Performance of information system implementation based on coupling-cohesion among subunits*

Wang Tienan**, Li Yijun and Wang Mingzhu

(School of Management, Harbin Institute of Technology, Harbin 150001, China)

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Abstract The intermediate information system benefit and the coupling-cohesion of subunits are presented to study the performance of information system implementation. Based on the organizational information processing theory and the organizational behaviour theory, a theoretical model is established from the perspective of coupling-cohesion of subunits. The reliability and validity of the model are checked up with the structural equation models and the data collected with questionnaires. The results of the study give some theoretical and practical guidance.

Keywords: information system, coupling among subunits, cohesion among subunits, intermediate benefits.

The application of computers has played a particularly important role in business management. With the increase in the investment ratio of information technology in the total investment, its impact on performance has become the focus for both scholars and entrepreneurs. Many scholars have done extensive research on it, which is concentrated mainly in the United States. Brynjolfsson and Hitt[1, 2] estimated the flexibility of computer capital, labour and other factors of production using the production function. They discovered that the expenditures of information system had made significant contribution to practices. Thereafter, the research turned gradually from "the investment in information technology is worthy or not" to "how, when returns". Dehning and Richardson[3] summed up the relationship between the investment in information technology and the performance.

Organizational information processing theory (OIPT) suggests that researches should be done on the level of organizational units, and points out the concept of interdependence among tasks of organizational units. Daft and Lengel gave the concept of the differentiation among organizational units in 1986[4]. Gattiker and Goodhue[5] made a systematical study on the impact of interdependence and differentiation between the performances using ERP and those without using ERP.

The study on the acceptance of information systems initially came from Davis' technology acceptance model in 1989[6]. Thereafter, a lot of research achievements had been put forth, focusing on "how to predict or explain the users' behaviour in the application of information technology", such as the theory of reasoned action[7], the theory of planned behaviour[8], innovation diffusion theory[9], model of PC utilization[10] and self-efficacy theory, etc.

Studies on the performance of information system implementation by Chinese scholars are mainly focused on the overall level of the organization; whereas overseas scholars have been focusing on the interdependence and differentiation among tasks of organizational units, which offers a new perspective. The impact of human factors on the performance of information system application has been mostly studied from the cognitive perspective by developing cognitive variables. However, there has been little systematic analysis of the way that cognitive variables exert their impact on the performance.

Based on the coupling and cohesion among subunits, this study establishes a theoretical model of the impact of information system on the organizational performance from the level of organizational units. In the model, the initial variables and intermediate information system benefits are introduced. The reliability and validity of the model are checked up with the structural equation models and the data collected

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** To whom correspondence should be addressed. E-mail: wtn@hit.edu.cn

with questionnaires. The impact of information technology on the performance through the intermediate processes is also discussed in the paper.

1 Hypotheses

In this work, coupling among subunits is defined as the links between the different organizational units, including interdependence and differentiation between organizational units. Business processing integration and data consistency is referred to as interdependence between organizational units. The difference in the handling of data and business process is called differentiation between organizational units. Cohesion among subunits refers to the intimate degree between human (including leaders and staffs) and information systems in the organization implementing information systems. Based on the pioneering achievements[5,7,11—13], some hypotheses for a department of an organization implementing information systems are presented.

(1) Hypotheses between the coupling of subunits and the intermediate benefits

H1a: the higher the degree of interdependence between organizational units is, the greater the efficiency is.

H1b: the higher the degree of interdependence between organizational units is, the greater the coordination is.

H1c: the higher the degree of interdependence between organizational units is, the higher the quality of data is.

H2a: the lower the degree of differentiation between organizational units is, the greater the efficiency is.

H2b: the lower the degree of differentiation between organizational units is, the greater the coordination is.

H2c: the lower the degree of differentiation between organizational units is, the higher the quality of data is.

(2) Hypotheses between the cohesion of subunits and the intermediate benefits

H3a: positive cognition of using information system is associated with greater efficiency.

H3b: positive cognition of using information system is associated with greater coordination.

H3c: positive cognition of using information system is associated with higher the quality of data.

H4a: the greater of the ability of using information system is, the greater the efficiency is.

H4b: the greater of the ability of using information system is, the greater the coordination is.

H4c: the greater of the ability of using information system is, the higher the quality of data is.

(3) Hypotheses between the intermediate benefits and organization overall information system benefits

H5a: the greater the quality of data is, the greater the efficiency is.

H5b: the greater the quality of data is, the greater the coordination is.

H6a: the greater the quality of data is, the greater the organization's overall information system benefits are.

H6b: the greater the efficiency is, the greater the organization's overall information system benefits are.

H6c: the greater the coordination is, the greater the organization's overall information system benefits are.

2 Research methodology

2.1 The survey instrument

In order to get accurate survey data, the research adopted the measures that had been verified and used in prior studies, with the exception of the capability variable.

Wybo and Goodhue developed the interdependence scale, which has been modified by Gattiker and Goodhue by conducting survey among managers in the manufacturing sector[5]. The interdependence scale of this study is mainly adapted from the studies of Gattiker and Goodhue.

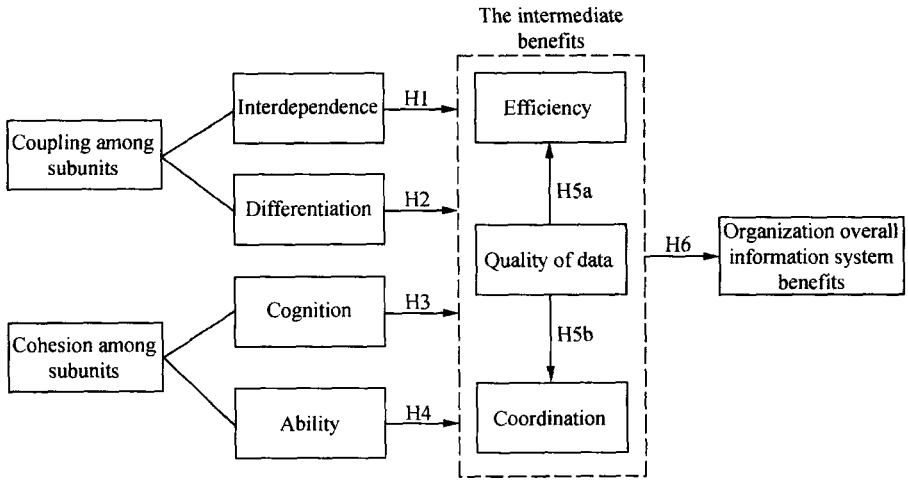

Fig. 1. Theoretical Model.

Tatikonda and Rosenthal[14] had studied differentiation among organizational units. They pointed out that the differentiation in relation with information systems was mainly in the production process, such as technology, design, production cycle, process and so on. Therefore, the differentiation scale of this paper is developed in the aspects of tasks, processes, the degree of specialization, design, production cycle and key technology etc.

Based on the planned behaviour theory, there are three aspects in the cognition variable, which are the impact cognition of using information systems, the subjective norm cognition of using information systems and the self-efficacy cognition of using information system. According to technology acceptance model and innovation diffusion theory, this study develops measurement scale of the impact cognition of using information system in three aspects, which include perceived technology usefulness, perceived technology usability and perceived technology compatibility. Based on Ajzen and Fishbein's survey methods[15], this study develops measurement scale of subjective norm cognition of using information system in four aspects, which include colleagues, direct supervisor, organization leaders and customers. According to Refs. [16, 17], this study develops measurement scale of self-efficacy cognition of using information system in three aspects, which include breadth, depth and overall degree.

As the individual capability of using information system is defined according to their knowledge and skills of information systems, the ability scale is developed from the two aspects.

Three aspects are considered in developing efficiency variables, which are the operation time, the management time and the response rate of business. Four aspects are considered in the quality of data, which includes completeness, relevance, security and compatibility of data. Coordination includes timeliness and convenience.

Considering organization's overall information system benefits, this study uses the balanced scorecard by referencing Gattiker and Goodhue's research[5], taking into account four elements, namely cost, production operations, customer service and organizational learning and growth.

2.2 Sampling

On the basis of the measurement scales of all the variables, the questionnaires are designed correspondingly. After two pre-tests, the final questionnaires are made. By means of convenience sampling and quota sampling, 22 manufacturing enterprises in 15 cities in China are selected. At the same time, this study makes full use of investigative resources to maximize the size of sample and enhances the accuracy of the findings. According to the requirement of statistic analysis, the size of sample should not be less than 500. A total of 690 questionnaires were issued, and 636 were returned. The return rate is 92.17%. Among the returned ones, a total of 581 questionnaires were valid, accounting for 91.35% of the received questionnaires.

3 Data analyses and results

3.1 Assessing measurement model

The structural equation models (SEM) make it possible to estimate the instrument items' internal consistency reliability, convergent validity and discriminate validity.

Wixom and Watson pointed out that the assessment of internal consistency is normally performed for the reflective items in the model[18]. Table 1 lists the reflective items and their internal consistency reliability. All reliability measures are above the recommended level of 0.60 for exploratory research[18]. The following is the formula of internal consistency reliability:

$$\rho_c = \frac{\left(\sum \lambda_i\right)^2}{\left(\sum \lambda_i\right)^2 + \sum \theta_i} \quad (1)$$

where ρ_c is the internal consistency reliability, λ_i is the loading and θ_i is the error variance.

Table 1. Assessment of internal consistency reliability and convergent validity

Latant variables	Obverved variables	Loading (λ)	Error variables	Error variance	ρ_c	ρ_v
F1	INTER1	0.734	e1	0.185	0.896	0.635
	INTER2	0.591	e2	0.451		
	INTER3	0.719	e3	0.203		
	INTER4	0.761	e4	0.193		
	INTER5	0.619	e5	0.326		
F2	DIF3a	0.619	e6	0.495	0.730	0.405
	DIF3b	0.547	e7	0.644		
	DIF5b	0.678	e8	0.674		
	DIF6	0.701	e9	0.583		
F3	ITPB1	0.517	e10	0.255	0.841	0.571
	ITPB4	0.538	e11	0.283		
	ONG2	0.576	e12	0.26		
	ONG3	0.663	e13	0.198		
F4	ITA3c	0.538	e14	0.279	0.884	0.605
	ITA3d	0.578	e15	0.267		
	ITA3e	0.676	e16	0.216		
	ITA3f	0.668	e17	0.221		
	ITA3g	0.615	e18	0.259		
F5	DATA2	0.658	e19	0.188	0.880	0.710
	DATA3	0.718	e20	0.204		
	DATA4	0.691	e21	0.191		
F6	EFFC1	0.666	e22	0.185	0.901	0.696
	EFFC2r	0.605	e23	0.237		
	EFFC3r	0.689	e24	0.167		
	EFFC5	0.692	e25	0.18		
F7	CB1	0.602	e26	0.237	0.913	0.679
	CB2	0.68	e27	0.178		
	CB4	0.618	e28	0.221		
	CB5	0.696	e29	0.184		
	CB6	0.692	e30	0.206		
F8	IMPACT2	0.639	e31	0.236	0.908	0.622
	IMPACT3	0.566	e32	0.286		
	IMPACT4	0.628	e33	0.229		
	IMPACT5	0.651	e34	0.235		
	IMPACT6	0.698	e35	0.241		
	IMPACT7	0.673	e36	0.287		

For discriminate validity, the average variance extracted (AVE) for each construct should be greater than the variance shared between the construct and other constructs in the model[18,19]. The following is the formula of AVE:

$$\rho_v = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum \theta_i} \quad (2)$$

where ρ_v is the average variance extracted, λ_i is the loading, θ_i is the error variance.

Table 2 lists the correlation matrix with the square root of the average variance extracted for each construct listed on the diagonal. If the square root of AVE is larger than each coefficient under diagonal, discriminate validity is satisfied. It is evident that all constructs satisfy the discriminate validity.

3.2 Assessing structural model

AMOS4.0 procedures give the results of the hypotheses model. By estimating the fit indicator, including Discrepancy/df, GFI, NFI, and *RMSEA*, etc, it is evident that survey data and model have better fitness. Fig. 2 shows the result of the hypotheses model, and Table 3 show the result of path hypotheses. Fig. 2 shows the R^2 values which represent the amount of variance explained by the independent variables, thereby providing insights into the model's predictive power. The greater the R^2 values are, the better the model's predictive quality[18] is.

Table 2. Correlations matrix with square root of AVE scores

	F4	F3	F2	F1	F5	F7	F6	F8
F4	**0.778**							
F3	0	**0.756**						
F2	0	0	**0.636**					
F1	0	0	0	**0.797**				
F5	0.341	0.34	−0.037	−0.006	**0.843**			
F7	0.439	0.478	0.077	0.018	0.595	**0.824**		
F6	0.451	0.442	0.03	−0.063	0.392	0.443	**0.834**	
F8	0.344	0.36	0.041	−0.009	0.443	0.618	0.494	**0.789**

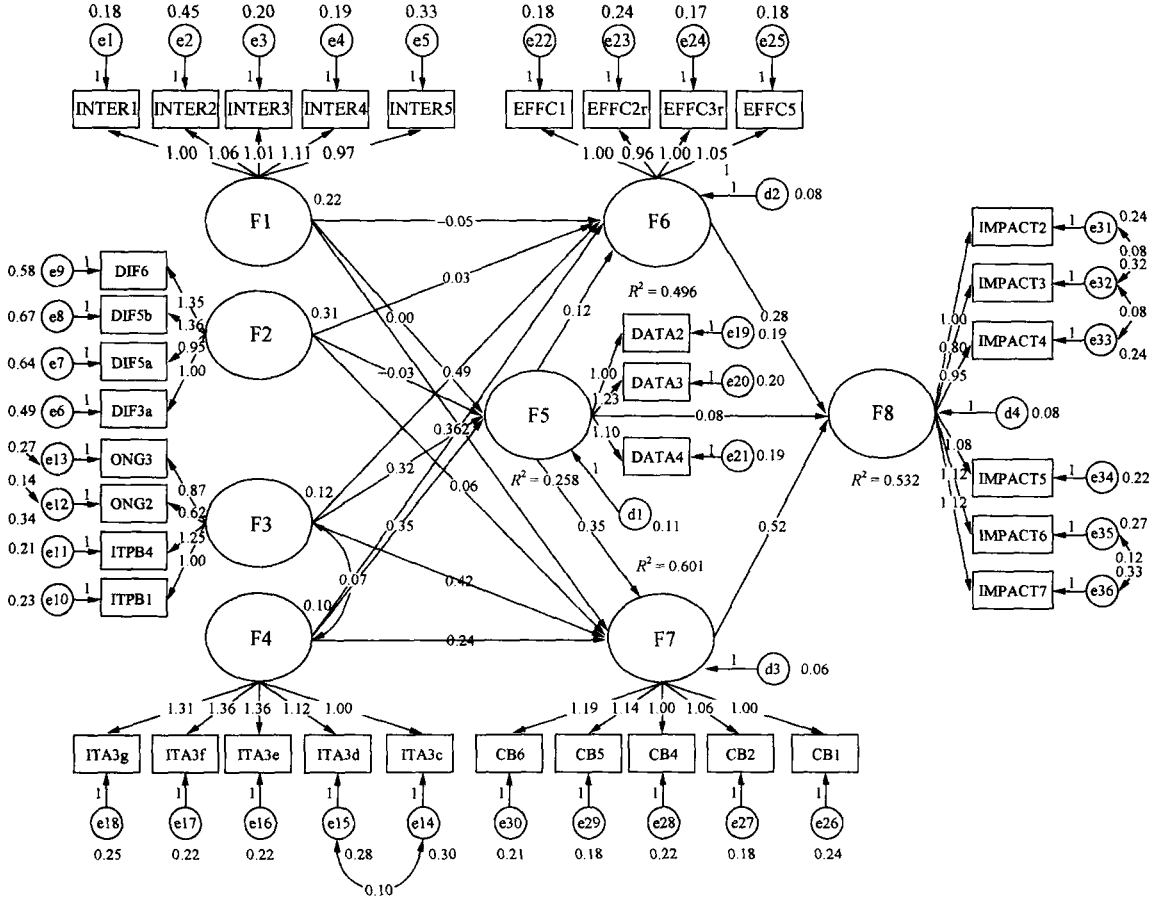

Fig. 2. Result of theory model.

Table 3 shows the supported and unsupported hypotheses. According to t-value test method of statistics, the supported hypotheses are made by $p < 0.05$ or $t > 1.96$ or $t < -1.96$.

4 Conclusions

(1) This study, focusing on the level of organizational units, expounds the concept of the organization unit and categorizes the relationship of organization subunits into coupling and cohesion according to the intrinsic characteristics of the information system application. The concepts of coupling and cohesion among subunits are then defined, which offers a new perspective in defining the organization units' factors influencing the performance of information system implementation in the organization.

Table 3. Summary listing of the supported and unsupported hypotheses

Hypothese	Path	Estimate	t-value	p	Y/N
H1a	F1→F5	0.005	0.098	0.922	N
H1b	F1→F6	−0.058	−1.345	0.179	N
H1c	F1→F7	0.021	0.542	0.588	N
H2a	F2→F5	−0.037	−0.71	0.478	N
H2b	F2→F6	0.035	0.765	0.444	N
H2c	F2→F7	0.088	2.102	0.036	Y
H3a	F3→F5	0.283	3.183	0.001	Y
H3b	F3→F6	0.423	4.922	0.000	Y
H3c	F3→F7	0.379	4.811	0.000	Y
H4a	F4→F5	0.278	3.251	0.001	Y
H4b	F4→F6	0.275	3.507	0.000	Y
H4c	F4→F7	0.187	2.668	0.008	Y
H5a	F5→F6	0.119	2.038	0.042	Y
H5b	F5→F7	0.368	6.201	0.000	Y
H6a	F5→F8	0.074	1.146	0.252	N
H6b	F6→F8	0.281	4.833	0.000	Y
H6c	F7→F8	0.491	6.444	0.000	Y

Items are significant at the $p<0.05$ level or $t>1.96$ or $t<-1.96$

(2) A theoretical model is proposed based on coupling and cohesion among subunits in the organization. To test the hypotheses, a questionnaire is designed based on the theoretical model and survey data is then collected. The reliability and validity of the survey are tested with the structural equation models.

(3) The results represent that the explained degree of the model is acceptable. The R^2 values of efficiency, data quality, coordination and organization overall information system benefits are 0.496, 0.258, 0.601 and 0.532 respectively. These values indicate that the factors we discuss are very important in the organization's overall information system benefits.

(4) By analyzing the hypotheses, it is found that the main factors of data quality (F5) include cognition (F3, estimate = 0.283) and capability (F4, estimate = 0.278). Both of the hypotheses are supported. The main factors of efficiency (F6) include cognition (F3, estimate = 0.379) and ability (F4, estimate = 0.187), and both of the hypotheses are also supported. The main factors of coordination (F7) include differentiation (F2, estimate = 0.088), cognition (F3, estimate = 0.379) and ability (F4, estimate = 0.187). These three hypotheses are all supported as well. The main factors of organization overall information system benefits (F8) include efficiency (F6, estimate = 0.281) and coordination (F7, estimate = 0.491). Both of the hypotheses have passed the test.

(5) For the data quality variable (F5), the greatest force is cognition variable (F3, estimate = 0.283). The differentiation variable (F2, estimate = −0.037) has a negative impact. For the efficiency variable (F6), cognition variable (F3, estimate = 0.457) has the great positive impact while the interdependence variable (F1, estimate = −0.057) has a negative impact. For the coordination variable (F7), the greatest force is cognition variable (F3, estimate = 0.483) and the data quality variable (F5, estimate = 0.368) is the second force. For the variable of organization's overall information system benefits (F8), the greatest force is the coordination variable (F7, estimate = 0.491).

(6) Other important findings are obtained as well in the process of information system application. Firstly, the size of departments has significant impacts on the interdependence and differentiation between organizational units, employees' ability to use information systems, task efficiency, coordination and organization's overall information system benefits. Secondly, the time of using information systems has significant impacts on the ability to use information systems, task efficiency, the quality of data and organization overall information system benefits. Thirdly, differentiation between organizational units has some impact on organization overall information system benefits, but the impact of interdependence between organizational units is not very prominent.

Since the study was conducted only within the manufacturing field in China, there are also some limitations in this study, which present some directions for future studies. On the one hand, some macro-level factors might have affected this study to some extent. It would, therefore, be useful to replicate this research in other industries and other countries.

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