal-process performance. The result of the second regression model shows that system maintenance ($\beta = .287, p < 0.01$) and data maintenance ($\beta = .308, p < 0.01$) have significant influence on the financial performance. Overall, post-implementation maintenance of the ERP system has a positive and significant impact on the performance of business, as shown in Table 5. Meanwhile, none of the control variables has significant influence on any performance factor.

5.2.2. *Hypothesis 2: The interaction between post-implementation maintenance and knowledge management mechanism has a positive influence on the performance of business*

Next, the interaction between the knowledge management mechanism and post-implementation maintenance of ERP system on the performance of business is explored. After adding the knowledge management mechanism as the moderating variable, the result of Model 6 in Table 6 shows that the interaction between knowledge sharing and data maintenance ($\beta = .359, p < 0.01$) has a significant influence on the financial performance. Note that models 1 and 4 in Table 6 correspond to the two regression models in Table 5.

In a further analysis of the interaction, the mean values of 'knowledge sharing' and 'data maintenance' were clustered into high and low groups and converted into a dummy variable to construct a graph of the interaction between the independent variable and the moderator variable (see Figure 2). In this figure, business performance is measured by the composite average of the two performance factors. As shown in Figure 2, the two regression lines are not in parallel. This indicates that knowledge sharing may influence the relationship between data maintenance and performance of business. If knowledge sharing in an organisation is adequate, the relationship between data maintenance and the performance of business may be enhanced, and vice versa. In other words, knowledge sharing will moderate the effect of data maintenance on the performance of the business.

Table 5. Results of regression analyses of post-implementation maintenance of the ERP system on the performance of business.

Independent variable	Dependent variable	
	Internal-process performance	Financial performance
Industry type	0.044	0.018
Corporate capital	-0.023	0.040
Duration of implementation	-0.040	-0.067
	<i>Post-implementation maintenance</i>	
System maintenance	0.387***	0.287**
Data maintenance	0.359***	0.308**
R ²	0.440	0.290
Adjusted R ²	0.413	0.256
F value	16.364***	8.507***
Dubin-Watson	2.159	1.620

** $p < 0.01$; *** $p < 0.001$.

Table 6. Results of hierarchical regression analyses of post-implementation maintenance and knowledge management on the performance of business.

Independent variable	Dependent variable					
	Internal-process performance			Financial performance		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Industry type	0.044	0.040	-0.040	0.018	0.030	0.002
Corporate capital	-0.023	-0.032	-0.075	0.040	0.017	-0.002
Duration of implementation	-0.040	-0.038	-0.039	-0.067	-0.062	-0.068
	<i>Post-implementation maintenance</i>					
System maintenance	0.387***	0.356**	0.353	0.287**	0.210	0.282**
Data maintenance	0.359***	0.341**	0.355	0.308**	0.263**	0.192
	<i>Knowledge management</i>					
Knowledge sharing		0.034	0.040		0.086	0.160
Knowledge storage		0.053	0.029		0.132	0.044
Knowledge sharing × System maintenance			-0.057			-0.216
Knowledge sharing × Data maintenance			0.056			0.359**
Knowledge storage × System maintenance			0.011			0.226
Knowledge storage × Data maintenance			0.015			-0.200
R ²	0.440	0.444	0.447	0.290	0.315	0.375
Adjusted R ²	0.413	0.406	0.385	0.256	0.268	0.305
F value	16.364***	11.648***	7.201***	8.507***	6.688***	5.350***
Dubin-Watson		2.175			1.731	

** $p < 0.01$; *** $p < 0.001$.

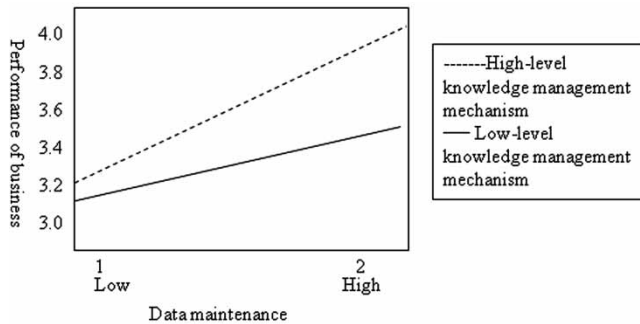


Figure 2. Interaction between knowledge management and post-implementation maintenance.

Moreover, system maintenance has a significant impact on financial performance, but not on internal-process performance. None of the demographical control variables (industry type, corporate capital, and duration of implementation) has significant influence on any performance factor.

6. Conclusions and recommendations

In this study, we explore the effect of knowledge management on the successful implementation of ERP in an enterprise. The results show that post-implementation

maintenance of an ERP system has a positive effect on business performance and that knowledge management has a significant moderating effect on the relationship between ERP post-implementation maintenance and business performance. This implies that if the knowledge of organisational members is effectively stored but not further shared with other members, knowledge is only statically stored in the organisation and cannot amplify the effects of post-implementation maintenance on the performance of business. This finding confirms the results of previous studies such as Tiwana and Keil (2006) and Patnayakuni, Rai and Tiwana (2007).

In addition, the knowledge management mechanism has a positive effect on only financial performance, not on the internal process performance, through data maintenance. It appears that the direct impact of system maintenance on the financial performance (such as increase of profit rate) is greater than that on the internal-process performance (such as accelerating responses to customers and improving operational efficiency). However, its impact is not as good as that of data maintenance interacting with knowledge sharing. This is to our expectation because knowledge sharing with proper data maintenance is very likely to improve the decision making quality, and in turn, increase the effectiveness of an ERP system. Financially, this can increase the company profit as a result. For example, the 7-11 stores in Japan collect the daily sales data from their POS system and translate them into marketing information for decision makers to formulate marketing strategy. From the marketing information provided by the POS system, consumer shopping behaviours in different geographical areas can be revealed and used as the references for sales strategy in that particular market. It is very helpful to the organisation in their strategic and business performance. This finding suggests that when an upgrade or construction of a system is considered, attention should be moved from managing the processes in the project to managing the knowledge in the company. Therefore, the most important factor that influences the success or failure of an ERP implementation is the ability of the information technology department to effectively manage organisational knowledge in addition to properly performing post-implementation maintenance. Without effective knowledge management, the ERP system cannot sustain its positive effect on business performance.

7. Limitations and future research

Although we have ensured the absence of potential biases common to survey studies, two limitations remain in this study. First, the study adopted cross-sectional analysis to examine the KSFs of ERP implementation. Research data were collected from various enterprises at the same time to examine the differences in post-implementation maintenance of ERP systems and knowledge management mechanisms and verify the correlation between these factors and the performance of business. These data are static and do not reflect 'how' post-implementation maintenance of an ERP system and a knowledge management mechanism affect the performance of business in the long run. Therefore, future studies could repeat our study to conduct a longitudinal analysis. An individual enterprise could analyse the conditions of the early, middle, and later stages of ERP implementation and determine how these two factors affect the performance of its business in these stages.

Furthermore, there are other factors that might affect business performance. Studies have shown that organisational management mechanisms, such as reward-penalty systems, could affect the work performance of organisational members, and in turn, the enterprise as a whole (Dekker & de Hoog, 2000; Slater & Narver, 1995; Wilkins, Wegen, & de Hoog, 1997). Therefore, future studies could include such organisational

mechanisms along with the existing two factors to explore their interaction effects on business performance.

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