# Meta Analysis of ERP Performance

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## Abstract

With the expectation of seamlessly integrate all information flowing into and out of one company's database, ERP has experienced the fastest growing software adoption. According to Davenport (1998), the wide spread of ERP systems in business organizations in fact can be considered as the most important development in the corporate use of information technology in the 1990s despite that the rise of the Internet has attracted most of the media attention nowadays. In practice, not all ERP systems live up to companies' expectations due to the fact that ERP systems are too complex, very time-consuming, expensive, own logic of workflow embedded software packages. Therefore, the assessment of ERP performance or ERP benefits is always an important managerial challenge. This research aims to investigate the ERP performance reported in the literature. Meta-analysis is performed on published literature to identify what ERP performance or ERP benefits were reported. An analysis framework is also proposed in this research to analyze the reported ERP performance or ERP benefits. It is found that past research emphasized more on the organizational improvement than on individual impact of ERP systems. The research findings suggest individual impact of ERP systems should be also taken into accounts for the overall assessment of ERP performance.

Keywords: Meta-analysis, ERP, ERP performance

## 1. Introduction

Many companies tried to implement enterprise resource planning (ERP) systems to replace their legacy systems in last decade. According to AMR report, in 2001, organizations are expected to invest more than \$47 billion on ERP systems packages. Firms adopted ERP to resolve the Y2K problem, to replace outdated IT infrastructure, or to support future business needs. According to the observation of Ross [13], the performance of ERP project will get worse before it gets better. Organizations should have a clear understanding of the ERP impacts. Just like Davenport [3] warns that "ERP systems can deliver great rewards, but the risks they carry are equally great".

The designs of ERP systems reflect a series of

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assumptions about the way companies operate in general, that is so-called "best practices". The availability of ERP systems for all kinds of industries and organizations offer business an integrated approach to improve their performance. In some cases, ERP will enable a company to operate more efficiently, others do not. ERP often complex itself and require huge investments of money, time and expertise. Managers are now feeling the heat to give proof that the time and money associated with implementing ERP systems were worthy.

However, the short history of widely-adopted ERP systems in business does not indicate a direct link between the money investment in ERP implementation and the performance improvement. Therefore, great care and attention needs to be paid to the performance assessment of ERP implementation in order to find out what process, activities, or area involved do not meet the expected standard.

In this study, we will collect relative ERP systems research articles, and then use meta-analysis to fine out a proper ERP systems evaluation model. Section two will briefly describe the researches on impacts of ERP systems. Then, section three will simply introduce meta-analysis. Next section will discuss how to evaluate ERP success through the viewpoint of its impact on performance and the benefits they bring about. The final section will give a conclusion and discuss the implication to business and organizations.

## 2. Conceptual Background

Palaniswamy and Frank (2000) [11] use case analysis in five manufacturing firms to investigate the enhanced manufacturing performance of ERP systems. There five manufacturing companies are Valenite, Diebold, Leeson, Owens Corning, and Viskase. They conduct interviews with the MIS directors or chief information officers or ERP project leaders. Owens Corning and Viskase implement SAP as their ERP system, while Valenite and Diebold select Baan. However, Leeson chose Oracle as their ERP system.

They find that these companies all benefit from the better cross-functional integration. Even though the system of these five companies chose may be different, they all enhance the manufacturing performance. The significant performance improvement such as reduction in inventory, coordination amount various functions, and information diffusion. They also use various criteria to measure performance, such as coordination in manufacturing. The result shows that implementing ERP systems has many advantages. ERP provide company a more integrated and enhance manufacturing performance.

It still has debate on the contribution of enterprise resource planning (ERP) systems to organization performance. Poston and Grabski (2001) [12] use economic and organization theories as basis to exam how ERP affect the coordination and transaction cost of organization. According to the features of ERP, such as system integration, it can improve organization performance by reducing costs and enhancing decision-making. Based on the organization cost categories proposed and defined by Gurbaxani and Whang (1991), they first discuss how these costs are affected by ERP and match these costs to the appropriate financial statement categories.

Poston and Grabski develop four main hypotheses of this study. First, they assume that the selling, general and administrative costs on revenues before ERP implementation should bigger than the selling, general and administrative costs on revenues after ERP implementation. Then, they hypothesize that cost of goods sold on revenues before ERP implementation should decrease after ERP implementation. Third, they expect that Residual income (RI) would increase after implementing ERP. RI is defined as net operating income less interest (Horngren et al. 1999), to represent the absolute amount of income. Because RI value is generally unavailable from public source, they assume 12% cost of capital to substitute for each firm's RI value. Finally, they suppose that number of employees on revenues before ERP implementation should decrease after ERP implementation. Prior research has indicated that a time lag is necessary for capturing the performance improvements information form technology (Brynjolfsson 1993; Brynjolfsson and Hitt 1993). Therefore, they examine the changes in organization performance from one year before to one, two, and three years after ERP implementation.

The sampling firms were selected that had publicly disclosed ERP adoption from 1980 to 1997, and firms that implemented one of the five ERP packages: SAP, PeopleSoft, Oracle, Baan, and J.D. Edwards. They get firms' cost and revenue information through the COMPUSTAT database and use the ratio of cost to revenues in order to figure out the effects of ERP on the organization. Finally, they filter out 54 firms and remove four firms for outliers. They use paired sample t tests to compare performance ratios after and before ERP implementation.

According to the research results, there is no significant change in costs of revenue until three years after implementing ERP. There is a significant decrease on cost of goods sold to revenue. They find that the decrease of selling, general, and administrative costs of

revenue is not significant, nor does RI. But, there is a significant decrease in the number of employees of revenue in all three time lags. This research gives us an incipient evidence on performance of the ERP implementation and only focus on the financial return of ERP.

User satisfaction is often considered the most widely to measure information systems success (DeLone and McLean 1992). Doll and Torkzadeh (1988) develop a 12-item instrument of End-User Computing Satisfaction (EUCS). The instrument consists of five subscales measuring content, format, accuracy, ease of use and timeliness. Nelson and Somers (2001) [10] believe that users play an important role in ERP implementation. Therefore, they follow and slightly modify the instrument to fit to ERP circumstance. Data collection is via a nationwide mail survey of ERP systems' end users and use 5 point Likert scale for the items. They assess the reliability and validity of the instrument through the factor analysis and calculate the Cronbach's alpha of the subscales. This study represents a first effort to empirically assess user satisfaction of ERP systems.

Soon after roughly testing the reliability of EUCS applied to ERP circumstance, Somers, Nelson, and Karimi (2003) [18] examine the structure, reliability, and validity with the framework of confirmatory factor analysis (CFA). In order to gather data from a wide variety of industry companies with ERP, they use a snowballing technique to sent questionnaires to the chief information officer or other top-level executive at 1,162 firms in United States. Finally, there are 407 usable respondents for further analysis. The results consistent with previous findings and confirm that EUCS can be applied to ERP systems. They also suggest that content and ease of use are important to increase the satisfaction with ERP systems. This study provides a better understanding of the factors that can affect user of ERP system.

Hitt, Wu, and Zhou (2002) [7] try to use statistical evidence to prove that the benefits of ERP implementation exceed the costs and risks. They extend existing data on IT and productivity originally used by Brynjolfsson and Hitt (2000) for research on the relationship between IT investment and productivity growth. Then, they combine these data with firms that implemented ERP system. The data of firms implemented ERP is collected from SAP America's sales database over the time period 1986 to 1998. They use Standard and Poor's Compustat II database to calculate the values, productivity, stock market valuation, and firm performance, that are used to examine the effect of ERP adoption.

They analyze the performance impact of ERP implementation in the perspective of performance ratios, productivity (by using production functions), and stock market valuation (by using Tobin's q). These three performance indicators are calculated by using several models that have been applied in previous work (Hitt and

Brynjolfsson 1996; Brynjolfsson and Yang 1997; Brynjolfsson et al. 2000). Then, they have some hypotheses. First, they assume that the firms that adopt ERP will have better performance than those nonadopter. Second, performance ratios and productivity will drop during implementation and shortly after implementation. Third, stock market valuation will increase at the initiation and completion of implementation. Finally, firms can benefit from increasing the degree of implementation, but may have negative impact at some level of implementation.

They find that ERP adopters have higher performance than nonadopers. The adopters show better performance in terms of sales per employee, profit margins, return on assets, inventory turnover, asset utilization, and accounts receivable turnover. Echo to the observation of Ross (1999), they also find there is a reduction in business performance and productivity in short-term and the market value increase both during and after the adoption.

Cotteleer (2002) [2] utilizes a company's operation data to examine the influence of ERP implementation on operational performance. He wants to determine the implementation of ERP will to converge or diverge in operational performance. This study investigates performance change within three operating divisions (North America, Europe and Asia) of a single firm. Using order lead-time as operational performance, he collected lead-time data covering approximately 113,000 orders from 12 months before through 24 months after ERP adoption.

The results show an initial improvement in lead-time across divisions. Performance began a steady decline across all divisions during the first year after ERP implementation. However, near the end of the first year, the performance tend to reverse upward.

Sedera, Gable, and Chan (2003) [17] conduct two surveys of evaluating ERP success in 27 organizations in Queensland, Australia. These companies had implemented SAP during the second half of the 1990s. They follow the full research cycle proposed by Mackenzie and House (1979) and use a two-phased data collection approach. Firstly, they conduct an exploratory survey to identify ERP success measures. A following confirmatory survey is used to investigate the current status of ERP systems' adopters in Queensland.

They follow the information system success model proposed by DeLone and McLean (1992) and revise the original model to a measurement model for assessing ERP success. In their measurement model, they exclude the use dimension. As DeLone and McLean (1992) mention that usage, either perceived or actual, only can take into account when such use is not mandatory. Because the use of ERP system in their research objective is mandatory, their measurement model consists of system quality, information quality, satisfaction, individual impact, and organizational impact.

After the phase of exploratory survey, they develop a

five constructs and 42 measures and test validation of instrument. They hold series of expert workshops to review and improve the instrument items. Then, they utilize the factor analysis technique with principal component extraction and varimax rotation to test the construct validity. Finally, they identify four dimensions of success: individual impact, organizational impact, information quality, and system quality satisfaction. Study Cronbach's alpha values for all dimensions are high to produce reliability.They revise the information systems success model proposed by Delone and McLean by excluding the 'use' construct. They treat satisfaction as an overall measure of success, rather than as a dimension of success.

Sarkis and Sundarraj (2003) [15] utilize a process-oriented framework to describe the implementation of TI's ERP system. TI expects to implement ERP to standardize processes and information systems as important as to integrate manufacturing, procurement and logistics to support market trends.

TI went through its implementation that lasted over 3 years. After ERP implementation, there were some initial dips in productivity and on-time delivery. The ERP system allowed TI to manufacture and deliver its orders efficiently. They also find that there were better response and inventory reduction. Over 70% of TI's external transactions are executed electronically. According to some factories reports, the output increases of 5-10% and there is up to 15% reduction in work-in-process inventory.

The ERP systems and business-to-business (B2B) electronic commerce technologies may be used independently, organization may benefit by having more than one of them to gain more value provided by each separately. Bendoly and Kaefer (2004) [1] investigate the complementarities between these two technologies. ERP systems provide a seamless integration of business processes. The purpose of implementing B2B working environment is to make inter-organizational communication more efficient and decrease transaction costs.

They basis on the theory of swift even flow, transaction cost, and concept of complementarities to discuss the impact of ERP implementation on the efficiencies of B2B working environment. They assume that the organization implemented ERP systems can perform greater levels of transactional efficiency with B2B e-commerce technologies. Moreover, they suppose that if the organization implements ERP before a B2B working environment is established will has greater levels of transactional efficiency than implement after B2B has already existed.

Their sample population was drawn form the 186 firms that active in an ongoing project. They develop a questionnaire with 10 transactional efficiency items and questions about relative timing of system adoption. There are 115 respondents, 59 are manufacturing firms and 56 are service firms. Then, they use factor analysis to extract

four constructs of transactional efficiency: communications, system development, personnel, and capital.

They use t-test to examine the hypotheses they proposed. As for manufacturing firms, it has significant difference transaction efficiency on communication, system development, and capital if the firms have or do not have ERP systems. As for service firms, it only has different transaction efficiency on communication and system development. This study implicate that organization with ERP systems can perceive better transactional efficiencies.

Tchokogue, Bareil, and Duguay (2005) [19] use case study to present the lessons from a successful implementation of ERP systems. They choose to analyze the implementation of SAP R/3 at Pratt & Whitney Canada (P&WC), which is a large aeronautics firm. The implementation began in June 1996 and ended in January 1999. Two of the authors interview with the P&WC project manager to obtain detailed data of ERP implementation.

The objective of P&WC's ERP implementation is to be new information infrastructure called the Total Enterprise System (TES). They wanted to improve customer response time, reduce work-in-process, increase inventory turnover, and increase visibility of inventory and operating cost. The TES replaced about 35 legacy systems by SAP R/3 system. This implementation project affects more than 3000 employees in all company departments.

After implementing ERP, the inventory level become stable, other improvement such as better materials management, production planning, quality and service. The production start delays of various subsets are significantly reduced by TES. Other tangible benefits such as cost saving, increasing productivity, reducing receivable days, achieving return-on-investment, and increase visibility into inventory costs. This study provides evidence of successful implementation of ERP.

## 3. Meta-analysis

In order to research into an issue or a phenomenon, it needs to collect the result of past research to get an objective finding and conclusion. Not like engineering and electronic science, social science can not use an experiment to control some variables to find out their real relationship between variables. Therefore, we can accumulate the efforts of past researchers to close to the true facts of research question.

As for social science, it is hard to systematically accumulate the research results. The effect sizes often small and only can explain negligible proportion. Consequently, it can not substantially exert an influence. In the past, due to lack of research fund and researcher, it is limited amounts of research on the same issue. In terms of the information technology and research method progress, researchers now can study effectively, so that the amounts of articles under the same research question increase rapidly. Hence, it is possible to use meta-analysis to collect the results of many researches under the same issue.

Hunter, Schmidt, and Jackson (1982) [8] discuss six different methods of integrating results of individual studies. The traditional narrative procedure is a qualitative and nonquantitative research method. Researchers try to find out the commonness of the results under the same issue. It involves a verbal description of studies in an area and an attempt at integrating findings that usually are contradictory, especially if there are many studies in the area. The traditional voting method involves tabulating the findings of the studies by the significance or nonsignificance of the findings. Researchers should divide the relationship between dependent variable and independent variable into significant positive-related, significant negative-related, and nonsignificant. Most research results can be categorized into one category (Light and Smith 1971).

The third technique is accumulation of p values across studies. The method is to cumulate the p-value of many results to produce an accumulated one. It needs to carefully discuss the effect size. Hunter et al. (1982) also discuss two vote-counting methods that according to the authors are statistically correct. The two methods yield significance levels and estimates of effect sizes.

In 1976, Glass defines meta-analysis as "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the characteristic of findings". The main Glass's meta-analysis is the emphasis on effect sizes and not on significance levels. The purpose of the meta-analysis is descriptive not inferential. Subsequently, Hunter and Schmidt's psychometric meta-analysis extended Glass's method to correct for variations in effect sizes due to sampling error, measurement unreliability, and other study artifacts.

To take ERP research development into account, the amount of research under the same issue is not enough for us to utilize the method proposed by Glass (1976) or Hunter et al. (1990). We still can use the traditional way, such as voting method and cumulated p-values, to have some implication from ERP research.

# 4. Research framework

## 4.1 Organizational impact

The organizational impacts of ERP systems implementation is that operational efficiency improvement, to process business transactions effectively, and to gather and deliver timely information to managers. Prior research use performance indicators, such as productivity and efficiency, to evaluate the performance of organization after implementing ERP. There are still some studies focuses on the financial improvement of ERP, such as the return on assets after ERP adoption, costs versus revenues, and market value of company. Nevertheless, other organizational impacts like internal coordination and communication improvement or increase inter-organizational transaction are also important to assess the ERP systems.

After reviewing the literaturial report, the organizational impacts of ERP implementation can be divided into four dimensions: financial improvement, productivity, efficiency, and other. Consequently, we will discuss each aspect in turn.

### 4.1.1 Financial improvement

The financial improvement means that companies implemented ERP systems can improve their performance and reflect on the financial indicators, such as return-on-investment, cost reduction, or profit margins increase. Poston and Grabski [12] find that there is a significant decrease on cost of goods sold to revenue especially three years after adopting ERP. Decrease of selling, general, and administrative costs of revenue is not significant, so does residual income. Hitt, Wu, and Zhou [7] propose that ERP adopters have higher performance than nonadopers in terms of profit margins and return on assets. The result also show that the market value increase both during and after the adoption. Sedera, Gable, and Chan [17] follow the success model proposed by DeLone and McLean and revise the model to measure ERP success. They suggest that organizational costs will be improved through ERP implementation. Tchokogue, Bareil, and Duguay [19] find that organization achieves return-on-investment by implementing ERP systems.

## 4.1.2 Productivity

The productivity improvement reflects that more output or less input after implementing ERP systems. Palaniswamy and Frank [11] mention that companies adopt ERP systems do enhance their manufacturing performance through reducing inventory and providing better manufacturing cycles. Hitt, Wu, and Zhou [7] propose that ERP adopters have higher performance than nonadopers in terms of sales per employee. Sedera, Gable, and Chan [17] suggest that overall productivity can be used to assess ERP success. Sarkis and Sundarraj [15] find that there were better response and inventory reduction and over 70% of TI's external transactions are executed electronically. According to some factories reports, the output increases of 5-10% and there is up to 15% reduction in work-in-process inventory. After analyzing P&WC's implementation, Tchokogue, Bareil, and Duguay [19] find that there is improvement of productivity by 11% above plan.

## 4.1.3 Efficiency

The efficiency improvement means that organizations will have better working environment and

process the transaction more efficient. According to Palaniswamy and Frank [11] investigation, organization can have a better coordination and integration among the various facilities after implementing ERP. Furthermore, they also suggest that ERP systems can increase availability of information, and the information can be diffused across the firm efficiently. Hitt, Wu, and Zhou [7] suggest that ERP implementation can bring about better operational efficiency by increasing inventory turnover, asset utilization, and account receivable turnover. Cotteleer [2] use order lead-time as performance measurement and find that there is an initial improvement after ERP implementation. Sarkis and Sundarraj [15] find that ERP system allowed TI to manufacture and deliver its orders efficiently. Bendoly and Kaefer [1] find that companies with ERP would have significant difference transaction efficiency on communication (by reducing communication and travel costs), system development (by reducing system modification or enhancement costs), either manufacturing firms or service firms. As for manufacturing firms, they can benefits form ERP implementation by speeding up transaction or shorting product cycles. Tchokogue, Bareil, and Duguay [19] suggest that the production start delays of various subsets are significantly reduced by ERP systems.

#### 4.1.4 Other

Other improvement encompasses issues not covered previously. As we mentioned before, many companies implement ERP to overcome the Y2K problems. After case analysis, Palaniswamy and Frank [11] propose that ERP implementation can alleviate Y2K problems. Simultaneously, ERP systems can enhance ability to serve their customers, increase profitability and visibility of organization, and provide better internal supply chain management. Poston and Graski [12] find that the number of employees will decrease after implementing ERP systems. Sedera, Gable, and Chan [17] mention that staff requirements, product/service, and business process change can be used to evaluate ERP success. Moreover, they also propose that system quality and information quality can be utilized to assess ERP implementation. Tchokogue, Bareil, and Duguay [19] find that the inventory level become stable and organization has better materials management, production planning, quality and service after implementing ERP. Other tangible benefits are cost saving, reducing receivable days, and increase visibility into inventory costs.

## 4.2 Individual impact

In order to efficiently use ERP systems in the global business environment, we need to figure out what factors influence end-user to have a better understand ERP performance. Many users at different organizational levels are involved in ERP implementation. The individual impacts of ERP systems implementation response to the usage and satisfaction with systems. ERP systems can efficiently process the transactions within and inter- organization. The workload of employee will be reduced by the efficient processing ability and integrated information transform. After reviewing the literaturial report, the individual impacts of ERP implementation can be divided into four dimensions: usage, satisfaction, workload, and other. Consequently, we will discuss each aspect in turn.

## 4.2.1 Usage

Usage is mostly used to be substitute measurement of system success. Following the DeLone and McLean [4,5] definition, usage is that users consume the output of ERP system. But, DeLone and McLean suggest this dimension with caution for carefully taking intension into mandatory. Sedera et al. [17] suggest that ERP in nature are mandatory to use, so the usage of ERP system does not consist in their measurement model. Seddon [16] suggest that information system usage should take expectations, consequences, perceived usefulness, and net benefits to society into consideration. In spite of prior ERP performance research has less effort on systems' usage; we still suggest when it comes to assess ERP performance usage can be encompassed.

#### 4.2.2 Satisfaction

The satisfaction of systems is also important to assess information systems success. Satisfaction means that the response to the use of the output of an ERP system. Nelson and Somers [10] believe that users play an important role in ERP implementation. They suggest EUCS instrument can appropriately revise to ERP circumstance as a means to assess the satisfaction of ERP systems' user. Somers, Nelson, and Karimi [18] examine the structure, reliability, and validity with the framework of confirmatory factor analysis (CFA). They propose that content and ease of use are important to increase the satisfaction with ERP systems.

#### 4.2.3 Workload

ERP systems are integrated systems to handle multiple functions. It aims to reduce the workload of employees before implementing ERP systems. According to Palaniswamy and Frank [11] observation, ERP implementation can reduce paperwork and manual work to reduce the workload of employees.

#### 4.2.4 Other

Other effects on the behavior of ERP implementation such as Sedera, Gable, and Chan [17] find that ERP can increase learning, awareness to recall, decision making effectiveness, and individual productivity.

#### 4.3 Analysis framework

According to the literature reviewed, we propose an

analysis framework in this research to analyze the reported ERP performance or ERP benefits. Then, the voting method of meta-analysis is performed on published literature to identify what ERP performance or ERP benefits were reported. It is found that past research emphasized more on the organizational improvement than on individual impact of ERP systems. The research findings suggest individual impact of ERP systems should be also taken into accounts for the overall assessment of ERP performance. The voting result is shown as Table 1.

## 5. Discussion and future research

This study aims to investigate the ERP performance reported in the literature. Meta-analysis is performed on published literature to identify what ERP performance or ERP benefits were reported. An analysis framework is also proposed in this research to analyze the reported ERP performance or ERP benefits. According to the voting result, it is found that past research emphasized more on the organizational improvement than on individual impact of ERP systems.

Two main dimensions, organizational and individual impact, are suggest to assess ERP performance or ERP benefits. The organizational impacts in financial improvement, productivity, efficiency are found to be improved by the implementation of ERP. Individual impacts are used to identify ERP performance according to literaturial reported evidences. The research findings suggest individual impact of ERP systems should be also taken into accounts for the overall assessment of ERP performance.

This analysis framework introduced in this study is useful to future research. It gives a comprehensive view of ERP performance. The framework provides a coherent way for researchers and practitioners to evaluate the post-implementation stage of ERP system. It also helps to explain the results of ERP implementation finding in a clear framework.

Even though that prior ERP performance researches do not have much effort on usage, we still suggest when it comes to assess ERP performance usage can be encompassed. Further research should carefully discuss the definition of ERP system's usage. The EUCS has been proven validated to ERP circumstance. Further research can utilize EUCS as means of measurement of ERP systems' satisfaction and analyze the difference of industry and implementation scope. Further research can use this framework as basis to evaluate the impact of ERP on organizational performance.

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Table 1 voling result with Extr performance analysis framework.						
Organizational impact		Financial improvement	Productivity	Efficiency	Other	
Palaniswamy and Frank	(2000)		$\checkmark$	$\checkmark$	$\checkmark$	
Poston and Grabski	(2001)	$\checkmark$			$\checkmark$	
Hitt, Wu, and Zhou	(2002)	$\checkmark$	$\checkmark$	$\checkmark$		
Cotteleer	(2002)			$\checkmark$		
Sedera, Gable, and Chan	(2003)	$\checkmark$	$\checkmark$		$\checkmark$	
Sarkis and Sundarraj	(2003)		$\checkmark$	$\checkmark$		
Bendoly and Kaefer	(2004)			$\checkmark$		
Tchokogue, Bareil, and Duguay	(2005)	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	
Individual impact		Usage	Satisfaction	Workload	Other	
Palaniswamy and Frank	(2000)			$\checkmark$		
Nelson and Somers	(2001)		$\checkmark$			
Somers, Nelson, and Karimi	(2003)		$\checkmark$			
Sedera, Gable, and Chan	(2003)				$\checkmark$	

 Table 1 Voting result with ERP performance analysis framework.