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Model of post-implementation user participation within ERP advice network

Pei-Hung Ju ^a, Hsiao-Lan Wei ^{b,*}, Chung-Che Tsai ^c^a Department of Business Administration, School of Management, National Kaohsiung University of Applied Science, Kaohsiung, Taiwan, ROC^b Department of Information Management, School of Management, National Taiwan University of Science and Technology, Taipei, Taiwan, ROC^c Department of Software Application Development, ASUSTeK Computer Inc., Taipei, Taiwan, ROC

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ABSTRACT

Base on the social network theory, this study attempts to investigate whether the network centrality will affect the user participation in ERP system post-implementation or not. In aspects of network centrality, we used degree, closeness, betweenness and eigenvector as indicators to investigate the relationships between individual network centrality and user participation. Then we further explore the impact of user participation on system use and user satisfaction. We adopted the ERP post-implementation of TSC Company as an example. The sample data has 211 questionnaires. Our empirical results show that network centrality positively affects the three dimensions of user participation; hands-on activity and communication activity positively affect system use; user–IS relationship, hands-on activity, and communication activity positively affect user satisfaction. Through the lens of social network, we argued that ERP user network plays an important role to influence user participation in post-implementation period, which is critical for system use and user satisfaction.

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1. Introduction

Many researchers study the key factors of how to implement enterprise resource planning (ERP) system successfully (Chou & Chang, 2008; Chung, Skibniewski, & Kwak, 2009; Morton & Hu, 2008). These successful factors may broadly be classified as human/organizational, technical, and economic ones (Chen, 2001; Sarker & Lee, 2003). While each set of factors is important, there appears to be a growing consensus among researchers that human factors, more than technical or economic, are critical to the success of ERP projects (Alvarez, 2008; Sarker & Lee, 2003). Sarker and Lee (2003) suggest that empowering the team-members for self-management and communication issues are seen as central to success of an ERP implementation project. Salmeron and Lopez (2010) indicate that encouraging the active participation of all users involved in the process of post-implementation ERP systems is essential in the success of the ERP maintenance. To deal with technical complexity and overambitious demands associated with

ERP systems, user participation is important to mitigate risk (Amrit, van Hillegersberg, & van Diest, 2013). Therefore, user participation is an important factor when implementing the ERP system.

User participation refers to the favorable behaviors and activities that users perform in the systems development process to promote efficient and effective implementation of ERP systems (Bagchi, Kanungo, & Dasgupta, 2003; Barki & Hartwick, 1989; Ives & Olson, 1984; Kawalek & Wood-Harper, 2002). When organizations plan to use an ERP system, a number of user representatives participated in software package configuration and there might have a conceptual gap between developers and users (Barki, Rivard, & Talbot, 2001; Kappelman, 1995; Markus & Ji-Ye, 2004). To close the gap to ensure ERP system implementation success, it's essential for organizations to handle user participation carefully (Dong-Gil, Kirsch, & King, 2005; Markus, Axline, Petrie, & Tanis, 2000). User participation can improve system quality by giving developers the information they need to produce a high-quality design (Barki et al., 2001; Byrd, Cossick, & Zmud, 1992; Markus & Ji-Ye, 2004). Besides, user participation in change management activities such as planning or conducting training is much more likely to affect system acceptance and use outcomes (Kappelman, 1995; McKeen & Guimaraes, 1997; Yetton, Martin, Sharma, & Johnston, 2000). ERP system is an integrated solution in an enterprise, which involves internal workflow within inter-departmental cooperation. The

* Corresponding author. Tel.: +886 2 27303226; fax: +886 2 27376777.

E-mail address: hlwei@cs.ntust.edu.tw (H.-L. Wei).

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communication and coordination in related users are extremely important as well as the communication with consultants. With the efforts in both sides, the implementation can be ensured to correspond to the entire workflow in the enterprise.

The timing issue of user participation over ERP lifecycle is highlighted as an important but ignored dimension recently (Wagner & Newell, 2007). As post-implementation success of ERP is critical for adopting organizations in order to fully benefit from system's potential, user participation is extremely important at this stage. During the implementation stage, only limited key users are participated in the configuration of ERP to help the system go live. After the installation of an ERP system, a critical mass of users start the exploitation and evaluation of the system and some uncontrolled problems may also appear. Post-implementation phase including the stabilization, operation and extension of the ERP system involves a large number of different users from different functions and previously silent users may express their dissatisfaction with the system, which will influence the acceptance of the ERP system (Markus & Ji-Ye, 2004; Wagner & Newell, 2007). Therefore, investigating post-implementation participation is critical for the system's survival and assimilation in the organization because users themselves need situated learning through use to figure out what is best from ERP system for existing practices.

A person's behavior intention is influenced by his/her personal relationship network in an organization (Sykes, Venkatesh, & Gosain, 2009; Zagenczyk & Murrell, 2009). This impacts the result of learning and knowledge exchange during the ERP post-implementation process. Therefore, a concept of social network is proposed to study the influences in different network relationship. How to use the network to achieve the enterprise target has been highly valued by the management because understanding an employee's network relationship is beneficial to find out the influential users during the process of ERP post-implementation. The potential users have greater influences in drawing the participation of other users and thus they indirectly enhance the possibility of successful post-implementation. Many researches show that the social network has significantly influence in individual job performance (Ahuja, Galletta, & Carley, 2003; Sparrowe, Liden, Wayne, & Kraimer, 2001). More and more studies reveal the behavior influence impacted by individual's network relationship (Sykes et al., 2009; Zagenczyk & Murrell, 2009). The network relationship in an organization has certain impact on user participation. Sykes et al. (2009) indicated that the counseling network relationship has significant influence on system usage. Meanwhile, the network relationship influences one's job involvement (Zagenczyk & Murrell, 2009). Individual's network relationship is a key variable in one's participation. During the post-implementation, the relevant users will be impacted by the social network, and the following behavior changes are key factors of successful post-implementation.

As studies on the ERP post-implementation phase are still underrepresented (Esteves & Bohórquez, 2007; Grabski, Leech, & Schmidt, 2011) and the call for investigating post-implementation user participation (Markus & Ji-Ye, 2004; Wagner & Newell, 2007), this research explains the influence of user participation and the relationship of the successful ERP post-implementation, based on the social network theory (Bonacich, 1972; Freeman, 1979) and the user participation theory (Barki & Hartwick, 1994a; Hartwick & Barki, 2001). It intends to understand the relationship of social network, user participation and the success of system post-implementation and to discover the role of social network in post-implementation and in the enhancement of user participation to accomplish the system post-implementation successfully.

Section one covers the relevant background literature. This is followed by theoretical framework and hypotheses section and

then the methodology one. We then analyze the results and we draw conclusions in the final section.

2. Conceptual background

2.1. Social network

A social network can be defined as a relationship comprising a series of persons, objects, and events; different networks can be formed with the same elements because of different types of relationship. In social network theory, these persons, objects, and events are defined as actors or nodes. The relationships between actors in a structural relationship and an individual actor in a network have a strong influence on the behavior, perception, and attitude of an individual or an entire organization (Knoke & Kuklinski, 1982).

When a corporation introduces an IS system, network centrality is one of the crucial elements; the corporation must invest considerable resources during the introduction, which makes the transmission and control of these resources highly valuable. The knowledge, intentions, and behavior of using the new system is also affected by the network (Sykes et al., 2009). Network centrality is defined as "the scope of individual participation in the network which facilitates information exchange among colleagues" (Sparrowe et al., 2001). Knoke and Kuklinski (1982) indicated that the interactions of numerous relationships, including the transmission and receipt of information, exist in the process of contact among individuals, and that the level of individual involvement can be judged by the number of relationships.

Researchers consider network centrality an essential structural attribute in social networks. Individuals situated in the network center can control the flow of resources and related knowledge. An individual is not affected by others; instead, he or she has influence on individual power in an organization, as well as resource control (Ibarra, 1993; Ibarra & Andrews, 1993). However, if the individual is situated at a lower level of network centrality, he or she must rely on others to pass on resources and knowledge and is subsequently easily influenced by the environment (Freeman, 1979). Freeman (1979) and Bonacich (1972) analyzed network centrality by using four dimensions: degree, closeness, betweenness, and eigenvectors.

In 1974, researchers started to apply social network concepts to the technology innovation diffusion model of an organization (Czepiel, 1974) and discovered that an informal communication network within an organization can ease the adoption of a new system. The network is also crucial to the IS system post-implementation, as well as the transmission and transfer of related resources and knowledge in the organization. Some studies have indicated that the structures of a social network can affect the transmission of valuable resources in an organization (Brass, 1984; Ibarra, 1993). Work-related resources, such as work counseling and strategic information, can be transmitted through a social network, as can social recognition, discipline, and support (Sykes et al., 2009). How knowledge and usage methods can be transferred to users during the post-implementation process of an ERP system is crucial. Informal personal networks play a key role in transferring the knowledge about a new system. Hence, Sykes et al. (2009) considered it difficult to accomplish the absorption and transmission of professional knowledge about a new system within a short timeframe; transferring knowledge among people with similar training, backgrounds, and work characteristics is easier. When an organization introduces a new IS system, it is more effective to share and transmit knowledge of the new system by using staff in the same department of the organization. In

summary, the social network perspective in IS implementation has become a prominent topic in recent years (He, Qiao, & Wei, 2009).

2.2. User participation

In the development of information systems, user participation and user involvement are key success factors. Early studies have indicated that user participation or involvement has positive effects on the success of systems (Swanson, 1974). However, these early studies did not clearly differentiate between user participation and user involvement. Ives and Olson (1984) proposed that participation, including board behavior, activities, and responsibilities, refers to users or system developers. Barki and Hartwick (1994a) defined user participation as a series of operations and activities conducted by users or their representatives during system development.

Compared with user participation, which is demonstrated by the user's external behavior and activities, user involvement represents a user's inner subjective state of mind. According to early studies, a user's state of mind affects his or her attitudes, satisfaction, and intention to use a system. Furthermore, user participation has an obvious positive influence on user involvement. Therefore, actual participation in the form of behavior or activities during a system's development may improve a user's state of mind; this in turn affects the user's satisfaction and the extent of his or her intention to use the system.

In the activities of user participation, some scholars have proposed that participation should not be limited to only before system implementation, but also afterwards. Before system implementation, if the user clearly understands the relevance of the system to him or her, it may increase the user's eagerness to participate in the process of system development. After system implementation, user satisfaction must be improved. The system and its fitness can be modified through user participation to improve user satisfaction (Wagner & Newell, 2007).

Recently, ERP studies have emphasized the importance of post-implementation concerns and have suggested that user participation plays a critical role for the assimilation and business benefits of ERP (Liu, Feng, Hu, & Huang, 2011; Staehr, Shanks, & Seddon, 2012; Wagner & Newell, 2007). Wagner and Newell (2007) indicated several factors inhibiting user participation during the initial implementation phase, such as legacy thinking, pseudo participation, and motivation. Aligning ERP software with existing practices is easier after actual implementation and through situated learning. The sustained use of an ERP system is a critical component for realizing its anticipated benefits. Liu et al. (2011) argued that the business value of ERP cannot be fully realized until it is extensively assimilated into business processes and individual-level assimilation focuses on the understanding of ERP and the ability to use ERP for non-routine tasks. Therefore, post-implementation engagement is an effective method of increasing user interest and enhancing the ability to exploit ERP, leading to increased system use and assimilation (Wagner & Newell, 2007).

3. Theoretical framework and hypotheses

In this study, individuals in the network of relations within an enterprise were the focal point of how an enterprise implements its ERP system and how participation behavior arising from personal network relationships influences the success of enterprise system implementation. The four indicators of degree, closeness, betweenness, and eigenvectors were used to define the individual within the enterprise network centrality. User participation was divided into three parts: the relationship between users and information technology (IT) staff, actual participation in activities, and communication activities. Finally, user satisfaction and system

use were used to measure the success of post-ERP implementation. The theoretical research model is depicted as Fig. 1.

3.1. Network centrality and user participation

Network centrality is an essential aspect of research on social networks (Ahuja et al., 2003; Sparrowe et al., 2001; Sykes et al., 2009). It is defined as the scope of individual participation that helps working partners exchange information (Sparrowe et al., 2001). Network centrality is measured by the number of relational connections in an individual network. One study showed that if individuals within an organization's network center, which has more links, may have a high impact capacity (Freeman, 1979). Scholars also believe that the degree of network centrality affects individual performance within the organization (Ahuja et al., 2003), work involvement (Zagenczyk & Murrell, 2009) and resource control (Ibarra, 1993).

The relationship between users and IT staffs is defined as development activities that reflect the communication and influence among users and IT staffs (Barki & Hartwick, 1994a). Some studies have indicated that when the implementation of an information system faces a problem, individuals search their network of relations for a solution, not only to enhance their job performance but also to have a major influence on the degree of participation in information system implementation (Sparrowe et al., 2001; Sykes et al., 2009). Thus, network centrality is key to the relationship between users and IT staff. The degree of network centrality represents the linkage level for an individual in relation to others within the organization, and shows the communication relationship between the individual and related IT staff (Ahuja et al., 2003; Sparrowe et al., 2001), as well as personal power within the organization (Ibarra, 1993; Ibarra & Andrews, 1993). It can influence relationship building within an organization. Therefore, the following hypothesis was proposed.

H₁: Network centrality is positively associated with the relationship between users and IT staff in post-ERP implementation.

Brass and Burkhardt (1993) stated that employees with a higher degree of network centrality have increased power within the organization. In addition, the personal closeness of network centrality can represent the power of individuals within an organization, and the power affects other people's views and perspectives in the network (Ibarra, 1993; Ibarra & Andrews, 1993; Sparrowe et al., 2001). The influence or drive from center members of the network affects whether an individual actually participates in decision-making in the new system (Sykes et al., 2009). In addition, network centrality positively influences individual

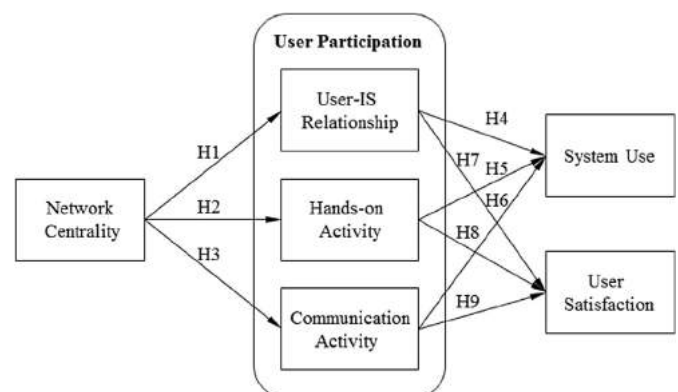


Fig. 1. Research model.

behaviors, and enhances the degree of participation for related work (Zagenczyk & Murrell, 2009). Network centrality can affect the actual behavior of users to pay for the process of information system post-implementation. Therefore, the following hypothesis was proposed.

H₂: Network centrality is positively associated with actual participation in hands-on activity in post-ERP implementation.

Communication activities are regarded as an essential part of the process of information system implementation; the interactive communication between users and the project team allows the functions of information systems to fit with individual daily work. Hartwick and Barki (2001) explored the various dimensions of user participation and defined communication activities as a crucial aspect. Users exchange information through formal or informal communication with other participants. As such, communication activities have become a factor in post-implementation ERP. Following social networks theory, an individual's degree of network centrality can be regarded as an indicator for potential communication activities (Freeman, 1979). Through the degree of network centrality, the interaction between individuals and other people in organizations can be understood; it also represents the degree to which individuals will participate in projects or related communication activities (Ahuja et al., 2003; Sparrowe et al., 2001). Users related through an interactive network of communication within an organization answer questions about information systems and assist in the implementation process. Members with a high network centrality act as a valuable bridge for promoting the use of the system by others (Sykes et al., 2009) and the degree of work participation (Zagenczyk & Murrell, 2009).

We present the following hypothesis:

H₃: Network centrality is positively associated with the communication activities in post-ERP implementation.

3.2. User participation and system use

Effective use of an information system is considered the main determinant for enhancing organizational competitiveness and productivity. System use is included in the six categories of IS success in the model by DeLone and McLean (1992). It is mainly used to determine the level of actual use of information system. Studies have indicated that user participation can help users develop ownership feelings for the ERP system, which strongly influences their acceptance of the system (Barki & Hartwick, 1994b; Barki, Pare, & Sicotte, 2008).

The relationship between users and developers is one of the factors that affect the result of system implementation (Cavaye, 1995). This relationship is crucial because ERP systems may cause comprehensive changes to the business process. Users review or evaluate the work completed by information system staff such that the system can meet actual work processes (Hartwick & Barki, 2001). This enhances their feelings of control, intimate knowledge, and ownership of the ERP (Barki et al., 2008; Pierce, Kostova, & Dirks, 2001). The feelings of possession toward an ERP can effectively improve the willingness of users to use the system for their work. Therefore, the following hypothesis was proposed.

H₄: The relationship between users and IT staff is positively associated with ERP system use in post-ERP implementation.

Studies have shown that actual participation in implementation activities has a significantly positive effect on the willingness to use

the system in the future (Wu & Marakas, 2006). Users with work-related knowledge obtained through actual participation in implementation activities can effectively reduce the gaps between users and IS staff and increase the possibility to develop user-friendly solutions. By participating in design activities, users perceive the ERP system as much more relevant, useful, and essential for their job (Barki et al., 2008). The literature on technology acceptance has suggested that a system with a higher level of perceived usefulness leads to a higher degree of use; hence, users that help design the ERP system can enhance the willingness to use ERP after introducing the system (Kositanurit, Ngwenyama, & Osei-Bryson, 2006; Saleem, 1996). Therefore, the following hypothesis was proposed.

H₅: Actual participation in hands-on activity is positively associated with ERP system use in post-ERP implementation.

A successful ERP system must be reworked and continuously improved to satisfy new or changed business processes, through a series of post-implementation projects (McGinnis & Huang, 2007; Rajagopal, 2002). In the post-implementation process, system-related knowledge and information must be conveyed through communication activities. Communication and learning among users after implementation is critical. The knowledge created during the implementation process is a valuable resource and should be shared for the ultimate success of ERP (McGinnis & Huang, 2007). Education and training after the system goes live is one of the channels of communication; however, this can distribute only explicit knowledge. Tacit knowledge could be exchanged through meetings, chat, discussion, and other socialization activities. Communication activities allow users to absorb and learn ERP-related knowledge, which can facilitate the willingness and ability to actively use the new system. Therefore, the following hypothesis was proposed.

H₆: Communication activities are positively associated with ERP system use in post-ERP implementation.

3.3. User participation and user satisfaction

Previous studies have suggested that user participation in the information system implementation process can improve user satisfaction (Hwang & Thorn, 1999; Wu & Marakas, 2006). By incorporating the expectancy disconfirmation, equity, and needs theories, Au, Ngai, and Cheng (2008) indicated that user satisfaction is a function of IS performance, IS performance expectations, equitable work performance fulfillment, equitable relatedness fulfillment, and equitable self-development fulfillment. Participation in the formal approval of specifications and the continuous review of the system can improve control in the outcome of ERP in the post-implementation stage and obtain the desired information and system quality. After the daily situated learning of using the ERP system, users gain confidence with their outcome control to obtain improved system performance. Participation activities may also enhance psychological ownership of the ERP, thereby creating feelings of control and power, and fulfilling the needs of relatedness for end users (Au et al., 2008; Barki et al., 2008). In summary, user participation should lead to a greater commitment to and a higher value of resultant systems, ultimately leading to greater satisfaction (McKeen, Guimaraes, & Wetherbe, 1994). Therefore, the following hypothesis was proposed.

H₇: The relationship between users and IT staff is positively associated with user satisfaction in post-ERP implementation.

User participation in activities related to system development can improve the information system to fit the organization or work, which has a significant influence on user satisfaction (McKeen et al., 1994; Wagner & Newell, 2007). In the post-implementation stage, users explore ERP as implemented to identify the functionality necessary for performing daily tasks and deficient functionalities. This exploration is a learning process that allows users to be more competent with ERP features (Gallagher, Worrell, & Mason, 2012). As users participate in activities to design extended functionality of the system to align ERP with business needs, the experiential knowledge of the system is enriched. Therefore, actual participation may increase user motivations to make the ERP system useful for their jobs and enhance user absorptive capacities, leading to higher levels of ERP assimilation during the post-implementation stage (Liu et al., 2011). Satisfaction with the ERP system is improved as it becomes more closely aligned with business needs.

We present the following hypothesis:

H₈: Actual participation in hands-on activity is positively associated with user satisfaction in post-ERP implementation.

Research has suggested that communication relations between users and developers have a significant influence on user satisfaction (McKeen et al., 1994). Saleem (1996) confirmed that users have expertise relevant to the work. The interaction and the ability to exchange information between users and IT staff can affect system satisfaction through knowledge exchange and learning. Communication activities can transmit relevant knowledge and needs, improve the quality of system outputs, and improve the ability to meet user needs. To successfully manage the knowledge of ERP, organizations must establish a knowledge-sharing community to provide a common frame of reference for all ERP activities (McGinnis & Huang, 2007). This common frame of reference is exchanged, assimilated, and distributed through communication activities among users, IS staff, and managers. As such, users and IS developers can have a shared understanding of an ERP system, leading to reasonable user expectations for the system (Saeed, Abdinnour, Lengnick-Hall, & Lengnick-Hall, 2010). The increased realization of expected benefits of ERP use has a great influence on user satisfaction (Bhattacharjee, 2001). Therefore, we present the following hypothesis:

H₉: Communication activities are positively associated with user satisfaction in post-ERP implementation.

4. Methodology

4.1. Data collection

The subject of this study is based on personal social networks within an organization, users in the information system, and the successful implementation of a system. A well-known domestic company (hereinafter referred to as TSC) with an ERP system implementation project was thus chosen for this study. TSC developed a new WebERP system in 2006, which included the following modules: distribution, production management, finance, human resources management, and project management. This new generation of online WebERP was expected to reduce paper work, achieve fully electronic processes, and streamline ERP to improve the efficiency of the enterprise. The ERP system implementation project is still undergoing maintenance and improvement.

The total number of employees in TSC was approximately 400. Through our contact with the relevant authorities to identify and obtain ERP system implementation information, we initially

identified approximately 300 people in TSC as users for the ERP system implementation project, to whom we issued questionnaires. Out of 300 questionnaires, a total of 243 were returned, leading to a return rate of 81%. Some respondents did not want to disclose information for the personal networking questions, leading to 32 invalid or incomplete questionnaires. The total number of valid questionnaires was 211, and the effective rate was 70.33%. The respondents covered various departments and job functions, and had worked for more than one year; thus, all respondents had a certain degree of understanding of the ERP system implementation (Table 1).

4.2. Measures

To measure network centrality, we used Freeman (1979) and Bonacich's (1972) four-measure index: degree, closeness, betweenness, and eigenvectors. *Degree* was the extent of interaction with other members of the network. *Closeness* represented a person's freedom from dependence on other members of the network. *Betweenness* gauged the extent which an employee is a key intermediary, i.e., in a position to control communication or information exchange. *Eigenvector* was associated with greater network influence because it was highly depending on the connections to well-connected employees. It is a recursive measure in which a user's centrality is proportional to the sum of centralities of the users to which they are connected, weighted by the strength of connection (Bonacich, 1972). An open-question survey was used to ask each ERP user the following question adapted from Sykes et al. (2009) and Zagenczyk and Murrell (2009): "when implementing/using ERP, who will you get advice and help for your system problems?" We asked respondents to list one to ten persons including their name, department, and weight (interaction degree, 1 = low, 5 = high). These data were used to compute the four network centrality aspects discussed earlier.

The user participation constructs were measured with items developed by Hartwick and Barki (2001). We only indicated that the project/system was ERP project/system. The relationship between users and IT staffs was defined as the interaction between users and IT staffs during the information system implementation project; eight questions were used to assess this measure. Actual involvement in activities was defined as activities related to the case actually involved during the information system implementation project; nine questions were used to assess this measure. Communication activity was defined as communication circumstances among all relevant members during the information system implementation project; 12 questions were used to assess this measure (Hartwick & Barki, 2001). System usage was defined as the performance changes caused by users actually using the system after the information system went into production; five questions were used to assess this measure using item developed by Park, Suh, and Yang (2007). User satisfaction was defined as the user views and evaluation of the system after the information system went into production; 12 questions were used to assess this measure adapted from Doll and Torkzadeh (1989).

5. Result

This study used social network and structural equation modeling (SEM) analysis for data analysis. The study divided analyzing process into three parts: the first part calculated TSC personal network centrality; second part assessed the reliability, convergent validity and discriminant validity for measurement model; the third part evaluated an overall structural model.

Table 1
Respondents background.

Background variables		No. of samples	Percentage
Sex	Male	123	58.29%
	Female	88	41.71%
Seniority	Under 1 y	15	7.11%
	1–3 y	66	31.28%
	3–5 y	42	19.91%
	5–7 y	40	18.96%
	7–9 y	10	4.74%
	Over 9 y	36	17.06%
Age	20–29	45	21.33%
	30–39	116	54.98%
	40–49	47	22.27%
	50–59	3	1.42%
	ExecutivesMid. Mgr.	18	8.53%
Job	Low Mgr.	11	5.22%
	Eng.	48	22.75%
	Secretary	33	15.64%
	Sales	34	16.11%
	IT staff	49	23.22%
		17	8.06%

5.1. Network centrality analysis

This study collected data of the advice network when the TSC implement ERP to build up personal social networks. Table 2 describes the top twenty users' network centrality data sorting by degree centrality. In the TSC ERP implementation process, the high degree of network centrality were dominated by members of IS department which is responsible for important related work (such as: demand planning, database design, training ... etc.) during the information system implementation process and play as an important role in consulting relation network. Other members of non-IT departments also have high network centrality, such as members in C Business Group, D Business Group, financial department, and operating administration Department. Fig. 2 shows the get-help ties centered on employee WCM, who is staff of C business group. It indicates that many users get advice from WCM when they encounter some ERP related problems. The ERP implementation should not ignore these key persons' position in the corporate network. Through their influence in the network, the related knowledge of ERP systems or operating procedures may spread to all departments easily within the enterprise.

Table 2
Top twenty users with high network centrality sorting by degree centrality.

Name	Sex	Age	Department	Work year	Network centrality			
					Degree	Closeness	Betweenness	Eigenvector
CYL	F	30–39	IS	Over 9 y	33.21	26.39	16.66	43.80
LLC	M	30–39	IS	3–5 y	31.73	26.21	16.35	42.16
CCJ	F	20–29	IS	1–3 y	30.63	26.08	16.82	40.69
YSC1	M	30–39	IS	1–3 y	25.46	26.06	11.51	38.44
TCH	M	30–39	IS	1–3 y	23.25	25.26	6.26	36.63
TTP	M	40–49	IS	Over 9 y	21.40	25.00	12.11	24.28
HYT	M	40–49	IS	Over 9 y	20.30	25.47	6.81	32.14
CSW	M	30–39	Operation	3–5 y	17.71	24.66	13.77	17.46
SWF	M	30–39	IS	7–9 y	14.39	23.16	10.39	12.10
CJJ	M	30–39	IS	5–7 y	12.18	23.44	4.04	16.87
KPC	M	40–49	IS	3–5 y	10.70	23.92	3.17	17.53
CPS	M	20–29	IS	3–5 y	10.70	23.34	2.92	11.98
WCC	F	20–29	BG D	5–7 y	9.23	24.11	6.01	15.96
HWW	F	20–29	Operation	3–5 y	8.12	23.40	2.58	14.18
CHH	M	20–29	IS	Under 1 y	7.01	23.48	1.60	16.17
WCM	F	30–39	BG C	5–7 y	6.64	22.42	0.79	11.83
HKF	F	30–39	Operation	5–7 y	5.90	23.57	0.85	12.68
LCC2	F	30–39	Finance	Over 9 y	5.90	22.57	0.96	13.03
LSJ	F	30–39	Operation	Over 9 y	5.54	22.72	1.00	8.38
HCY1	F	20–29	IS	3–5 y	5.17	22.29	1.03	9.89

By the analysis of Network Centrality, we can further understand members who have important influences in the ERP system implementation process. Using UCINET 6, this study calculated degree of centrality, closeness-centrality, betweenness centrality and eigenvector centrality. Through these four values calculated by this analysis, we understand high and low level of network centrality, and to explore its influence on user participation in ERP system implementation.

5.2. Measurement model

The measurement model was analyzed by SmartPLS. The psychometric properties of the scales were assessed in terms of item loadings, discriminant validity, and internal consistency. Item loadings and internal consistencies (also known as composite reliability) greater than 0.70 are considered acceptable (Fornell & Larcker, 1981). From the factor analysis results, all the items loaded highly (>0.70) on their respective construct (see Appendix A). All the constructs also exhibited good internal consistency as evidenced by their composite reliability scores, which were all greater than 0.90 (see Table 3).

Discriminant validity was assessed by two criteria (Chin, 1998): (1) items should load more highly on the construct that they are intended to measure than on other constructs (i.e. loadings should be higher than cross-loadings) and (2) the square root of the average variance extracted (AVE) should be larger than the inter-construct correlations. Cross-loadings were computed by calculating the correlations between latent variable's component scores and the manifest indicators of other latent constructs (Agarwal, Gupta, & Kraut, 2008; Chin, 1998). Without exception, all items loaded more highly on their own construct than on other constructs (see Appendix A). Also, by comparing the inter-construct correlations and the square root of AVE (shaded leading diagonal), the square root of the AVE for each construct was greater than 0.707 (i.e., AVE > 0.50) and also greater than the correlations between the construct and other constructs, indicating that all the constructs share more variance with their indicators than with other constructs. Overall, the self-report measurement instrument exhibited sufficiently strong psychometric properties to support our subsequent test of the proposed structural model.

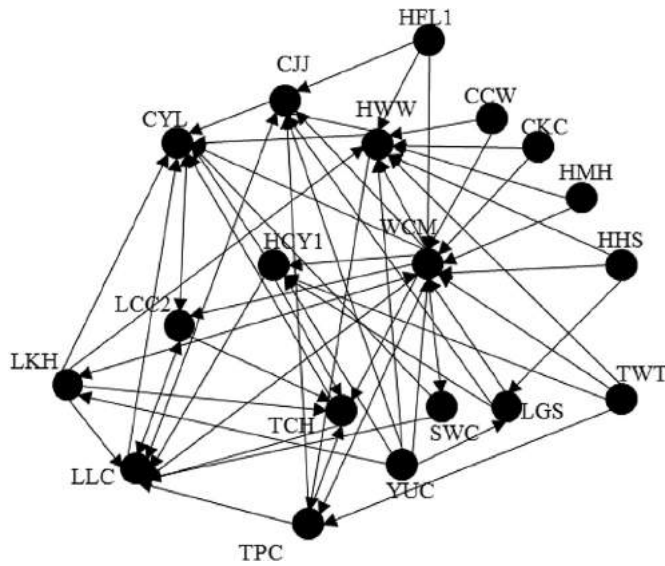


Fig. 2. Partial advice network diagram of employee WCM.

5.3. Structural model

The PLS structural model and hypotheses were assessed by examining path coefficients (similar to standardized beta weights in regression analysis) and their significance levels. All of the constructs were modeled as reflective. Following Chin (1998), bootstrapping (with 500 resamples) was performed to obtain the estimates of standard errors for testing the statistical significance of path coefficients using *t* test.

Fig. 3 and Table 4 summarize the model-testing results. As for Hypothesis 1, we find that network centrality is positively

associated with user–IS relationship ($t = 3.67, p < 0.01$). Hypothesis 2, which posits that network centrality would influence hands-on activity, is supported ($t = 6.19, p < 0.01$). As for Hypothesis 3, we find that, network centrality is positively associated with communication activity (validating $H_3, t = 7.11, p < 0.01$). Hypotheses 4, 5, 6 posit that user participation would positively influence system use. Hypothesis 4, which posits that user–IS relationship would influence system use, is not supported ($t = 0.81$). As for Hypothesis 5, we find that hands-on activity is positively associated with system use ($t = 2.58, p < 0.01$). Hypothesis 6, which posits that communication activity would influence system use, is supported ($t = 2.56, p < 0.01$). Hypotheses 7, 8, 9 posit that user participation would positively influence user satisfaction. As for Hypothesis 7, we find that user–IS relationship is positively associated with user satisfaction ($t = 2.11, p < 0.05$). Hypothesis 8, which posits that hands-on activity would influence user satisfaction, is supported ($t = 2.07, p < 0.05$). Hypothesis 9, which posits that communication activity would influence system use, is supported ($t = 1.99, p < 0.05$). Network centrality explains 3%, 17% and 13% of the variances in user–IS relationship, hands-on activity and communication activity respectively. Explained variances for system use and user satisfaction are 21% and 20%.

6. Conclusion

We theorized that the social network construct of network centrality would influence individual system use and system satisfaction through enhanced user participation in the post-implementation of an ERP system. The empirical results supported the proposed model, with the social network construct positively influencing user participation and thus leading to improved system use and user satisfaction. This is the first empirical study to investigate post-implementation user participation based on the majority of ERP users' network relationships. In

Table 3
Correlation analysis and composite factor reliability scores.^a

Variables	Mean	Std.	C.R	α	NC	UIS	HOA	COM	USE	SAT
NC	N/A	N/A	0.94	0.91	0.89					
UIS	2.58	1.01	0.95	0.94	0.16*	0.84				
HOA	2.12	1.01	0.97	0.96	0.40**	0.50**	0.88			
COM	2.90	0.99	0.96	0.95	0.38**	0.40**	0.56**	0.81		
USE	3.44	0.65	0.95	0.93	0.25**	0.27**	0.40**	0.37**	0.88	
SAT	3.45	0.59	0.95	0.95	0.26**	0.29**	0.37**	0.39**	0.57**	0.80

NC = Network Centrality; UIS = User–IS Relationship; HOA = Hands-on Activity; COM = Communication Activity; USE = System Use; SAT = User Satisfaction.

Significant level: ** $p < 0.01$.

^a Items on diagonal (shaded) represent the square root of the AVE scores.

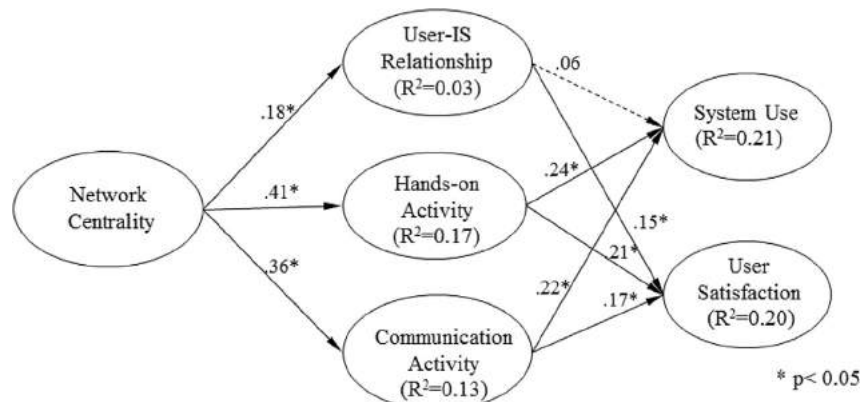


Fig. 3. PLS results of path model.

Table 4
PLS results of path significance.

Hypothesis	Coefficient	t-Value	Significance	R ²
Network centrality → user–IS relationship (H ₁)	0.18	3.67**	Yes	0.03
Network centrality → hands-on activity (H ₂)	0.41	6.19**	Yes	0.17
Network centrality → communication activity (H ₃)	0.36	7.11**	Yes	0.13
User–IS relationship → system use (H ₄)	0.06	0.81	No	0.21
Hands-on activity → system use (H ₅)	0.24	2.58**	Yes	
Communication activity → system use (H ₆)	0.22	2.56**	Yes	
User–IS relationship → user satisfaction (H ₇)	0.15	2.11**	Yes	0.20
Hands-on activity → user satisfaction (H ₈)	0.21	2.07**	Yes	
Communication activity → user satisfaction (H ₉)	0.17	1.99**	Yes	

Significant level: **p < 0.05.

contrast to the participation of key users in the ERP implementation stage, a greater number of users engaged in the modification and customization of ERP in the post-implementation period. Encouraging user participation during the post-implementation period is a key to facilitating the exploitation and adaptation of ERP (Wagner & Newell, 2007). For large numbers of users, it is beneficial to understand the influence of social networks on user participation.

The results indicated that network centrality had significant and positive effects on user participation in the user–IS relationship, hands-on activity, and communication activity. Previous studies have suggested that a high degree of network centrality indicates stronger power, and that such power can control resource flow in the organization (Brass, 1984; Ibarra, 1993; Ibarra & Andrews, 1993), as well as affect an individual's willingness to participate in the IS system post-implementation. In addition, when an IS system is implemented, the power an individual possesses in allocating and controlling resources represents the overall responsibility he or she bears for the project. A higher degree of network centrality means stronger connections between the individual and others; such a connection can become an effective communication channel during post-implementation (Ahuja et al., 2003; Sparrowe et al., 2001). Consequently, this study revealed that the higher the degree of network centrality is, the closer the relationship the individual has with others; a person with a high network centrality can effectively change and improve the behaviors of other people in the surrounding environment brought about by the IS system and subsequently promote their willingness to participate in the post-implementation stage. In addition, because members with a high network centrality can effectively control knowledge and resources, related knowledge can be disseminated and transferred through these members' communication activities. Hence, this study revealed that network centrality can substantially facilitate user participation during the post-implementation processes of an IS system.

Furthermore, the results also suggested that hands-on activities and communication activities have considerable and positive effects on system use and user satisfaction. Some studies indicated that user participation and communication in various stages of system implementation could familiarize users with knowledge about the system and facilitate the improvement of system quality (McKeen & Guimaraes, 1997; Wagner & Newell, 2007). Furthermore, users do not truly understand the relevance and value of a system in relation to themselves without having participated in or communicated about the process (Cavaye, 1995), which in turn promotes their motivation to actually use the system. Hence the results of this analysis are consistent with previous studies in finding that hands-on participation and the communications of associated users in an organization can effectively increase system use and user satisfaction.

In improving business processes and work efficiency to create strategically competitive advantages, many corporations have

started to implement ERP to assist with their daily business activities. However, as much as 90% of IS projects could not be completed to the expected standard or within the expected time-frame, particularly the introduction of an ERP system (Martin, 1998). IS system implementation may change original business processes or organizational structures of a company, and consequently it is prone to user resistance, which could lead to failure. Hence, reducing user resistance and promoting user participation in IS system implementation is crucial. This study found that personal networks in an organization could affect an individual's decision to participate in IS system implementation. Users in the network center play an essential role as a communication bridge in an organization, and they possess more knowledge and power related to the system's introduction. Therefore, corporations must value users with a high degree of network centrality and use their status in personal networks to disseminate the knowledge and strengths of the ERP system. By doing so, other users can be influenced to change their attitudes or behaviors toward the ERP system, which can improve participation and promote the chance of system success. According to a social network analysis, corporations can identify users who have strong influence in personal networks, and then train them to become key users in the ERP system's implementation. This can help solve the problems of other users during the system's introduction and effectively extend knowledge of system use to associated users, which in turn makes other users willing to accept and use the system. Therefore, this study suggests that corporations should effectively manage the personal network in an organization to enhance the degree of user participation during ERP system implementation.

Numerous studies have indicated that user participation behavior is a crucial element in IS system implementation (Barki & Hartwick, 1994a; McKeen & Guimaraes, 1997; Saleem, 1996; Wu & Marakas, 2006). This study suggests that corporations must be able to improve associated users' attitudes and opinions of the ERP system during implementation, and promote user motivation to participate in implementation. Effective communication can be achieved only through the participation of associated users, and such participation enhances the effects of the optimal use of the new system and the daily work in an organization.

IS systems must be implemented through continuous communication and coordination among the project team and associated users, and only in this way can an ERP system truly be integrated with corporate processes. This study mainly considers strong tie aspect of the social network theory for studying ERP post-implementation. As individuals have diverse skills and knowledge to implement and use ERP system, it is crucial to exchange knowledge in this situation. However, Granovetter (1973) asserts that strong ties among individuals facilitate information flows but weak ties increase the likelihood of finding novel ideas. The innovative aspect of weak ties may be another important issue to study ERP implementation in future research. Besides, an increase in aptitude

enhances the willingness to use the system, and in turn reduces user resistance. If corporations want to increase the probability of system success, they must focus on the degree of user participation and the opinions raised by users after their participation.

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Appendix A

Factor loadings and cross-loadings table.

	Centrality	UIS	HOA	COM	System usage	SAT
Betweenness	0.90	0.13	0.37	0.27	0.19	0.20
Closeness	0.74	0.13	0.30	0.31	0.24	0.18
Degree	0.97	0.17	0.40	0.32	0.26	0.25
Eigenvector	0.96	0.20	0.40	0.39	0.29	0.29
UIS1	0.15	0.75	0.42	0.38	0.22	0.24
UIS2	0.11	0.80	0.46	0.36	0.16	0.20
UIS3	0.06	0.84	0.41	0.34	0.19	0.27
UIS4	0.09	0.88	0.44	0.36	0.23	0.26
UIS5	0.15	0.87	0.41	0.33	0.24	0.33
UIS6	0.15	0.89	0.53	0.44	0.29	0.29
UIS7	0.22	0.89	0.51	0.42	0.29	0.30
UIS8	0.22	0.81	0.49	0.44	0.32	0.36
HOA1	0.39	0.51	0.91	0.58	0.37	0.36
HOA2	0.36	0.48	0.89	0.55	0.35	0.36
HOA3	0.37	0.54	0.92	0.60	0.39	0.38
HOA4	0.40	0.48	0.91	0.56	0.35	0.34
HOA5	0.35	0.55	0.92	0.59	0.39	0.41
HOA6	0.36	0.47	0.71	0.59	0.26	0.28
HOA7	0.37	0.48	0.91	0.54	0.42	0.39
HOA8	0.32	0.44	0.89	0.51	0.36	0.33
HOA9	0.34	0.39	0.84	0.48	0.38	0.31
COM1	0.28	0.29	0.43	0.74	0.24	0.22
COM2	0.25	0.31	0.50	0.84	0.34	0.37
COM3	0.32	0.32	0.47	0.85	0.34	0.31
COM4	0.34	0.30	0.50	0.86	0.33	0.32
COM5	0.28	0.35	0.47	0.79	0.25	0.25
COM6	0.37	0.44	0.54	0.87	0.38	0.37
COM7	0.38	0.47	0.54	0.88	0.38	0.35
COM8	0.40	0.45	0.55	0.83	0.40	0.39
COM9	0.17	0.36	0.53	0.73	0.26	0.19
COM10	0.19	0.37	0.55	0.76	0.28	0.22
COM11	0.17	0.39	0.53	0.75	0.30	0.26
COM12	0.23	0.41	0.56	0.77	0.32	0.25
USE1	0.25	0.22	0.33	0.32	0.90	0.55
USE2	0.20	0.27	0.36	0.33	0.92	0.56
USE3	0.32	0.24	0.39	0.37	0.83	0.54
USE4	0.20	0.28	0.33	0.28	0.88	0.50
USE5	0.23	0.30	0.41	0.43	0.87	0.56
SAT1	0.20	0.31	0.34	0.36	0.49	0.75
SAT2	0.15	0.25	0.30	0.30	0.44	0.82
SAT3	0.15	0.24	0.33	0.32	0.53	0.79
SAT4	0.09	0.18	0.23	0.23	0.42	0.78
SAT5	0.16	0.19	0.25	0.20	0.42	0.76
SAT6	0.18	0.24	0.27	0.21	0.45	0.78
SAT7	0.23	0.30	0.29	0.25	0.48	0.78
SAT8	0.31	0.27	0.35	0.34	0.53	0.84
SAT9	0.20	0.30	0.42	0.33	0.50	0.80
SAT10	0.18	0.30	0.34	0.24	0.46	0.76
SAT11	0.25	0.32	0.31	0.33	0.55	0.86
SAT12	0.33	0.33	0.35	0.38	0.58	0.85

The bold and italic numbers indicate the factor loadings on each construct. **UIS** = User–IS Relationship; **HOA** = Hands-on Activity; **COM** = Communication Activity; **USE** = System Use; **SAT** = User Satisfaction.

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