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Identifying critical factors for corporate implementing virtualization technology

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ABSTRACT

Virtualization technology has attracted great attention with its advantages of multiple platform operation and resultant cost and power reduction. This study investigated the key factors for corporations to implement virtualization information environment from the viewpoint of IT staffs. Through purposeful sampling, 400 effective questionnaires were collected from IT personnel currently working in the virtualization-related fields. From key factor analysis, seven influential factors were identified for corporations to implement virtualization. These seven factors include: (1) system quality, (2) information quality, (3) simplified management and maintenance, (4) integration of resources, (5) cost reduction, (6) ease of deployment, test and development, and (7) organizational consensus. Based on the obtained findings, suggestions for corporations and to IT system integrators were provided to the implementation of virtualization information environment. The scales developed in this study provide useful measures to study common factors of the implementation of virtualization information technology.

1. Introduction

Cloud computing issue has become one of the greatest concerns to the IT field in the 21st century. The features of cloud computing technology may include super-large scale, dynamic scalability, and on-demand deployment in which virtualization plays a central role and the industry realizes its importance and begins to implement it (Li & Yang, 2010). Virtualization has such advantage as having a single server to carry multiple operating systems. It not only saves the quantity of purchased servers, reduces the management and the maintenance costs, but also reduces the consumption of electricity and cooling power. The global market of virtualization technology is now on the rise. According to the forecast by Global Industry Analysts, Inc., the global virtualization software market is projected to reach US$11.98 billions by 2015 (Global Industry Analysts, Inc. [GIA], 2010).

The success of a new technology requires the careful coordination from various aspects. For virtualization technology, most prior studies focused on aspects in the information engineering domain such as principles, architecture, performance tuning, and backup mechanism of virtualization. However, in the process of adopting virtualization technology, the opinions from engineers who are in charge of managing and maintaining the system must be taken into serious consideration to ensure a successful implementation. So far, limited studies have been found regarding the analysis of the key factors influencing corporations' implementing virtualization technology from the viewpoints of IT staff. As a result, for those corporations in the evaluation process of whether or not to introduce virtualization technology, this subject is certainly worth of discussion.

The rest of this paper is organized as follows. After the introductory section, Section 2 reviews literatures regarding virtualization and its key factors for implementation. The next section discusses the research methodology including questionnaire design and sampling. Section 4 focuses on statistical analysis of research data. A conclusion is given in Section 5 which also addresses the implications, contributions and future research directions in this subject field.

2. Literature review

2.1. Virtualization

The concept of virtualization was originated in the 1960s when mainframes were highly expensive. IBM divided a UNIX mainframe into multiple logic units in order to enable users to fully utilize a mainframe's calculation resources.

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In 1974, Popek and Goldberg proposed a set of requirements to examine whether the architecture of a computer system can be efficiently virtualized. They defined a virtual machine as "an efficient, isolated duplicate of a real machine (Popek & Goldberg, 1974)." These requirements, called "The Popek and Goldberg virtualization requirements," provide a convenient way to search for a computer architecture that supports virtualization, and lay down the guiding principles to design a system with architecture suitable for virtualization. They considered a virtual machine monitor (VMM) must present the following three properties: (1) Efficiency: Statistically dominant instructions from VMM are executed by the hardware directly, without any software intervention from VMM; (2) Resource Control: VMM must have the full control of all virtual resources; (3) Equivalence: Any program running under the VMM should exhibit behaviors identical to those exhibited when running on a equivalent real machine.

With the advancement of cloud computing technology, virtualization has attracted a great attention in the past decade. New definitions have been given to virtualization to clarify its scope and related functions. The study of Fichera (2002) pointed out that virtualization divides the mainframe into the individual logic units and input/output units among them and has the full control of the functions of these units. Further, Singh's study (2004) defines virtualization as a technology that provides multiple operating environments in a computer through assembling or dividing resources such as CPU, memory or hard drive. VMware (2006a) considers virtualization as the separation of resources or demands from the hardware setting and Waters (2007) describes virtualization as the provision of an abstract layer between the computer hardware and software running on the hardware to allow users to execute multiple operating systems on a single machine. Moreover, Tulloch (2009) regards the virtualization as a method to deploy operating resources and utilize these resources through different information layers such as hardware, software, data, network, and memory. The study of Shavit and Migliore (2009) defines a virtual machine as a program or an operating system that establish an independent guest environment within the host, which allows multiple guest environments to be executed and dynamically allocates resources among them.

With the rapid development in the area of cloud computing, researches and /or studies have been directed into various application areas of virtualization in the past few years, as summarized in Table 1. In the aspect of architecture design, for example, Smith and Nair (2005) explained and compared different types of virtual machines for different hardware/software interfaces; Uhlig et al. (2005) explored the virtual machine platform based on Intel's virtualization technology. In terms of implementation and performance, the study of Seetharaman and Murthy (2006) provided a comparison of effectiveness and resource utilization efficiency among different types of virtualization software. In addition, Menasce and Bennani (2006), Sotomayor, Keahey, and Foster (2006), and Jung et al. (2009) proposed mechanisms for efficient resource management and the study of Chen's and Xin's (2005) and Oguchi's and Yamamoto's (2008) investigated issues of planning and implementing virtualization in enterprises. For the aspect concerning the benefits of virtualization, some researchers pointed out the fact of the improved server efficiency through the utilization of virtualization (Sehgal & Ganguli, 2006; Tsai, 2007), while some others mentioned the cost-reduction benefits of using virtualization (C. T. Chen, 2007; Rasmussen, 2009; Symantec, 2009; Weltzin & Delgado, 2009). In terms of operating issues, Arce (2007), Prueksaaroon, Varavithya, and Vannarat (2009), Yang, Zhao, Zhao, and Yang (2009), and Silva, Alonso, and Torres (2009) addressed the realization of system recovery through virtualization; Thein, Chi, and Park (2008) and Prueksaaroon et al. (2009) discussed the implementation of cluster for virtual server. About the issue of information security, Perez, van Doorn, and Sailer (2008) examined the information security strength of emerging hardware and software virtualization technologies and the study of Hoesing (2009) established a mechanism for corporation risk recognition and safety control.

2.2. Key factors to implementing virtualization

The purpose of this study is to explore the key success factors to implementing virtual information environment in corporations, from the viewpoint of IT staffs. The concept of key success factors (KSFs) actually originated from the "limited factor" proposed by Commons (1934). Initially KSF was applied in economics theory; and later, Barnard (1948) transformed KSF to "strategic factor" and applied it in the management decision theory.

There have been many research literatures focusing on key factors analysis in various industries and businesses. However, most of these previous literatures focused on the key factors through the strategic management view, and only few of them were related to the management of information system (MIS). For example, Desanctis and Gourtney (1983) suggested six KSFs to the implementation of information systems and they are: (1) Top management involvement, (2) desire for the system from the intended users, (3) an immediate problem to address, (4) an established MIS group, (5) involvement of users in the design process, and (6) support for users to the system implementation. Laughlin (1999) proposed 10 KSFs based on his experiences in assisting corporations to implement ERP system: and these factors include (1) Clearly Defined Vision, (2) Change Management Effort, (3) Aggressive Schedule and Timelines, (4) Strong Sponsorship, (5) Target Communications, (6) Focused Issue Resolution, (7) Limited Scope, (8) Early Success, (9) Appropriate Project Staffing, and (10) Solid Project Management. Wixom and Watson (2001) investigated the success factors to data warehouse and identified three facets of warehousing implementation success: (1) Organizational Implementation Success, (2) Project Implementation Success, and (3) Technical Implementation Success.

There were also limited studies on the key factors to the implementation of virtualization. VMware in the white paper "The

Table 1
Summary of prior studies on different application areas of virtualization. *Source*: organized by this study.

Application phase	Researchers
Architecture design	Smith and Nair (2005), Uhlig et al. (2005), Vaughan-Nichols (2006)
Implementation and performance	Kallahalla et al. (2004), Khanna, Beaty, Kar, and Kochut (2006), Seetharaman and Murthy (2006), Menasce and Bennani (2006), Sotomayor et al. (2006), Zhang, Li, and Guan (2008), Oguchi and Yamamoto (2008), Jung et al. (2009), Friedman (2006), Chen and Xin (2005)
Benefits	Sehgal and Ganguli (2006), Tsai (2007), C. T. Chen (2007), Jin (2008a, 2008b), Symantec (2009), Rasmussen (2009), Weltzin and Delgado (2009), Hu (2009), Mevag (2007), Ribiere (2008)
Operating virtualization systems	Arce (2007), Singh, Korupolu, and Mohapatra (2008), Thein et al. (2008), Prueksaaroon et al. (2009), Yang et al. (2009), Silva et al. (2009), Matthews et al. (2005)
Information security	Perez et al. (2008), Hoesing (2009)

roadmap to virtual infrastructure" pointed out some key factors to implement virtualization (VMware, 2006b):

(1) Top-down sponsorship ensures the success of virtualization implementation.
(2) Treat virtualization as an architectural decision throughout the organization.
(3) Design for the big picture, but deploy incrementally.
(4) Achieve stakeholder buy-in early and maintain through all phases.
(5) From a virtualization core team to be the agents of change, ensuring early success.
(6) Ensure high quality design and remediation to avoid early shutdown.

The study of Hsieh (2008) conducted a case study research about a software company implementing virtualization. Through the results, Hsieh derived the following factors as criteria for corporations to implement virtualization: (1) Server consolidation, (2) computer room management, (3) terminal management, (4) software development life cycle improvement, (5) total cost reduction, (6) feasibility analysis, (7) security, and (8) personnel training.

The aforementioned studies regarding key factors to implementing virtualization mainly focused on factors in the management aspect. As virtualization environment is also one type of information system, technical factors should also be included to cover key factors in all aspects. The Information System Success Model (IS Success Model) initially proposed by DeLone and McLean (2003) provides good candidates of additional key factors from the technical aspect. The IS Success Model is shown in Fig. 1 (DeLone & McLean, 2003).

As shown in Fig. 1, the three fundamental factors proposed in the IS Success Model (DeLone & McLean, 2003) are: (1) System Quality – measures of the information processing system, (2) Information Quality – the quality of the information system output, and (3) Service Quality – assessment from information system users on the usage of information output. The three fundamental factors combined to generate influences on the Use, User Satisfaction, and Net Benefits (DeLone & McLean, 2003). Several key measures of System Quality, Information Quality, and Service Quality are listed in Table 2, with references of related studies.

In summary, in addition to the traditional key factors proposed from the management aspect, the IS Success Model also provide key influencing factors from the technical aspect. Factors in different aspects should be joined to give a full spectrum analysis on the implementation of virtualization information environment.

3. Research method

This section describes the research design, questionnaire design, research objects and analysis method. First, through literature review and analysis, this study identified factors that may affect the effectiveness of a corporation's implementation of virtualization information environment, and listed questionnaire items related to the research topic. A group of experts were invited to further evaluate the validity of each questionnaire item. All validated items were included in the finalized questionnaire for the formal study to collect opinions from IT staffs in corporations on key factors to implement virtualization information environment.

3.1. Questionnaire design

The design of questionnaire followed literatures and referenced other questionnaires in similar studies. Hopefully through systematic and structural investigation, this study can understand the key factors that IT staffs consider during the implementation of virtualization information environment in corporations.

Items in the questionnaire are collected from academic researches related to key success factors to implement virtualization information environment and information systems from the management aspect. After identifying and eliminating factors with similar meanings and choosing factors supported by at least two studies, this study categorized 10 dimensions as variables for evaluating key factors to implement virtualization information environment. The 10 dimensions are: (1) Ease of Deployment, (2) Test and Development Agility, (3) Integration of Resources, (4) Simplified Management and Maintenance, (5) Cost Reduction, (6) Impact to Organization, (7) Training, (8) Security, (9) Specialized Team, and (10) Support from Organization.

In addition, as virtualization information environment is regarded as one type of information system, this study adopts the criteria proposed by many researchers to assess the successfulness of an information system as additional key factors to evaluate the implementation of virtualization information environment from technical aspects. These three additional key factor dimensions from technical aspects are: (1) System Quality, (2) Information Quality, and (3) Service Quality. Following up the study of Seddon and Kiew (1996), this study generated 13 and 10 items for "System Quality" and "Information Quality," respectively. As for "Service Quality," following the measures proposed by Pitt, Watson, and Kavan (1995), this study lists 22 items for assessing "Service Quality."

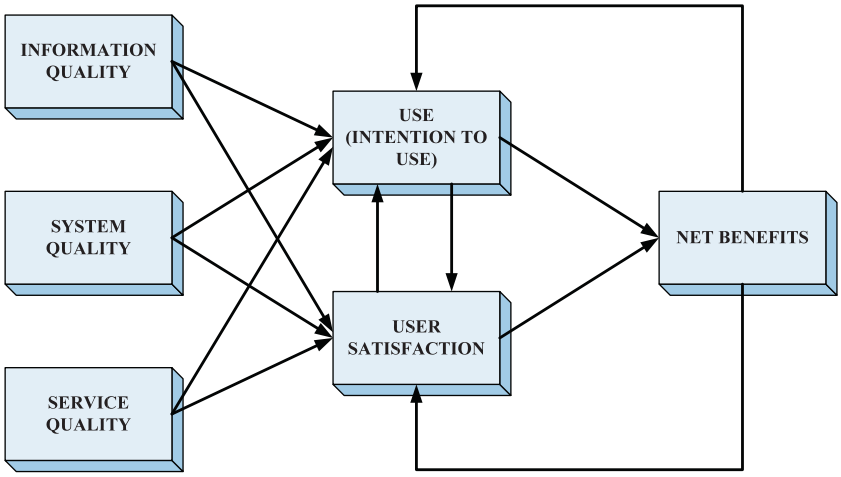

Fig. 1. The information system success model (DeLone & McLean, 2003).

Table 2
Measures for system quality, information, and service quality. *Source*: organized by this study.

Factors	Measures	References
System quality	Response time	Emery (1971), Swanson (1974), Hamilton and Chervany (1981), DeLone and McLean (1992)
	Data accuracy	Emery (1971), Hamilton and Chervany (1981), Belardo, Karwan, and Wallace (1982), Bailey and Pearson (1983), Srinivasan (1985), Sigwart, Van Meer, and Hansen (1991), DeLone and McLean (1992)
	System reliability	Emery (1971), Swanson (1974), Hamilton and Chervany (1981), Sigwart et al. (1991), DeLone and McLean (1992), Seddon (1997)
	Completeness	Hamilton and Chervany (1981), Bailey and Pearson (1983), Srinivasan (1985), Miller and Doyle (1987)
	System flexibility	Hamilton and Chervany (1981), Belardo et al. (1982), Bailey and Pearson (1983), Srinivasan (1985), DeLone and McLean (1992)
	Ease of use	Swanson (1974), Hamilton and Chervany (1981), DeLone and McLean (1992), Seddon (1997)
	Usefulness of system features and functions	Emery (1971), DeLone and McLean (1992)
	Ease of learning	Belardo et al. (1982), Bailey and Pearson (1983), Srinivasan (1985), DeLone and McLean (1992)
	Data currency	Hamilton and Chervany (1981), DeLone and McLean (1992)
	Integration of systems	DeLone and McLean (1992), Bailey and Pearson (1983)
Information quality	Timeliness	Bailey and Pearson (1983), Doll and Torkzadeh (1988), DeLone and McLean (1992), Rainer and Watson (1995), Seddon (1997)
	Accuracy	Bailey and Pearson (1983), DeLone and McLean (1992), Rainer and Watson (1995), Seddon (1997)
	Completeness	Bailey and Pearson (1983), DeLone and McLean (1992)
	Reliability	Bailey and Pearson (1983), King and Epstein (1982), Doll and Torkzadeh (1988), DeLone and McLean (1992), Eighmey and McCord (1998)
	Usefulness	Bailey and Pearson (1983), Davis (1989), Seddon (1997), Eighmey and McCord (1998)
	Relevance	Bailey and Pearson (1983), Davis (1989), DeLone and McLean (1992), Rainer and Watson (1995), Seddon (1997)
	Understandability	Srinivasan (1985), Mahmood and Medewitz (1985)
	Comparability	King and Epstein (1982), Srinivasan (1985), Mahmood and Medewitz (1985)
	Quantitativeness	King and Epstein (1982), Srinivasan (1985), Mahmood and Medewitz (1985)
Service quality	Access	Parasuraman, Berry, and Zeithaml (1988)
	Communication	Parasuraman et al. (1988)
	Competence	Parasuraman et al. (1988)
	Courtesy	Parasuraman et al. (1988)
	Tangibles	Parasuraman et al. (1988), Pitt et al. (1995), DeLone and McLean (2003)
	Reliability	Parasuraman et al. (1988), Kettinger and Lee (1994), Pitt et al. (1995)
	Responsiveness	Parasuraman et al. (1988), Pitt et al. (1995), DeLone and McLean (2003)
	Security	Sasser, Olsen, and Wyckoff (1978)
	Assurance	Parasuraman et al. (1988), Kettinger and Lee (1994), Pitt et al. (1995), DeLone and McLean (2003)
	Empathy	Parasuraman et al. (1988), Kettinger and Lee (1994), Pitt et al. (1995), DeLone and McLean (2003)

A preliminary questionnaire with a total of 68 items categorized in 13 dimensions was organized by this study to investigate key factors to implementing virtualization information environment, as listed in Table 3.

An expert panel was formed and 14 experts were invited to join in the panel to assess the adequacy of items in the preliminary questionnaire to match the research theme. These experts come from the business community, the IT industry, and the academia, with deep understandings and practical experiences in virtualization information environment. Table 4 lists the backgrounds of these experts.

The 68 items in the preliminary questionnaire were evaluated by the expert panel using the Content Validity Ratio (CVR) method proposed by Lawshe (1975). Experts were asked to assess the importance of each item to this study using three ordinal scales: "Not Relevant," "Important but Not Essential," and "Essential." The CVR for each item was calculated using the following formula:

$$\mathrm{CVR} = (n - N/2)/(N/2),$$

where n was the number of experts identifying an item as "Essential," and N was the total number of experts.

Lawshe (1975) recommended that for items suitable for the research theme, the minimum acceptable value of CVR should be 0.51 for a 14-member panel. Table 5 lists the evaluated items with CVR values surpassing the 0.51 threshold. A total of 30 items were selected from Table 5 to form the formal questionnaire to investigate key factors to implementing a virtualization information environment. All items in the formal questionnaire in this study were assessed using the 7-point Likert scale. The 7-point Likert scale ranges from 1 to 7, corresponding to "Strongly Disagree," "Disagree," "Slightly Disagree," "Neutral," "Slightly Agree," "Agree," "Strongly Agree," respectively.

3.2. Research subjects and sampling

The object of this study is to investigate key factors for corporations to implementing virtualization information environment. The population of subjects of this study comprises IT staffs implementing virtualization information environments for corporations, or staffs of information service providers assisting corporations to implement virtualization information environment.

Because virtualization information environment for ×86 servers is a relatively new technology with markets still under development, difficulties arises in sampling when research subjects are limited to those who have certain levels of understanding of and also participate in the implementation or maintenance of virtualization information environment. To increase the representativeness of research results, this study adopted the purposeful sampling method.

Purposeful sampling selectively conducts survey on information-rich respondents to provide in-depth discussion on issues of research focus. A researcher using purposeful sampling chooses the sample population from those who can best provide information needed by the research. The sample population chosen by this study consists of personnel related to the implementation of virtualization information environments and systems, including IT staffs for system management and maintenance and engineers from IT service providers providing support and consultation. To increase the number of qualified samples, this study first acquired

Table 3
Dimensions and items of the preliminary questionnaire. *Source*: Organized by this study.

Dimension	No.	Item	References
Ease of deployment	1	Facilitating deployment of system and services	Sehgal and Ganguli (2006), Hsieh (2008)
	2	Making the information system architecture more flexible	Ribiere (2008), Hsieh (2008)
Test and development agility	3	Increasing test and development agility of software or systems	Sehgal and Ganguli (2006), Hsieh (2008)
Integration of resources	4	Saving space for facilities	Chen and Xin (2005), Rasmussen (2009)
	5	Simplifying IT infrastructure	Singh et al. (2008), Zhang et al. (2008), Hsieh (2008)
	6	System fully utilizing server resources	Doherty and Kelisky (1979), Khanna et al. (2006), Tsai (2007)
Simplified management and maintenance	7	Reducing time for system management	Sotomayor et al. (2006), Hsieh (2008)
	8	Reducing the number of physical servers	Uhlig et al. (2005), Hsieh (2008)
	9	Reducing maintenance workforce	Hsieh (2008), Symantec (2009)
	10	Reducing service interruption time	Mevag (2007), Ribiere (2008)
Cost reduction	11	Reducing hardware establishment cost	C. T. Chen (2007), Hsieh (2008), Rasmussen (2009), Symantec (2009)
	12	Reducing hardware maintenance cost	Rasmussen (2009), Symantec (2009), Weltzin and Delgado (2009)
	13	Reducing electricity usage by facilities	C. Y. Chen (2007), Symantec (2009)
Impact to organization	14	Influence of virtualization system on application administrators	Wixom and Watson (2001), Hsieh (2008)
	15	Influence of virtualization system on users	Wixom and Watson (2001), Hsieh (2008)
Training	16	Training for maintenance staffs	Wixom and Watson (2001), Hsieh (2008)
	17	Training for entire staffs of the organization	Wixom and Watson (2001), VMware (2006a), Hsieh (2008),
	18	Training for users	Laughlin (1999), Hsieh (2008)
Security	19	Overall impression on security of virtualization systems and physical servers	Sehgal and Ganguli (2006), C. Y. Chen (2007), Perez et al. (2008), Gao (2009)
Specialized team	20	Establishing a core team specialized in virtualization	Laughlin (1999), VMware (2006a), Hsieh (2008)
	21	Establishing a expert center dedicated to providing consultancy and services related to virtualization	Wixom and Watson (2001), Hsieh (2008)
Support from organization	22	Support from top management	Desanctis and Gourtney (1983), Wixom and Watson (2001), Hsieh (2008)
	23	Support from users	Desanctis and Gourtney (1983), Wixom and Watson (2001), Hsieh (2008)
System quality	24	Easy-to-use interface	Davis (1989), DeLone and McLean (1992, 2003), Seddon and Kiew (1996), Seddon (1997), Rai, Lang, and Welker (2002)
	25	User-friendly interface	
	26	Easy to learn	
	27	Easy to operate	
	28	Easy to use functions with proficiency	
	29	Troublesome to operate	
	30	Exhausting in using	
	31	Frustrating in using	
	32	Speeding up work	
	33	Increasing individual job efficiency	
	34	Improving productivity	
	35	Making job easy	
	36	Convenient system	
	37	Providing useful reports	
Information quality	38	Having satisfactory information accuracy	Davis (1989), DeLone and McLean (1992), Seddon and Kiew (1996), Seddon (1997), Rai et al. (2002),
	39	Providing clear information	
	40	Providing correct information	
	41	Providing sufficient information	
	42	Providing timely information	
	43	Providing needed information in time	
	44	Providing necessary reports	
	45	Providing needed, accurate information	
	46	Content matching needs	
	47	Information service provider having up-to-date hardware and software	
Service quality	48	System having visually attractive functions	Kettinger and Lee (1994), Pitt et al. (1995), DeLone and McLean (2003)
	49	Staffs of IS provider dressing formally and neatly	
	50	Actual system functions and claimed functions being consistent	
	51	IS provider processing promised services within designated time	
	52	IS provider providing timely solutions	
	53	IS provider providing reliable systems	
	54	IS provider completing services within promised time	
	55	IS provider maintaining flawless record	
	56	IS provider precisely notifying the time to complete services	
	57	IS provider willing to promise services it should provide	
	58	IS provider willing to help me to solve problems	

Table 3 (*continued*)

Dimension	No.	Item	References
	59	IS provider always responding to my needs	
	60	IS provider's attitude giving users confidence	
	61	IS provider making user feel safe during communication	
	62	IS provider always maintaining polite attitude	
	63	IS provider have sufficient knowledge to do the job	
	64	IS provider providing unique services	
	65	IS provider providing convenient services within office hours	
	66	IS provider providing personalized services	
	67	IS provider respecting customers	
	68	IS provider understanding corporation's special needs	

Table 4
Backgrounds of panel experts. *Source*: organized by this study.

Expert	Job title	Related experiences
A	Director	(1) 20 years of work experiences in IT related fields (2) specialized in planning and setup of information systems and facilities
B	Assistant Professor	(1) 10 years of work experiences in IT related fields (2) currently in charge of implementing virtualization information environment
C	Senior Engineer	(1) 10 years of work experiences in IT related fields (2) VCP (VMware Certified Professional) (3) specialized in planning and setup of virtualization information environment
D	Vice Director	(1) 15 years of work experiences in IT related fields (2) specialized in ERP implementation, business process management, and information system analysis
E	Senior Engineer	(1) 11 years of work experiences in IT related fields (2) currently in charge of implementing virtualization information environment
F	Project Manager	(1) 16 years of work experiences in IT related fields (2) specialized in information system and network security planning and virtualization information environment planning
G	Senior Engineer	(1) 8 years of work experiences in IT related fields (2) currently in charge of implementing virtualization information environment
H	Section Manager	(1) 10 years of work experiences in IT related fields (2) specialized in network construction and maintenance, information system management (3) company has implemented virtualization for 4 years
I	Section Manager	(1) 12 years of work experiences in IT related fields (2) specialized in information system analysis and application maintenance (3) company has implemented virtualization for 5 years
J	Team Leader	(1) 10 years of work experiences in IT related fields (2) currently in charge of implementing virtualization information environment
K	Project Manager	(1) 10 years of work experiences in IT related fields (2) specialized in system architecture planning and virtualization implementation
L	Systems Engineer	(1) 7 years of work experiences in IT related fields (2) in charge of management and maintenance of virtualization information environment
M	Customer Service Engineer	(1) 8 years of work experiences in IT related fields (2) VCP (VMware Certified Professional) (3) specialized in assisting customers to implement virtualization information environment
N	Manager	(1) 14 years of work experiences in IT related fields (2) In charge of planning and implementing virtualization information environment

from panel experts a list of corporation IT personnel having experiences related to virtualization information environments, and distributed questionnaires to these personnel through personal communication. Second, this study distribute questionnaire to qualified personnel in the conferences related to the virtualization information environment.

3.3. Data analysis

This study employed questionnaire as the research instrument to survey IT staffs in corporations that have already implemented virtualization information environment. Data analysis in this study was mainly conducted using the statistical analysis software SPSS 12.0, plus structural equation modeling software AMOS 16.0. Methods used in this study for data analysis are described in the following.

3.3.1. Descriptive statistics

There are three parts of descriptive statistics analysis. One part is the analysis of respondents' demographic information, including education, occupation, industry sector, and the number of staffs in the IT department. Another part of analysis focuses on the current status of virtualization information environment within respondents' organizations, including time of implementation, the number of hosts on the virtualization system platform, and the number of guests on the platform. The third part is the analysis of research variables, containing the average and standard deviation of respondents' answers of each questionnaire item, to facilitate the understanding of the distribution of responses.

3.3.2. Reliability and validity analysis

Reliability measures the consistency and dependability of an assessment instrument. Validity measures the level of matching between the measured results and the targeted research issue. For reliability, this study applied Cronbach's α coefficient to examine the internal consistency of the questionnaire items. For validity, in addition to the CVR method (Lawshe, 1975) used to generate the formal questionnaire, this study conducted construct validity analysis to examine the validity of the questionnaire.

3.3.3. Factor analysis

Factor analysis deduces meaningful factors from a set a variables by grouping closely related variables sharing one common,

Table 5
Expert evaluation of questionnaire items. *Source*: organized by this study

No.	Item	CVR
1.	Virtualization system makes it easier to deploy system or services	0.571428
2.	Virtualization system can flexibly adjust to meet the needs of the company	0.714285
3.	Using virtualization system can increase the system development and testing flexibility	0.714285
4.	Using virtualization system can save space of computer room	0.714285
5.	Using virtualization system can simplify the IT infrastructure	0.571428
6.	Virtualization system can use the server resources fully	0.857142
7.	Using virtualization system can reduce my time to management system	0.571428
8.	Using virtualization systems can reduce the number of physical servers	0.857142
9.	Using virtualization systems can reduce maintenance manpower	0.714285
10.	Virtualization systems better than the physical servers to reduce service downtime	0.571428
11.	Using virtualization system can reduce hardware implementation cost	0.714285
12.	Using virtualization system can reduce system maintenance costs	0.714285
13.	Using virtualization system can reduce electricity consumption of computer room	0.714285
16.	When into virtualization system, the training of IT staffs is very important	0.714285
19.	Virtualization system has the security level provided by physical machines, and may be even more secure	0.714285
20.	The establishment of a core team is very important when importing virtualization	0.571428
22.	Have the senior manager's support is very important when importing virtualization	0.857142
26.	Virtualization system is easy to use	0.714285
27.	I find it easy to get virtualization system to finish my job	0.714285
28.	It is easy for me to become skilful at using virtualization system	0.571428
32.	Using virtualization system in my job enables me to accomplish my tasks more quickly	0.571428
33.	Using virtualization system improved my job performance	0.714285
35.	Using virtualization system enhances my effectiveness in the job	0.714285
37.	Using virtualization system makes it convenient to do my job	0.571428
40.	Is the information clear?	0.714285
41.	Is the system accurate?	0.714285
42.	Does the system provide sufficient information?	0.857142
44.	Can I get the information my need in time?	0.571428
46.	Does the system provide the precise information my need?	0.571428
47.	Does the information content meet my need?	0.571428

dominant characteristic into one category representing that characteristic. The objective of factor analysis is to find basic common factors from a set of variables and use these factors to describe the relationships between analysis indices and variables. By replacing large number of variables with few basic factors while keeping most of the information within the original data, factor analysis is suitable for the analysis and explanation of complicated data.

This study conducted factor analysis through the following steps:

(1) Confirm whether the data are suitable to use factor analysis.
(2) Extract common factors and the loading of each factor.
(3) List factors with eigenvalue >1 with their loading.
(4) Rotate the factor matrix to better interpret the meanings of factors.

3.3.4. Correlation analysis

Correlation analysis examines the level of dependence between variables. Typically, correlation is represented the Pearson's product-moment coefficient which measures the linear dependence between two variables and falls between −1 and 1. A larger correlation coefficient between two variables means that the two variables are more correlated, vice versa.

3.3.5. Structural equations modeling

To conduct complete structural analysis to the data, this study applied structural equations modeling (SEM) method to examine the data. SEM combines factor analysis and path analysis. Through measuring of different indicators, SEM can provide confirmatory examination to results of factor analysis.

4. Research results

The research subjects of this study comprise IT staffs in corporations having implemented virtualization technology. Qualified respondents were invited to fill out the questionnaire through paper-based or email-based personal communication. A total of 492 questionnaires were sent out (265 paper-based, 227 email-based), and 437 questionnaires were received. Questionnaires with disqualified respondents or incomplete answers were identified as invalid, and the final number of valid questionnaires was 400. The questionnaire survey results were analyzed using statistical analysis software SPSS 12.0 and structural equation modeling (SEM) software AMOS 16.0. Data analysis in this study contains three parts: descriptive analysis, reliability and validity analysis, and factor analysis.

4.1. Descriptive statistics

Descriptive statistics focuses on analyzing respondents' basic information, including education, occupation, industry sector, etc., as well as company's current status of implementing virtualization information environment. Table 6 lists the statistics of respondents' basic information.

4.2. Reliability analysis

Reliability is the assessment of the consistency of data acquired from repeated measurements on the same or similar maternal. This study adopted Cronbach's α coefficient to measure the internal consistency among items categorized under the same factor. Typically, the reliability of measured objects is considered acceptable with α value >0.7 (Hair, Black, Babin, Anderson, & Tatham, 2006; Santos, 1999) and excellent with >0.9 (George & Mallery, 2003). The overall Cronbach's α coefficient of measured variables in this study is 0.928, indicating high reliability and internal consistency.

4.3. Validity analysis

Validity refers to whether a measurement tool is suitable. Both content validity and construct validity are examined in this study.

Table 6
Statistics of respondents' basic information ($n = 400$). *Source*: organized by this study.

Items		Counts	Percentage
Education	High school and vocational school	7	1.7
	College	85	21.3
	University	246	61.5
	Research institute above	62	15.5
Occupation	IT staffs	254	63.5
	IT director	42	10.5
	Systematic-Integration engineer	55	13.8
	Systematic-Integration director	18	4.5
	IT contractor	31	7.7
Industry sector	Building trade	5	1.2
	Manufacturing	161	40.3
	Logistics	9	2.2
	Communications	3	0.7
	Commerce business	16	4
	Legal industry	4	1
	Health industry	16	4
	IT services	54	13.5
	Financial industry	42	10.5
	Mass communication	11	2.8
	Military and civil servant	20	5
	Educator	16	4
	Others	43	10.8
Number of employees in company's information department	Within 2 persons	38	9.5
	3–5 persons	57	14.2
	6–10 persons	63	15.8
	11–20 persons	63	15.8
	21–30 persons	94	23.5
	31 persons or more	85	21.2
Time for the implementation of virtualization technology	Within 1 years	85	21.2
	1–2 years	100	25
	2–3 years	98	24.5
	3–4 years	61	15.3
	4 years or more	56	14
Number of virtualization hosts	1–2	78	19.5
	3–5	197	49.3
	6–10	89	22.2
	11 or more	36	9
Number of guest in the virtualization system	1–2	30	7.5
	3–5	54	13.5
	6–10	98	24.5
	11–20	175	43.7
	21 or more	43	10.8

4.3.1. Content validity

Content validity refers to the adequacy of questionnaire items to support the intended research analysis (Hair et al., 2006). Churchill (1979) suggested that a preliminary test to the questionnaire content should be performed before the distribution of formal questionnaire, in order to identify confusing or improper content and make necessary modification to improve content validity. Tsai (2001) also pointed out that when the questionnaire content is developed based on literatures, a review or preliminary test can ensure validity.

To ensure the content validity of the questionnaire, this study designed the preliminary questionnaire items based on literatures, and invited 14 experts to assess the content validity based on the CVR method. A total of 30 items with high CVR values were selected to form the formal questionnaire, to ensure high validity.

4.3.2. Construct validity

Construct validity represents whether the questionnaire items can adequately reflect what the researcher intend to measure. Construct validity is usually evaluated through the suitability of factor analysis. This study adopted Kaiser–Meyer–Olkin Measure of Sample Adequacy (KMO) (Kaiser, 1974) and Bartlett's Test of Sphericity (Snedecor & Cochran, 1989) to evaluate whether the questionnaires items are suitable for factor analysis. The overall KMO value is 0.915, much larger than the 0.5 acceptable threshold; the significance of Bartlett's Test is 0.000, suggesting the questionnaire items in this study is suitable to apply factor analysis. Therefore, construct validity in this study is acceptable.

4.4. Results factor analysis

This research categorized 30 questionnaire items in the formal questionnaire into more meaningful factors through factor analysis. Table 7 shows the detail results of factor analysis. A total of 7 factors were extracted. Values of factor loading of all questionnaire times are all greater than 0.7, supporting construct validity.

4.5. Factor extraction and interpretation

Through factor analysis, this study identified 7 factors from 30 questionnaire items. The meanings of the 7 factors were carefully interpreted and proper names were given to these factors. The items were categorized into different factors based on their factor loading, and the name of each factor was determined based on the common characteristic of items categorized under it, as explained in the following:

Table 7
Results of factor analysis. *Source*: organized by this study.

Factor	Item	Factor loading	Eigenvalue	% Of variance	Cumulative %
1	3	0.818	10.692	35.641	35.641
	2	0.799			
	20	0.779			
	25	0.752			
	23	0.749			
	6	0.740			
	1	0.727			
2	29	0.881	3.878	12.926	48.568
	19	0.878			
	28	0.874			
	22	0.849			
	21	0.843			
	27	0.808			
3	14	0.744	2.439	8.131	56.699
	12	0.744			
	24	0.744			
	7	0.733			
	16	0.720			
4	10	0.861	2.123	7.075	63.774
	13	0.822			
	18	0.818			
5	9	0.834	1.581	5.270	69.043
	8	0.825			
	17	0.811			
6	15	0.854	1.271	4.235	73.279
	26	0.787			
	11	0.786			
7	4	0.908	1.012	3.372	76.651
	30	0.903			
	5	0.807			

Table 8
Correlation matrix. *Source*: organized by this study.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Factor 1	1						
Factor 2	0.290**	1					
Factor 3	0.647**	0.328**	1				
Factor 4	0.488**	0.217**	0.391**	1			
Factor 5	0.437**	0.399**	0.348**	0.501**	1		
Factor 6	0.501**	0.235**	0.477**	0.562**	0.368**	1	
Factor 7	0.098*	−0.070	0.138**	0.045	0.027	0.023	1

* $p < 0.05$.
** $p < 0.01$.

1. *Factor 1: System Quality*: The questionnaire items contained in factor 1 account for 35.641% of variance. As all 7 items were originated from the "System Quality" scale of the Information System Success Model (Seddon & Kiew, 1996), factor 1 was named as "System Quality." The individual questionnaire items for System Quality consider mostly in how virtualization systems can improve respondents' work efficiency and performance.
2. *Factor 2: Information Quality*: Factor 2 explains 12.926% of variance. It comprises 6 items, all deduced from the "Information Quality" scale of the IS Success Model (Seddon & Kiew, 1996). Therefore, factor 2 was identified as "Information Quality." Questionnaire items covered by Information Quality concern issues such as the accuracy, timeliness, helpfulness, and clarity of information provided from virtualization systems.
3. *Factor 3: Simplified Management and Maintenance*: The five items in factor 3 explain 8.131% of variance. With all 5 items related to the management and maintenance of virtualization servers, factor 3 was named as "Simplified Management and Maintenance." Issues under this factor include time management, maintenance management, and security management.
4. *Factor 4: Integration of Resources*: Factor 4 accounts for 7.075% of variance. Items categorized in this factor are related to the integration of server resources, and therefore factor 4 was given the name "Integration of Resources." Such integration includes physical servers and virtual server resources.
5. *Factor 5: Cost Reduction*: Factor 5 explains 5.270% of variance. It contains three items related to server expenses or costs. Therefore, the named of factor 5 is "Cost Reduction." Cost reduction covers hardware cost, maintenance cost, and electricity cost.
6. *Factor 6: Ease of Deployment, Test and Development*: The 4.235% of variance are explained by factor 6 with three items related to server deployment, test and development. Factor 6 was named as "Ease of Deployment, Test and Development." This factor actually concerns about the flexibility provided by virtualization systems.
7. *Factor 7: Organizational Consensus*: The three items categorized in factor 7 accounts for 3.372% of variance. All three items are considered related to the organizational support. Therefore, the name of factor 7 was chosen as "Organizational Consensus."

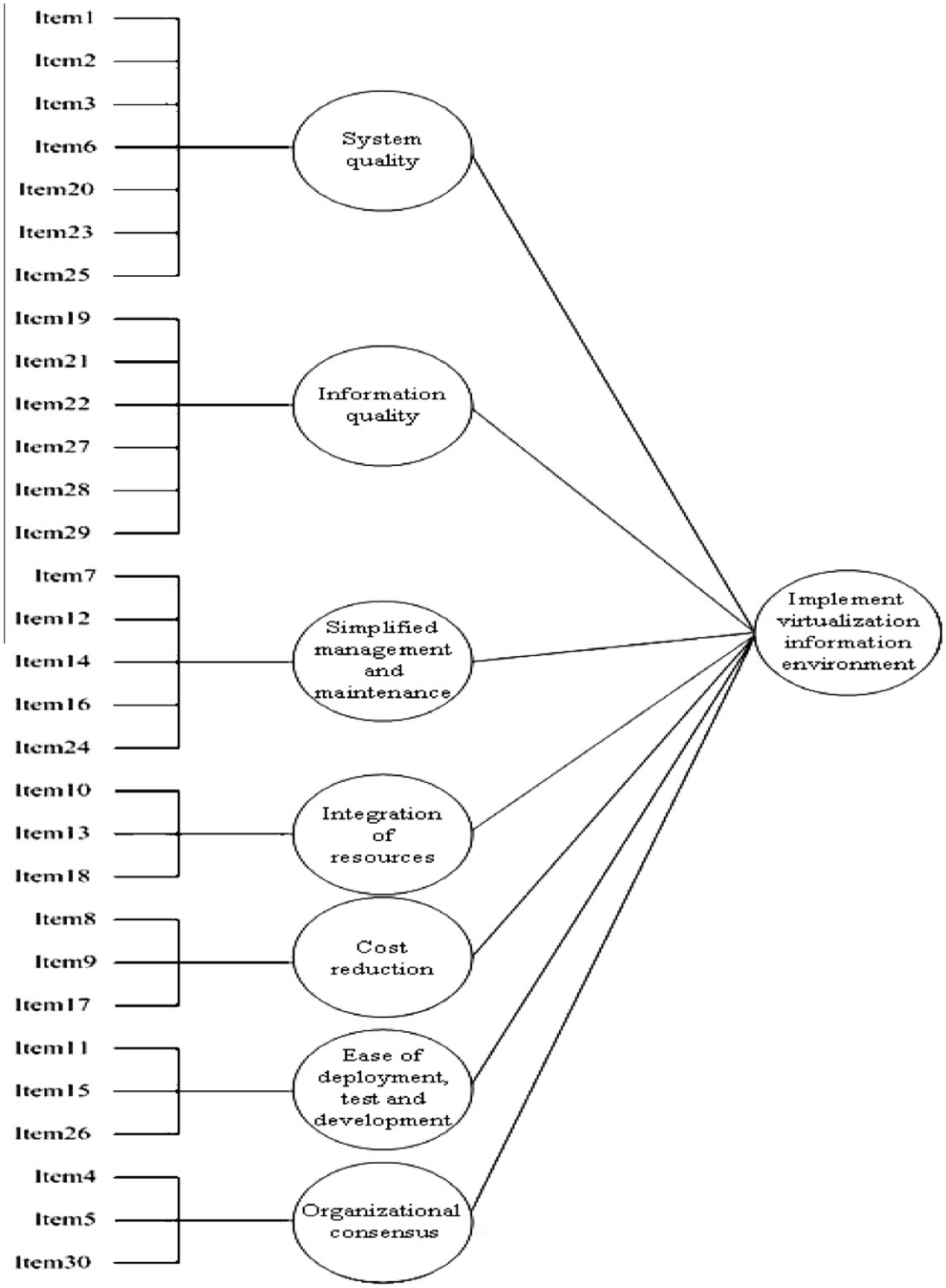

Fig. 2. Key factors to implement virtualization.

4.6. Correlation analysis

This study utilizes Pearson's correlation coefficient to investigate the correlation among different factors. The results of Correlation analysis are listed in Table 8. As all correlation coefficients between any two factors are smaller than 0.7, with most of them smaller than 0.5, the correlation among factors is considered low, further confirming the validity of the designed questionnaire used in this study.

4.7. Structural equations modeling analysis

Based on the results of aforementioned analysis, this study established a tree diagram to represent key factors that corporation IT staffs consider in the implementation of virtualization information environment, and their relationships to questionnaire items, as shown in Fig. 2. To further verify this relationship structure, this study applied confirmatory factor analysis (CFA) to measure the overall model fit. Structural equation modeling (SEM)

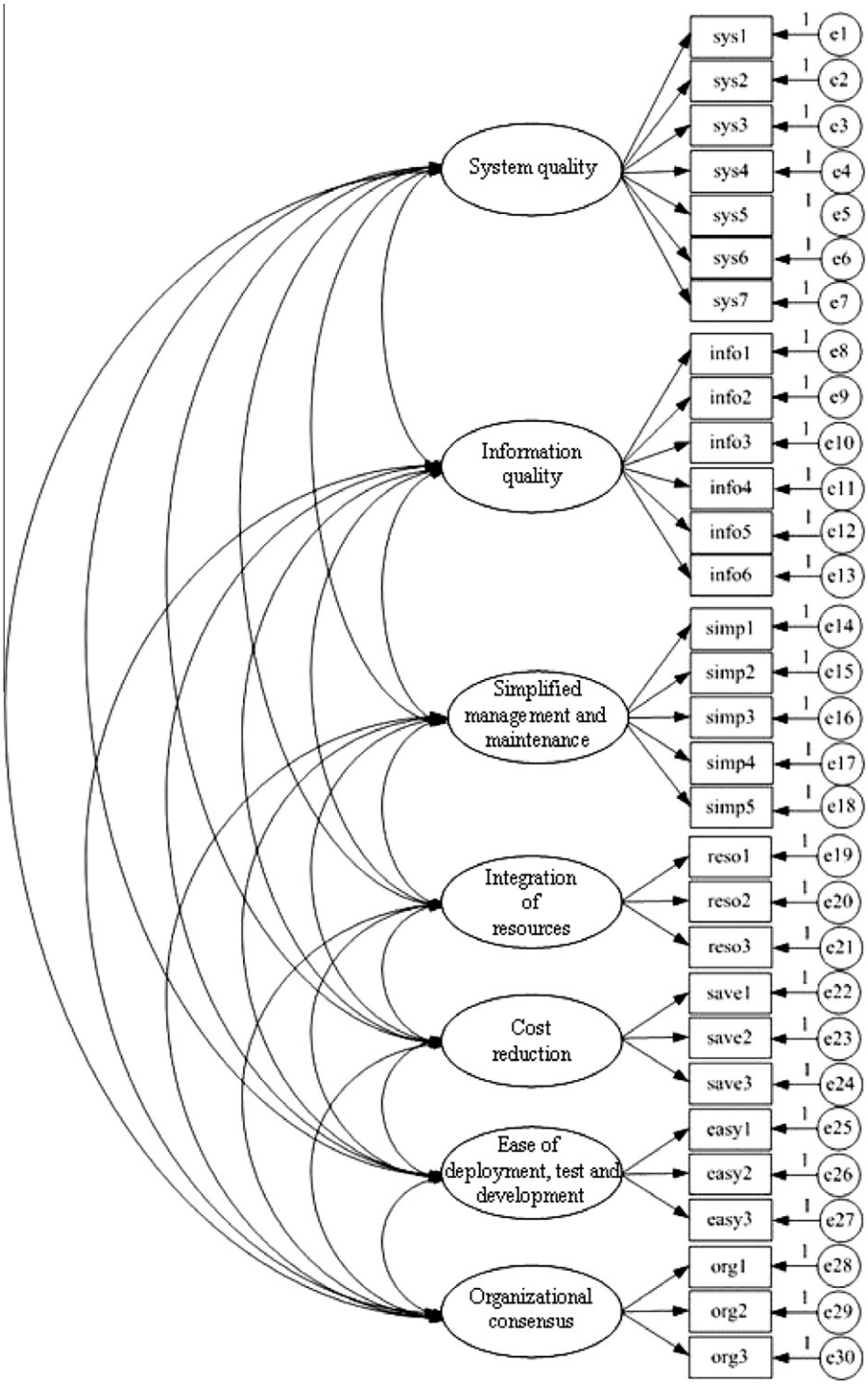

Fig. 3. Measurement model.

software AMOS 16.0 was used to support this analysis. Fig. 3 shows the measurement model for confirmatory factor analysis.

With Structural equation modeling (SEM) software, this study first applied various indicators to assess the overall model fit. Model fit represent the measure of consistency between the actually measured factor matrix and the model matrix. Table 9 lists test results of various model fit indicators, with the fit criteria suggested by Hair et al. (2006).

After examining the fit criteria of the overall measurement model, this study applied the Maximum Likelihood Estimation (MLE) method to analyze validity. In addition, following Hair et al. (2006), this study examined reliability through composite reliability and variance extracted. Table 10 lists the results of reliability and validity analysis of SEM. Except that the factor loading of item 5, 0.649, was less than 0.71, all other items had factor loading values greater than 0.71. All 7 factors had composite reliability greater than 0.7, and variance extracted greater than 0.5, indicating that the research construct of this study has high reliability and validity.

Finally, the discriminant validity of the measurement model was examined in this study. Table 11 lists the results of

Table 9
Model fit of measurement model. *Source*: Hair et al. (2006); this study.

Fit criteria	Calculated value	Suggested criteria
χ^2/df	1.761	<3
Normed Fit Index (NFI)	0.928	>0.9
Comparative Fit Model (CFI)	0.967	>0.9
Goodness Fit Model (GFI)	0.900	>0.9
Root Mean Square Residual (RMR)	0.037	<0.05
Adjusted Goodness Fit Model (AGFI)	0.879	>0.8
Root Mean Square Error of Approximation (RMSEA)	0.044	<0.1

discriminant validity analysis. The low correlation between different factors in the off-diagonal areas suggested good discriminant validity among factors identified in this study.

5. Conclusion and suggestion

In conclusion, this study intended to investigate the key influencing factors for corporation to implement virtualization information environment, from the view of IT staffs. A questionnaire was developed following literatures and further reviewed by an expert panel using the CVR method to determine items most related to the purpose of this study. Through purposeful sampling, 437 questionnaires were collected with 400 considered valid.

Results of validity and reliability tests suggested that the questionnaire developed by this study supported the purpose of this study. Factor analysis extracted the key factors from 30 questionnaire items and the results were further re-confirmed by the structural equation modeling method. A total of 7 influencing factors for corporations to implement virtualization information environment were identified: (1) System Quality, (2) Information Quality, (3) Simplified Management and Maintenance, (4) Integration of Resources, (5) Cost Reduction, (6) Ease of Deployment, Test and Development, and (7) Organizational Consensus. Among these factors, "System Quality," "Information Quality," and "Simplified Management and Maintenance" account for 56.7% of the variance, and therefore were considered the top three important factors for corporations to implement virtualization information environment, from the view of IT staffs.

Table 10
Reliability and validity analysis of SEM. *Source*: organized by this study.

Factor	Item No.	MLE		Composite reliability	Variance extracted
		Factor loading	Standard deviation		
System quality	1	0.815	0.336	0.929	0.652
	2	0.814	0.337		
	3	0.804	0.354		
	6	0.794	0.370		
	20	0.810	0.344		
	23	0.782	0.388		
	25	0.831	0.310		
Information quality	19	0.880	0.226	0.941	0.726
	21	0.815	0.336		
	22	0.836	0.301		
	27	0.802	0.357		
	28	0.882	0.222		
	29	0.893	0.203		
Simplified management and maintenance	7	0.811	0.342	0.884	0.605
	12	0.769	0.409		
	14	0.818	0.331		
	16	0.772	0.404		
	24	0.714	0.490		
Integration of resources	10	0.965	0.069	0.928	0.811
	13	0.915	0.163		
	18	0.816	0.334		
Cost reduction	8	0.853	0.272	0.893	0.735
	9	0.896	0.197		
	17	0.822	0.324		
Ease of deployment, test and development	11	0.835	0.303	0.892	0.734
	15	0.871	0.241		
	26	0.864	0.254		
Organizational consensus	4	0.914	0.165	0.861	0.678
	5	0.649	0.579		
	30	0.882	0.222		

Table 11
Results of discriminant validity. *Source*: this study.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Factor 1	**0.81**						
Factor 2	0.30	**0.85**					
Factor 3	0.71	0.36	**0.78**				
Factor 4	0.52	0.22	0.43	**0.90**			
Factor 5	0.48	0.44	0.39	0.54	**0.86**		
Factor 6	0.55	0.25	0.54	0.60	0.41	**0.86**	
Factor 7	0.13	−0.05	0.16	0.04	0.03	0.02	**0.82**

Through the combination of the IS Success Model and academic researches associated with the KSF of the implementation of virtualization and/or other information systems from management aspects, a new scale for evaluating key factors of the implementing virtualization is thus developed. Factor analysis reveals that as the incorporation of IS Success Model leads to the major factors (System Quality and Information Quality) of implementing virtualization, considerations from the management aspect also contribute greatly to the success of implementing virtualization. The detailed items under key factors suggest that successful implementation of virtualization relies on how virtualization systems can improve work efficiency and performance; provide detailed, timely, accurate, and most needed information; save time, money, and system resources; and provide flexibility. In addition, the support from corporations is also important for the success of implementing virtualization.

In the aspects of research contributions, this study tries to establish a new key factors analysis basis for the implementation of virtualization, which provides a new starting point for future academic researches regarding virtualization. As pointed out from this study that the key issues in the implementation of virtualization through IT practitioners' view, the results of this study may be used as a confirmation of theoretical considerations before implementing virtualization. For practitioners and corporations, in the process of implementing virtualization information environment, top management or project manager levels should pay a particular attention to the aspects including system quality, information quality, and simplification of management and maintenance.

For the possible directions of future studies, comparisons of the key factors in the implementation of virtualization among corporations with different scales and industry sectors may be helpful in understanding further the impacts of virtualization in organizations.

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References

Arce, I. (2007). Ghost in the virtual machine. *IEEE Security & Privacy, 5*(4), 68–71.

Bailey, J. E., & Pearson, S. W. (1983). Development of a tool for measuring and analyzing computer user satisfaction. *Management Science, 29*(5), 530–545.

Barnard, C. I. (1948). *The functions of the executive*. Cambridge, MA: Harvard University Press.

Belardo, S., Karwan, K. R., & Wallace, W.A. (1982). DSS component design through field experimentation: an application to emergency management. In *Proceedings of the 3rd international conference on information systems* (pp. 93–108).

Chen, C. T. (2007). *Planning and implementation for virtualized network security practical laboratory*. Master thesis. Taiwan: Tamkang University.

Chen, C. Y. (2007). *Exploring the model of energy conservation planning and implementation of information center*. Master thesis. Taiwan: National Chengchi University.

Chen, Q., & Xin, R. (2005). Optimizing enterprise IT infrastructure through virtual server consolidation. In *Proceedings of the 2005 informing science and IT education joint conference*.

Churchill, G. A. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research, 16*, 64–73.

Commons, J. R. (1934). *Institutional economics: Its place in political economy*. New York: Macmillan, pp. 627–633.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–339.

DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3*(1), 60–95.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4), 9–30.

Desanctis, G., & Gourtney, J. F. (1983). Toward friendly user MIS implementation. *Communications of the ACM, 26*(10), 732–738.

Doherty, W. J., & Kelisky, R. P. (1979). Managing VM/CMS systems for user effectiveness. *IBM Systems Journal, 18*(1), 143–163.

Doll, W. J., & Torkzadeh, G. (1988). The measurement of end-user computing satisfaction. *MIS Quarterly, 12*(2), 259–274.

Eighmey, J., & McCord, L. (1998). Adding value in the information age: Uses and gratifications of sites on the World Wide Web. *Journal of Business Research, 41*(3), 187–194.

Emery, J. C. (1971). *Cost/Benefit analysis of information systems*. Chicago, IL: The Society for Management Information Systems. 16–46.

Fichera, R. (2002). The future of the data center—Modularity and virtualization. *Forrester Research*.

Friedman, M. B. (2006). The reality of virtualization for windows servers. In *Computer measurement group conference* (pp. 907–918).

Gao, C. H. (2009). *A research of virtual training environment for information security*. Master thesis. Chung Cheng Institute of Technology, National Defense University.

George, D., & Mallery, P. (2003). *SPSS for windows step by step: A simple guide and reference. 11.0 Update* (4th ed.). Boston: Allyn & Bacon.

Global Industry Analysts, Inc. (2010). *Virtualization software: A global strategic business report*. <http://www.strategyr.com/Virtualization_Software_Market_Report.asp>.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis* (6th ed.). New Jersey, USA: Pearson Education Inc..

Hamilton, S., & Chervany, N. L. (1981). Evaluating information system effectiveness – Part I: Comparing evaluating approaches. *MIS Quarterly, 5*(3), 55–69.

Hoesing, M. T. (2009). Virtualization security assessment. *Information Security Journal: A Global Perspective, 18*(3), 124–130.

Hsieh, Y. F. (2008). *Virtualization of enterprise testing lab via VMware: A case study on a large software development company*. Master thesis. Taiwan: National Taiwan University.

Hu, K. (2009). The design and realization of server virtualization based on active directory. *International Forum on Information Technology and Applications, 2009*, 740–742.

Jin, H. (2008a). Desktop virtualization: techniques and applications. In *The 3rd international conference on pervasive computing and applications*.

Jin, H. (2008b). Virtualization technology for computing system: Opportunities and challenges. In *The 10th IEEE international conference on high performance computing and communications*.

Jung, Y. W., Kim, J. M., Bae, S. J., Koh, K. W., Woo, Y. C., & Kim, S. W. (2009). Standard-based virtual infrastructure resource management for distributed and heterogeneous servers. In *The 11th international conference on advanced communication technology* (pp. 2233–2237).

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39*(1), 31–36.

Kallahalla, M., Uysal, M., Swaminathan, R., Lowell, D. E., Wray, M., Christian, T., et al. (2004). SoftUDC: A software-based data center for utility computing. *Computer, 37*(11), 38–46.

Kettinger, W. J., & Lee, C. C. (1994). Perceived serviced quality and user satisfaction with the information service function. *Decision Sciences, 25*(5), 737–766.

Khanna, G., Beaty, K., Kar, G., & Kochut, A. (2006). Application performance management in virtualized server environments. In *The 10th IEEE/IFIP of network operations and management symposium* (pp. 373–381).

King, W. R., & Epstein, B. J. (1982). Assessing information system value: An experimental study. *Decision Sciences, 13*(4), 34–45.

Laughlin, S. P. (1999). An ERP game plan (enterprise resource planning). *Journal of Business Strategy, 20*(1), 32–37.

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology, 28*(4), 563–575.

Li, Q., Yang, C. (2010). Development trends of MIS based on cloud computing environment. In *3rd intl. symp. inf. sci. eng.* (pp. 145–148).

Mahmood, M. A., & Medewitz, J. N. (1985). Impact of design methods on decision support system success: An empirical assessment. *Information & Management, 9*(3), 137–151.

Matthews, J. N., Herne, J. J., Deshane, T. M., Jablonski, P. A., Cherian, L. R., & McCabe, M. T. (2005). Data protection and rapid recovery from attack with a virtual private file server and virtual machine appliances. In *Proceedings of the IASTED international conference on communication, network and information security* (pp. 170–181).

Menasce, D. A., & Bennani, M. N. (2006). Autonomic virtualized environments. In *International conference on autonomic and autonomous systems 2006* (p. 28).

Mevag, I. (2007). *Towards automatic management and live migration of virtual machines*. Master thesis. University of OSLO.

Miller, J., & Doyle, B. A. (1987). Measuring the effectiveness of computer-based information systems in the financial services sector. *MIS Quarterly, 11*(1), 107–124.

Oguchi, Y., & Yamamoto, T. (2008). Server virtualization technology and its latest trends. *Fujitsu Scientific & Technical Journal, 44*(1), 46–52.

Parasuraman, A., Berry, L. L., & Zeithaml, V. A. (1988). SERVQUAL: A multiple item scale for measuring consumer perceptions of service quality. *Journal of Retailing, 64*(1), 12–40.

Perez, R., van Doorn, L., & Sailer, R. (2008). Virtualization and hardware-based security. *IEEE Security & Privacy, 6*(5), 24–31.

Pitt, L. F., Watson, R. T., & Kavan, C. B. (1995). Service quality: A measure of information systems effectiveness. *MIS Quarterly, 19*(2), 173–187.

Popek, G. J., & Goldberg, R. P. (1974). Formal requirements for virtualizable third generation architectures. *Communications of the ACM, 17*(7), 412–421.

Prueksaaroon, S., Varavithya, V., & Vannarat, S. (2009). An implementation of virtualization cluster: Extending Beowulf cluster using virtualization cluster management and image storage. In *The 6th international conference on electrical engineering/electronics, computer, telecommunications and information technology* (pp. 700–703).

Rai, A., Lang, S. S., & Welker, R. B. (2002). Assessing the validity of IS success models: An empirical test and theoretical analysis. *Information Systems Research, 13*(1), 50–69.

Rainer, R. K., Jr., & Watson, H. J. (1995). The keys to executive information systems success. *Journal of Management Information Systems, 12*(2), 83–98.

Rasmussen, E. R. (2009). *Reducing IT costs and increasing IT efficiency by integrating platform-virtualization in the corporation*. Capstone report of AIM program. University of Oregon.

Ribiere, A. (2008). Using virtualization to improve durability and portability of industrial applications. In *The 6th IEEE international conference on industrial informatics* (pp. 1545–1550).

Santos, J. R. A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. *Journal of Extension, 37*(2), 1–5.

Sasser, W. E., Olsen, R. P., & Wyckoff, D. D. (1978). *Management of service operations: Text and cases, and readings* (p. 178). Boston, MA: Ally and Bacon Inc.

Seddon, P. B. (1997). A respecification and extension of the DeLone and McLean model of IS success. *Information Systems Research, 8*(3), 240–253.

Seddon, P. B., & Kiew, M. Y. (1996). A partial test and development of DeLone and McLean's model of IS success (revision of the ICIS 94 paper). *Australian Journal of Information Systems, 4*(1), 90–109.

Seetharaman, S., & Murthy, K. (2006). Test optimization using software virtualization. *Software, IEEE, 23*(5), 66–69.

Sehgal, N. K., & Ganguli, M. (2006). Applications of virtualization for server management and security. In *IEEE international conference on industrial technology 2006* (pp. 2752–2755).

Shavit, Y., & Migliore, D. (2009). *Virtual machine*. <http://searchservervirtualization.techtarget.com/sDefinition/0,,sid94_gci213305,00.html>.

Sigwart, C. D., Van Meer, G. L., & Hansen, J. C. (1991). *Software engineering: A project oriented approach*. Irvine, CA: Franklin Beedle & Assoc..

Silva, L. M., Alonso, J., & Torres, J. (2009). Using virtualization to improve software rejuvenation. *IEEE Transactions on Computers, 58*(11), 1525–1538.

Singh, A. (2004). *An introduction to virtualization*. <http://www.kernelthread.com/publications/virtualization/>.

Singh, A., Korupolu, M., & Mohapatra, D. (2008). Server-storage virtualization: integration and load balancing in data centers. In *Proceedings of the 2008 ACM/IEEE conference on supercomputing* (pp. 1–12).

Smith, J. E., & Nair, R. (2005). The architecture of virtual machines. *Computer, 38*(5), 32–38.

Snedecor, G. W., & Cochran, W. G. (1989). *Statistical methods* (8th ed.). Ames: Iowa State University Press.

Sotomayor, B., Keahey, K., & Foster, I. (2006). Overhead matters: A model for virtual resource management. In *The 2nd international workshop on virtualization technology in distributed computing* (pp. 5–12).

Srinivasan, A. (1985). Alternative measures of system effectiveness: Associations and implications. *MIS Quarterly, 9*(3), 243–253.

Swanson, E. B. (1974). Management information systems: Application and involvement. *Management Science, 21*(2), 178–188.

Symantec (2009). *White paper: The green data center—A Symantec green IT guide*.

Thein, T., Chi, S. D., & Park, J. S. (2008). Availability modeling and analysis on virtualized clustering with rejuvenation. *International Journal of Computer Science and Network Security, 8*(9), 72–80.

Tsai, W. C. (2001). *Performance measurement of enterprise resource planning*. Master thesis. Taiwan: National Taiwan University.

Tsai, C. F. (2007). *Comparisons of benchmark of virtualization technologies*. Master thesis. Taiwan: Tamkang University.

Tulloch, M. (2009). *Understanding Microsoft virtualization solutions*. Microsoft Press.

Uhlig, R., Neiger, G., Rodgers, D., Santoni, A. L., Martins, F. C. M., Anderson, A. V., et al. (2005). Intel virtualization technology. *Computer, 38*(5), 48–56.

Vaughan-Nichols, S. J. (2006). New approach to virtualization is a lightweight. *Computer, 39*(11), 12–14.

VMware (2006a). *White paper: Virtualization overview*.

VMware (2006b). *White paper: The roadmap to virtual infrastructure: Practical implementation strategies*.

Waters, J. K. (2007). *Virtualization definition and solutions*. <http://www.cio.com/article/40701/Virtualization_Definition_and_Solutions.2007>.

Weltzin, C., & Delgado, S. (2009). Using virtualization to reduce the cost of test. In *AUTOTESTCON, 2009 IEEE* (pp. 439–442).

Wixom, B., & Watson, H. J. (2001). An empirical investigation of the factors affecting data warehousing success. *MIS Quarterly, 25*(1), 17–41.

Yang, F., Zhao, Z., Zhao, H., & Yang, X. (2009). A virtualization-based business process management model for emergency response system. *International Colloquium on Computing, Communication, Control, and Management, 2009*, 94–97.

Zhang, J., Li, X., & Guan, H. (2008). The optimization of Xen network virtualization. *International Conference on Computer Science and Software Engineering, 2008*, 431–436.