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Investigating the success of ERP systems: Case studies in three Taiwanese high-tech industries

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Abstract

The measurement of enterprise resource planning (ERP) systems success or effectiveness is critical to our understanding of the value and efficacy of ERP investment and managerial actions. Whether traditional information systems success models can be extended to investigating ERP systems success is yet to be investigated. This paper proposes a partial extension and respecification of the DeLone and MacLean model of IS success to ERP systems. The purpose of the present research is to re-examine the updated DeLone and McLean model [W. DeLone, E. McLean, The DeLone McLean model of information system success: a ten-year update, Journal of Management Information Systems 19 (4) (2003) 3–9] of ERP systems success. The updated DeLone and McLean model was applied to collect data from the questionnaires answered by 204 users of ERP systems at three high-tech firms in Taiwan. Finally, this study suggests that system quality, service quality, and information quality are most important successful factors.

Keywords: ERP success model; DeLone and McLean model; High-tech firms

1. Introduction

Organizations today are constantly in search for ways to achieve better business performance and sustain competitive advantages through effective deployment of resources and business processes. To improve business performance, organizations require an efficient planning and control system that synchronizes planning of all processes across the organization. The key to competitiveness lies in a solid information system (IS) infrastructure seamlessly aligned with core business processes developed for the delivery of high quality products and services to customers within the optimal time. These demands have prompted more firms to shift their IS strategies from developing in-house information systems to purchasing application software, such as ERP systems, to generate synergies and enhance operating efficiency [1].

However, scarce literature has concentrated on measuring success for an ERP system. Although it is very important to evaluate the success of ERP implementation projects since a lot of financial and human resources are invested, Bradford and Sandy [2] reported that 57% of the interviewed companies launched no assessments on the performance of ERP systems owing to lack of empirically effective evaluation models.

Information systems (IS) success is one of the most widely used dependent variables in information systems research. Not surprisingly, much attention has been given to how best to measure it (e.g., [3–6]).

This research accordingly attempts to propose a success model for ERP systems and to empirically investigate the multidimensional relationships among the success measures. Additionally, three case firms among the success measures are also empirically tested. In this paper, I do not assess more complex concepts, such as right information needs or users' interest because it is difficult to get a reliable measure of this kind of attributes just by interviewing. The goal is to obtain the users' perceptions about the importance of CSF in order to establish a rank among them. It is a valuable effort, since IS users and IS experts have significantly different perceptions on IS success [7].

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2. Theoretical overview

2.1. Impact of ERP systems

Literature on the impact of ERP systems is growing. However, most studies in the literature are interviews, case studies, and industry surveys [8–10]. Participating companies reported substantial performance improvement in several areas thanks to the ERP systems, such as the ability to provide real-time information to customers, shorter production cycle, and on-time completion rates.

2.2. Information system success model

The success of IS is widely recognized by practitioners and academics as a difficult concept to define even many studies have endeavored to describe and justify the evaluation of IS success [3,4,6,11–13]. An IS has many stakeholders, each with a different definition of system success. IS development projects have been plagued by budget overruns and unmet user requirements [14]. Thus, from a developer's perspective, a successful IS may be one that is completed on time and under budget, with a complete set of features that are consistent with specifications and that function correctly. From an innovator's perspective, a successful system is one that attracts a large, loyal, and growing community of users. More recently, Jiang et al. [7] identified a set of critical success factors for system development including clearly defined goals, top management support, sufficient resources, competent team members, and adequate communication. So, from a management perspective, a successful system may be one that reduces uncertainty of outcomes and thus lowers risks, and leverages scarce resources. From the end user's perspective, a successful system may be one that improves the use's job performance without inflicting undue annoyance. For example, Saarinen's paper [15] provided four metrics of system success. These included (1) the satisfaction with the development process, (2) satisfaction with system use, (3) satisfaction with the quality of the IS product, and (4) impact of the IS on the organization.

Meanwhile, researchers had developed a large number of system success criteria. Many had been empirically tested, including: system quality [16], user information satisfaction (UIS) [17], quality of decision making [18], IS usage [19], and productivity from a cost/benefit standpoint [20]. User perceptions had become particularly prominent within the IS literature [18]. The use of these psychometric measures was due to the difficulty in quantifying and linking costs and benefits to particular IS innovations.

One of the most important and popular works on IS success model is the DeLone and McLean model (D&M IS success model). DeLone and McLean [3] proposed a taxonomy and an interactive model as the framework for conceptualizing IS success. But, not all of the researchers have attempted to critique or modify the D&M IS success model. Some have developed and proposed alternate frameworks for measuring IS effectiveness.

After synthesize the previous studies, DeLone and McLean [3] using the six dimensions of IS success model—"Success Quality, Information Quality, Information Use, User Satisfaction, Individual Impact and Organizational Impact" to evaluate the success of IS. Since then, approximately 300 articles in refereed journals have referred to, and made use of, this IS success model. The broad fame of the model is strong evidence of the need for an extended framework in order to integrate IS research findings.

The description and examples of measures for these six dimensions are as follows. First, system quality denotes system performance like data accuracy, system efficiency, response time, etc. Second, information *quality* refers to the quality of the IS product, such as currency, relevance, reliability, and completeness. Third, *use* refers to the frequency an information system is used, examining items like the number of functions used, frequency of access, and amount of connecting time. Fourth, *user satisfaction* records the satisfaction level as reported by system users, including overall satisfaction and interface satisfaction, etc. Fifth, *individual impact* refers to measuring the impacts brought about by the information system on individual users, such as changes in productivity, decision model, and decision-making. Sixth, *organizational impact* requires the evaluation of the changes caused by the information system to the organization, such as decreases in operating costs, savings in labor costs, and growth in profits (Fig. 1).

According to the D&M IS success model, both system quality and information quality influence use and user's satisfaction, which in turn shape the impacts of the system on individual users and the organization. The reason for the existence of different measures for IS success is understandable when one considers "information" as the output of a system that can be measured at different levels – the personnel level, the technical level, the semantic level, and the effectiveness level – and different stakeholders are involved at each level.

However, Seddon and Kiew [84] recommend replacing use with usefulness, stating that use only affects satisfaction when use is voluntary. Seddon and Kiew [85] placed use outside a revised model of system success because it was

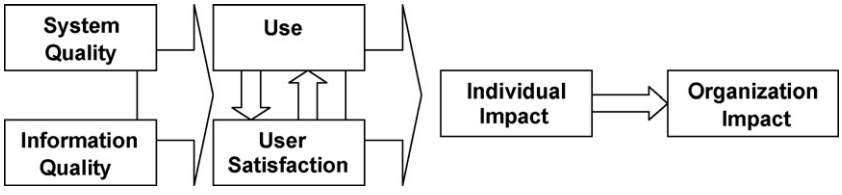

Fig. 1. D&M IS success model, DeLone and McLean [3].

deemed more a characteristic of user behavior than a measure of system success [6].

The primary purpose of the original D&M IS success model was to synthesize previous studies on IS success into a more coherent body of knowledge and to provide guidance to future studies [4]. The role of IS has changed and progressed during the last decade. Similarly, academic inquiry into the measurement of IS effectiveness has also advanced over the same period [4]. DeLone and McLean introduced an updated D&M IS success model as foundation for positioning and comparing IS empirical research.

Changes have occurred in the past decade. The role of IS has progressed, as well as IS management. ERP systems have become more prevalently adopted for integrated IS services companywide. Since ERP systems are usually complicated IS packages, the service quality of MIS department, ERP vendors and ERP consultants has become more critical than the service quality provided for isolated information systems before.

The quality of MIS service, as perceived by its users, becomes a key indicator of IS success [21]. MIS departments evaluate user satisfaction primarily to improve their service quality [22]. Nowadays, ''service quality'' as the overall support delivered by the service provider applies no matter this support is delivered by the MIS department or a new organizational unit, or outsourced to an Internet service provider (ISP); poor support, for whatever reason, will result in lost customers and sales recession [4]. However, commonly used measures of IS effectiveness focus on products, rather than services, of the IS function. Thus, there is a risk that IS researchers will misjudge IS effectiveness if they do not include a measure of IS service quality in their assessment package [23]. Pitt et al. [23] propose a model of information system success similar to the DeLone and McLean model, except service quality is included as one of the dimensions that affect use and user satisfaction.

In response to the progresses in IS applications, DeLone and McLean proposed an updated version in 2003. Service quality was added to the success model, and the individual impact and organizational impact were combined into a single variable named ''net benefits''. To catch up with the advancements of its applications, IS not only needs to provide users with information products but also to meet users' flexible information requirements. Service quality is thus added to the updated model to measure the service-level success since system quality focuses more on technology-level measure. Since it is difficult to describe the multi-dimensional aspects of IS use—mandatory or voluntary use, informed or un-informed use, effective or ineffective use, DeLone and McLean further suggested that ''intention to use'' may be adopted as an alternative measure for IS use in some contexts. Certain net benefits can occur as results of IS use or intention to use and user satisfaction.

The impact that information has on organizational performance is difficult to isolate amidst many other factors, both internal and external to the firm. Some researchers have attempted to look at the value of technology investments through quantifiable financial measures such as investment and ROI, market share, cost, productivity analysis, productivity paradox, and profitability.

Other studies have investigated relationships between information systems and qualitative measures, such as organizational structure, change, efficiency, responsiveness, coordination, flexibility, increased quality of decision-making, and increased quality of work life [11,24–27]. Other researchers have attempted to measure organizational impact by looking at the result of the IS function, such as measuring the quality of customer service and assessing the amount of resulting competitive advantage [26–31].

Net benefits are the most important success measures as they capture the balance of positive and negative impacts of the ERP system on organizations. Positive net benefits may encourage the use intention of ERP system and increase user satisfaction, while negative net benefits can decrease the intention to use and IS user satisfaction (Fig. 2).

3. Background and hypothesis development

The ''ERP system experience cycle'' framework [32] which is based on Soh and Markus' [86] model is adopted to delineate the ERP adoption process in this study. The framework models an organization's experience with ERP system from adoption to success as moving through four phases characterized by key players, typical activities, characteristic problems, appropriate performance metrics, and a range of possible outcomes. This paper is focused on exploring the project and shakedown phases of the framework, more commonly known as implementation phases.

3.1. Applying the IS success model in the research context

Following the logic framework of the updated DeLone and McLean model for IS success, this study proposes a success

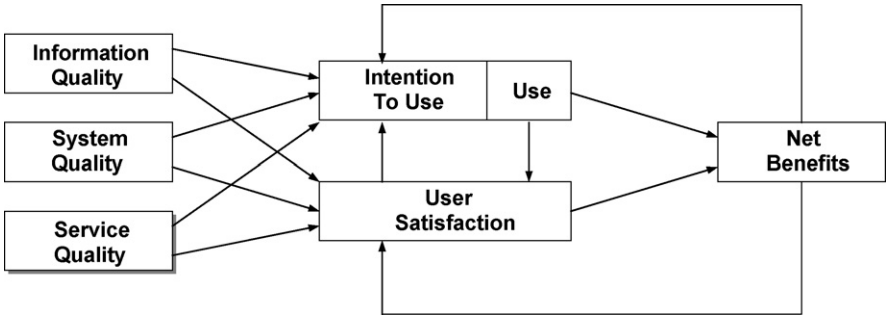

Fig. 2. Updated D&M IS success model, DeLone and McLean [4].

model for ERP systems. ERP systems are one type of integrated IS to cover all necessary business processes, thus system quality, information quality, and service quality need to be included in this model. Information quality is measured in terms of accuracy, timeliness, completeness, relevance and consistency of the information provided by ERP. System quality is measured in terms of ease-of-use, functionality, reliability, flexibility, data quality, and integration of ERP systems. Service quality is measured in terms of ERP service level, reliability of ERP service, and responsiveness and assurance of ERP service providers. When some add-on programs are required to be included in the ERP projects, service quality provided by the program providers and the information department will also be incorporated into this model since the add-on programs often serve as a bridge between the ERP packages and the corporate practices.

This study is based on the updated DeLone and McLean IS success model that proposed to serve as foundation for positioning and comparing IS empirical studies. The model highlights an important dimension of IS success related to service quality but fails to distinguish the roles of internal and external services. Furthermore, the notion that MIS departments are service providers has not been well established in the IS literature [23]; few have discussed the discrepancy of service quality between the MIS department and the interrelationship to IS success. Results of this study are expected to contribute comprehensive understandings of IS success from the view of service quality.

3.2. Measures of ERP success model

3.2.1. Measures of three quality dimensions

Our study, however, regards system quality as a functional feature of the system itself and finds applying the ‘‘ease of use’’ factor to describe system quality somewhat problematic. The study has therefore attached greater importance to criteria such as the system’s response time and accuracy when measuring system quality.

Information quality that captures the degree with which an ERP system generates information possesses three attributes: content, accuracy, and format. These attributes represent some of the most extensively studied aspects of information in the IS research literature (e.g., [24,33]).

‘‘MIS service quality’’ refers to the extent to which the MIS department fosters positive attitudes towards and good relationships with its users and provides convenient access to relevant and high quality services. This study suggests that ‘‘service quality’’ should be added as an important dimension of IS success based on the importance of IS support.

3.2.2. Measures of two use dimensions

The researchers always adopt TAM, which was proposed by Davis [34], to explain and forecast users’ behavior how new technology influence people’s life. IS use is directly impacted by behavioral intention (BI), a weighted function of attitude towards usage and perceived usefulness. Perceived usefulness and perceived ease of use determine attitudes toward usage. According to Davis [12], all other factors are expected to impact intentions and usage through ease of use and usefulness.

Instead of simply being used to measure the frequency of use, usage measures should be applied to capture the richness of use as a system phenomenon including the nature, level, and appropriateness of use. Yet our study believes that only after actually utilizing ERP systems and realizing their benefits, user satisfaction and the values of ERP systems to the organization can be further enhanced.

The instrument employed by the study to measure user satisfaction is adapted from Barooudi and Orlikowski [33]. ‘‘User satisfaction’’ remains an important means of measuring end-users’ opinions on ERP systems and should cover the entire end-users experience cycle from project management to receipt information. Given our interest in capturing a generally applicable measure of user satisfaction with ERP systems and our concerns about survey length and respondent convenience, we measure user satisfaction with three items (project satisfaction, information satisfaction and users satisfaction). This general three-item measure enables a reasonable assessment of IS usage variations in the current context.

3.2.3. General perceptual measures of net benefits of ERP systems

The primary benefits expected to result from ERP are closely related to the level of integration that is promoted across functions in an enterprise. Expectations for improved business performance after adoption may result from both operational and strategic benefits [35]. Some of the most significant intangible benefits included internal integration, improved information and processes, and improved customer service, while major tangible benefits covered cost effectiveness in inventory, personnel, procurement, improvements in productivity, cash/order management, and overall profitability. However, in assessing the extent to which interviewed companies had actually attained those expected benefits, it was evident that they were unable to improve profitability or lower personnel, inventory, or system maintenance costs as much as they had anticipated.

3.3. Proposed framework

The proposed success model is a multi-dimensional model, and the dimensions are interrelated. ERP systems are first implemented and exhibit various degrees of system, information and service quality. Users and managers then experience these quality dimensions by using ERP systems for their works and decisions. Users and managers are either satisfied or not satisfied with the ERP systems. The intention to use ERP and the three quality dimensions influence the individual value of using ERP. Collective individual values of using ERP systems trigger influence on organizational performance. Sequencing relative individual works from business processes, the individual impacts also collectively affect user satisfaction.

The entire research suggests that there can be positive benefits from the automation, process redesign activities, and increased timeliness or output quality associated with

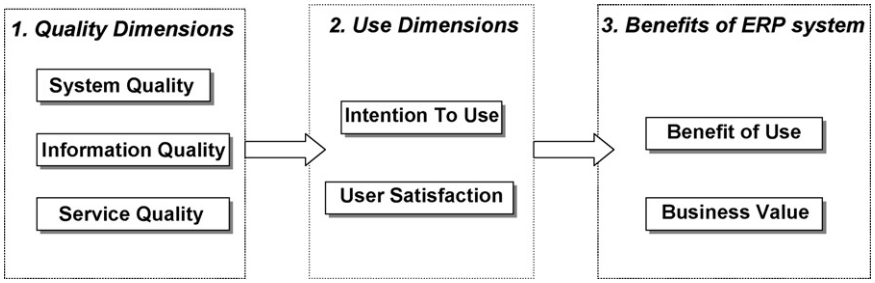

Fig. 3. Revised ERP success model.

successful ERP system deployment, although these effects in the specific context of ERP systems have not been previously studied statistically (Fig. 3).

4. Methods

4.1. Procedures and samples

The objective of the study is to explore the concept of success model in ERP systems and to identify the factors contributing to high-quality ERP systems. A qualitative approach is used to analyze a series of events exhibiting some theoretical principles. The purpose is to examine in details the dynamics present in relevant organizations and to conceptually interpret the significance of various factors that influence the quality of ERP systems.

Selection of the three organizations is based on the need to collect detailed data about the ERP implementation process in each organization. The selected organizations vary significantly in terms of company size, type of industry, as well as the degree of ''success'' in their ERP system implementation efforts. The interviews were conducted during the summer and winter of 2004. In all three cases, an initial interview was arranged, observations and results obtained from the initial interview were reviewed, and a second meeting with the same interviewees was conducted for necessary elaboration and clarification. The researcher also met with those in-house experts who were able to provide more detailed information on several issues presented in the interview protocol.

Our study further aims at proposing a success model for the ERP implementation and empirically testing the interrelationships between those dependent variables in the proposed model. A questionnaire survey was thus conducted in 2004. The questionnaires were first designed and pilot tested according to the framework mentioned in previous sections, and then sent to three organizations registered with the Ministry of Economic Affairs with annual revenue over NT$200 million. In this survey, questionnaires were sent to 600 end-users at the three companies in October 2004. Until November 2004, a total of 228 questionnaires were answered and sent back. The response rate reads 38%. After questionnaires with incomplete answers were deleted, 204 questionnaires remained for analysis. The effective return rate drops slightly to 34%. Table 1 presents essential information about ERP system implementation at the three firms as provided by these 204 end users.

4.2. Case evidence

4.2.1. Case background: UMC

As a world-leading firm in the semiconductor foundry, UMC specializes in the contract manufacturing of customer designed ICs for high performance semiconductor applications. Since entering the pure-play foundry industry in 1995, UMC has been the sector's fastest growing company.

Success factors of the ERP implementation project at UMC include the mature SAP system, fast acquisition of rich global resources, sufficient diversity and competence of consultants' expertise, thorough training provided to users during the introduction, and complete commitment and support from the high-level management.

For a vital project like ERP implementation, UMC demanded seamless cooperation between the SAP team and

Table 1
UMC, Compal and PSC on ERP systems implementation

	UMC	Compal	PSC
ERP system	SAP.CRM	SAP	SAP
The project phase	2000/7	2000/4	1995/10
Implementation period	6 months	9 months	6 months
The shakedown phase (Go-live)	2001/1	2001/1	1996/5
Original system	In-house Microsoft-Access	QAD	DSC in-house Microsoft-Access
Consultant	PwC	PwC-IBM	IBM
Implementing modules	PM, SD, FI	PP, MM, FI, CO, SD	AM, MM, PS, PD, SD, FI
Backup systems	No	Yes	No
End users	About 300	About 600	About 200
Add on	About 600	About 1300	About 1300, if plus report about 5000
Outsourcing	Both outsourcing and self-development	Almost MIS department development	Almost MIS department development

its IT department. Employees at the IT department were encouraged to grasp this opportunity to expand their professional strengths. The UMC case serves as a convincing paradigm that the benefits generated by the users' perfect acceptance of the adopted IT system can be truly amazing.

4.2.2. Case background: Compal

Founded in 1984, Compal Electronics has won the customer trust and has become a leading player in the global IT industry with its professional management team, recognized product quality, and admirable flexibility to design in response to the latest market trends. The company began the implementation of a SAP system across all business units in 2000. All divisions were required to provide quantifiable business cases before initiating any system implementation efforts. Most quantifiable benefits were related to improvements in customer response time, improved turnover by maintaining existing customers or by gaining customers from the competition, and by attaining scope efficiencies through acquisitions of other businesses in its vertical supply chain. The ERP system was considered to be a significant facilitator for the straightforward integration of new acquisitions into the company's information infrastructure.

4.2.3. Case background: PSC

Powerchip Semiconductor Corp. (PSC) was established in Hsinchu Science-based Industrial Park in December 1994 to help develop the DRAM industry in Taiwan. In roughly a decade of active business development, PSC has outrun other competitors in Taiwan to become the leader in the industry by enhancing the efficiencies of its 300-mm production technology and expanding its new foundry business.

In order to upgrade both its productivity and competitiveness, PSC is keenly aware of the impending need to introduce an ERP system. Prior to its ERP introduction, PSC adopted a non-platform MIS software developed by Data Systems. In October 1995, PSC management made the decision to introduce a SAP system that proved to be the keys to the company's successful ERP implementation.

4.3. Respondent characteristics

The personal information of 204 respondents was summarized as in Table 2. Noticeably, the gender ratio is 0.91:1 (male versus female). And 77% of the respondents has bachelor's degree or above, indicating that education is a critical concern for the employment in the high-tech industry

The cases of the three high-tech firms reflect successful implementation of ERP systems. Respondents participating in this study are all system end-users, who are generally highly experienced and educated, and have been working with the companies for 5.65 years. The earliest goes to PSC where respondents have used the system for 4.62 years (see Table 2). Experientially based differences in organizational positions, or the user's role in the development of the application, may cause distinct reference frames.

Moreover, 34% of the respondents are working in the finance and accounting department, followed by 30% in the production department, 19% in the MIS department, and 6% in both HR and sales/marketing departments (see Table 3).

Table 2
Profile of respondents

	UMC	Compal	PSC	Sub-total
Gender				
Male	25	36	35	96
Female	44	35	26	105
Total	69	71	61	201
Education				
High school	1	1	3	5
Tertiary school	16	15	11	42
College	33	36	39	108
Graduate school or above	20	19	8	47
Total	70	71	61	202

	UMC	Compal	PSC	Mean
Respondent	70	72	62	
Years of experience in ERP	3.39	4.41	4.62	4.14
Years of experience in work	6.32	5.87	4.75	5.65

4.4. Non-response bias

Before data analysis, the selected sample was tested for non-response bias. Given that the survey was anonymous, it could not identify those who failed to respond. It was not possible, therefore, to determine whether non-respondents differed systematically from those who responded. As an alternative test of non-response bias, an ANOVA was administered to analyze the background of three high-tech firms to avoid the potential bias. The results revealed that both the ratio of project members/total number of employees and the ratio of approved ERP maintenance budget/annual sales report no significant differences, thereby diminishing vastly the possibility of the presence of non-response bias (see Table 4).

4.5. Research instrument and variable measurement

4.5.1. Research instrument

Sekaran and Trafton [36] and Sekaran and Martin [37] found that the scaling techniques in different country has different reaction to the same measure. Barry [38] found that seven-point

Table 3
Department profile of respondents

Department	UMC	Compal	PSC	Sub-total
Finance & accounting	22	30	17	69
MIS	13	10	15	38
Human resource	7	5	–	12
R&D	–	2	–	2
Production management	28	10	23	61
Sales/marketing	–	5	7	12
Supporting staff	–	8	–	8
Total	70	70	62	202

Table 4
Non-response bias analysis

	PSC	UMC	Compal	*F*	*p*-Value
Organizational					
Project members/total number of employees[a]	1.274	1.186	1.366	.931	.396
Approved ERP maintain budget/annual sales[a]	1.145	1.116	1.113	.148	.863

[a] Use five-scale: 1: <1%; 2: 1 to <3%: 3: 3 to <6%; 4: 6 to <9%; 5: ≧9%.

Table 5
Question items

V.1	System quality (SQ)	DeLone and McLean [3]
SQ1	Does ERP system provide up-to-date information?	
SQ2	Do you get the information you need in time?	
SQ3	Is ERP system accurate?	
V.2	Information quality (IQ)	Rai et al. [5]
IQ1	Does ERP system provide the precise information you need?	
IQ2	Does ERP system provide output that is exactly what you need?	
IQ3	Are the output options (print types, page sizes allowed for, etc.) sufficient for your use?	
V.3	Service quality (SRQ)	DeLone and McLean [4]
SRQ1	MIS employees give prompt service to users (responsiveness)	
SRQ2	ERP system is dependable (reliability)	
SRQ3	MIS employees have the knowledge to do their jobs well (assurance)	
V.4	Behavior intention (BI)	Bedard et al. [47]
BI1	I intend to use ERP system in performing analytical procedures	Taylor and Todd [81]
BI2	I intend to use ERP system in planning and tailoring related programs	Martinsons et al. [82]
BI3	I intend to use ERP system in electronic mode, rarely printing out copies of work papers as I proceed through my tasks	
BI4	I intend to use ERP system to review decisions made by other members of the department	
BI5	I intend to use ERP frequently this term	
V.5	User satisfaction (USAT)	DeLone and McLean [3]
USAT1	Project satisfaction	Barooudi and Orlikowski [33]
USAT2	Information satisfaction	
USAT3	User satisfaction	
V.6	Benefit of use from end-users' view (BU)	Martinsons et al. [82]
BU1	Establish good relationships with the user community	
BU2	Satisfy end-user requirements	
BU3	Exploit IT opportunities	
BU4	Be perceived as the preferred supplier of ERP products and services	
BU5	Establish and maintain a good image and reputation with end-users	
V.7	Net value from business' view (NV)	Martinsons et al. [82]
NV1	Enhance competitiveness or create strategic advantage	Mirani and Lederer [83]
NV2	Enable the organization to respond more quickly to change	
NV3	Sell appropriate ERP products and services to third parties	
NV4	Ensure that ERP projects provide business	
NV5	Establish and maintain a good image and reputation with management	

The response scale for all statement is the following: 1, strongly disagree; 4, neutral; 7, strongly agree.

scale can measure subject correspond to reality precisely than other point scale. The research instrument contains a series of questions to which participants mark their level of agreement/disagreement on a seven-point scale ranging from strongly agree (score = 7) to strongly disagree (score = 1). Table 5 shows a complete listing of question items.

4.5.2. Variable measures

To determine whether all question items in Table 5 could be reduced to a smaller group of meaningful factors, a principal component analysis was conducted based on the responses obtained from all respondents. With no item dropped, seven components with Eigenvalues greater than one emerged; the best results were obtained with a varimax rotation. Results of confirmatory factor analysis indicated that a priori assumption was substantiated with a seven-factor solution, and the loadings of seven components are presented in Table 6. The Kaiser–Meyer–Olkin measure of sampling adequacy reads 0.917, and the percentage of variance explained by the 10 factors is 65.05%. Table 6 shows that the Cronbach's alpha coefficients for all dimensions are greater than 0.62, indicating that the internal consistency is acceptable.

Table 6
Results of factor analyses[a]

	1	2	3	4	5	6	7	Reliability
1								
BU1	0.715							0.7955
BU2	0.630							
BU3	0.623							
BU4	0.579							
BU5	0.565							
2								
BI1		0.789						0.8277
BI2		0.652						
BI3		0.637						
BI4		0.522						
BI5		0.475						
3								
USAT1			0.641					0.6659
USAT2			0.560					
USAT3			0.541					
4								
NV1				0.596				0.6299
NV2				0.556				
NV3				0.434				
NV4				0.531				
NV5				0.402				
5								
SRQ1					0.703			0.6628
SRQ2					0.576			
SRQ3			0.406		0.512			
6								
SQ1						0.851		0.6612
SQ2						0.545		
SQ3						513		
7								
IQ1							0.649	0.6212
IQ2							0.648	
IQ3							0.485	
% of variance	12.785	11.631	10.492	9.383	8.137	6.835	5.791	
Cumulative %	12.785	24.416	34.908	44.291	52.428	59.263	65.054	

Extraction method: principal component analysis; rotation method: varimax with Kaiser normalization.
[a] Only loading of 0.4 or above are shown.

5. Data analysis

In order to compare the difference between rating service quality dimensions and rating the importance of individual items, importance ratings of individual items were grouped into the dimensions proposed by Parasuraman et al. [87]. Each dimension was then ranked according to its overall score.

Analysis of quality dimensions for those three firms indicated that system quality is the most satisfactory factor as compared with others (see Table 7), implying that those firms are satisfied with the system function of SAP R3. Moreover, the means of ‘‘service quality’’ (5.097) is higher than that of ‘‘system quality’’(5.038) for PSC (see Table 7). This research assumed that PSC, as the hi-tech firm that first introduced SAP R3, has trained many experienced MIS staff for maintaining the ERP system. While respondents at UMC considered BU has the

Table 7
Means and standard deviation

	Means	S.D.	UMC	Compal	PSC
Quality dimensions					
SQ	5.360	0.809	5.667	5.338	5.038
IQ	5.179	0.853	5.367	5.046	4.925
SRQ	5.181	0.724	5.291	5.148	5.097
Use dimensions					
BI	5.109	0.780	5.309	5.011	4.997
USAT	5.049	0.854	5.243	5.007	4.879
Benefits					
NV	5.093	0.671	5.229	5.010	5.036
BU	5.099	0.710	5.337	4.966	4.984

Table 8
Comparison of key success factors ratings for UMC, Compal and PSC

Success factor	Means	Success factor	UMC	Success factor	Compal	Success factor	PSC
SQ	5.360	SQ	5.667	SQ	5.338	SRQ	5.097
SRQ	5.181	IQ	5.367	SRQ	5.148	SQ	5.038
IQ	5.179	BU	5.337	IQ	5.046	BI	4.997
BI	5.109	BI	5.309	BI	5.011	BU	4.984

highest usefulness, those at Compal and PSC argued that NV has the highest usefulness (see Table 7).

6. Conclusion

Table 8 shows that the first three dominant success factors of UMC, Compal and PSC are related to the quality dimensions, suggesting that the success of implementing ERP system is largely determined by the quality dimensions.

The results indicated that technological newness was the most important factor in determining the quality of the system. System quality, such as performance, flexibility of changes, response time, and ease of use, is a technical issue. This result confirmed conventional wisdom that the pursuit of state-of-the-art technology is a risky proposition. In addition, different aspects of system quality, such as response time, ease of use, system reliability, and flexibility of the system have been examined by IS researchers [16]. Most of these measures are fairly straightforward, reflecting the more engineering (technical)-oriented performance characteristics of the system. Researchers found that these engineering-oriented performance measures were significantly related to technical-related issues of the proposed projects [39].

This paper proposed a success model and empirically tested the relationships between variables. In summary, this research discovered that system quality and service quality are important dimensions for measuring post-implementation ERP success. Service quality and system quality dimensions play more important roles than their information quality counterpart in terms of influencing ERP benefit of use and user satisfaction.

The results not mean that any CSF is unimportant. It means what are the respondents' perceptions about the importance of them. This is a main issue, since it is possible to manage the development process with more information about the expectations of final users.

7. Limitations and future research

Like most studies on the business value of ERP, our analysis is limited by both data and empirical specification concerns. Only three high-tech firms were investigated; other organizations with successfully implemented ERP systems may have been overlooked. The extent of adoption might be misestimated when some firms combined SAP of the ERP systems with other ERP packages. Moreover, the practical implications inferred from such large public-listed firms may be inapplicable to smaller companies.

The strategic intentions of implementing ERP systems vary with the firm types. While some firms intend to improve operating effectiveness or add managerial controlling mechanisms, and even raise the empowerment for employees by facilitating information retrieval, some firms only attempt to replace the outmoded systems with new ones. Different strategic intentions affect the effectiveness aspects at the stage of post-implementation ERP, such as corporate innovative processes, knowledge management, workforce improvement, and obligation reallocation, even the corporate cultures, policies and actions. Those aspects contain quantifiable tangible effectiveness and immeasurably intangible effectiveness. Return of investment (ROI) is the most popular method to measure the quantifiable effectiveness.

Cost-benefit analysis, a way to calculate the ROI for establishing ERP systems, compares the resulting overall effectiveness with the investment costs of ERP systems. The system costs vary with firm size, type of ERP software, required IT infrastructure and project size. Indices for those costs are quantifiably calculated. From the view of effectiveness, reduction of inventory costs and shorter cycles of production and delivery are reasonably attributed to the implementation of ERP system. In the aspect of profitability, however, no adequate mechanism is available for measuring sales growth and customer satisfaction. Quantitative indices are suggested to be included in future studies.

ERP system has become a major software product line. The trouble is that too many ERP systems are available in the market. In Taiwan along, there are 61 ERP vendors, and the COBRES listed approximately 1500 different ERP solutions provided by variety of vendors in 2000 [40]. So, we have to select a representative sample in our study. An idea started by SAP in the early 1970s has evolved into a major information system software product line, which has revolutionized how large organizations approach business computing. At present, SAP is the pioneer and the largest firm than other ERP vendors. Moreover, SAP's modules are most complete than other ERP vendors. Besides, SAP expands sales to large and midsize firms [8,9,41,42]. At present, SAP has worked with over 10,000 small businesses to help them reach their goals. SAP expands sales to small firms [43]. In this ERP market, the SAP is leadership vendor. More than half of top 500 companies in the world use SAP's software [44]. The SAP's modules are the most complete than other ERP vendors. So, SAP's modules are representative sample. Therefore, our study choice three organization use SAP or SAP CRM in particular.

Future research needs to examine how importance scores might be used with performance scores for management

purposes, and whether importance scores or customer expectations provide more effective feedback to management. A number of methods of placing performance scores in perspective to expectations or importance need to be explored to avoid the use of difference scores. Researchers should examine the use of importance/performance maps or multi-dimensional scaling and gauge how useful this information is for managers compared to expectations. Methods of importance—performance mapping such as those advocated by Martilla and James [88] or Hawes and Rao [89] should be re-examined to determine if they offer more information for managers than expectations.

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