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Hwang, Wenli; Hsiao, Bo; Chen, Houn-Gee; and Chern, Ching-Chin, "Dynamically Assessing the Intertwined Influences of ISD Project Risk Factors" (2013). *PACIS 2013 Proceedings*. 40.

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DYNAMICALLY ASSESSING THE INTERTWINED INFLUENCES OF ISD PROJECT RISK FACTORS

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Abstract

This study aims to adopt an approach for assessing the mutual influences of risk factors on information system development project transferring from initialization to the control phases. Given that risks evolve dynamically, the variations of the degrees of risk influences throughout the development process of information system project must be analyzed so that effective risk management strategies can be devised in a cost-effective way at the right stage. Therefore, our study applies Decision Making Trial and Evaluation Laboratory to quantitatively assess the interdependencies among the risk factors for each project development phase. An application conducted in a private, medium-scale university in Taiwan is demonstrated. The results suggest the directions for possible improvements of risk management during university information system development process.

Keywords: Information System Development Project; DEMATEL (Decision Making Trial and Evaluation Laboratory); Risk influence; project development phase

1. INTRODUCTION

To keep a competitive advantage in the era of high informationalization and globalization, organizations continuously invest substantial resources and efforts on information system development (ISD) projects. Nevertheless, developing an information system project is a dynamic and complex process surrounded by factors of risk and uncertainty (Alter & Ginzberg 1978; Barki, Rivard & Talbot 1993; Boehm 1991; Charette 1989; McFarlan 1981). Managing the risks is a crucial and indispensable issue during the ISD process (Keil, Cule, Lyytinen & Schmidt 1998). As pointed out by McFarlan (1981), if managers fail to assess the individual and aggregate risks for projects and take appropriate management approaches, the project ends with budget overrun, schedule delay, or quality deficiencies. Thus, managers need better mechanisms to assess and manage the ISD project risks as early as possible (McFarlan 1981; Barki et al. 1993; Boehm 1991; Wallace, Keil & Rai 2004a).

ISD project risks are multidimensional and vary in nature, severity, influence, and consequences. The basic premise of risk management is to assess the significance of potential risks to guide the subsequent management efforts and control the risks in a cost-effective way (Ward 1999). A considerable volume of studies have already been conducted for the proposals of various methods to assess the relative importance and ranking of risks, as well as the investigation of their impact on project performance (Han & Huang 2007; Houston, Mackulak & Collofello 2001; Jiang & Klein 2000; Wallace et al. 2004a). However, the understanding of how the risk factors affect each other, and how the interrelationships of risk factors change along different project management phases still remains unexplored. Project risk factors are not independent of each other in practice; rather, they are mutually related, either directly or indirectly. Hence, any managerial intervention with one risk factor may affect the others (Tzeng, Chiang & Li 2007). Such feature complicates project risk management activities. In devising appropriate prioritization of actions and effective risk resolution strategies, the interdependence among risk factors is one of the important aspects that should be comprehensively addressed to enhance the risk assessment procedures.

Given that an ISD project is initiated, planned, executed, and controlled, various risks may arise or recur at each phase of the development process. The risk management activities can no longer be viewed as an add-on process and should be conducted throughout the entire project life cycle (Dey, Kinch & Ogunlana 2007). Despite the wide recognition of the importance of assessing the risks periodically and constantly, few studies have empirically examined the project risk factors in relation to their emphasis to the different phases of project development. Most studies have examined the project risks in an integrated fashion without distinguishing the variation of risks from phase to phase. Some studies have limited their investigation to a narrow portion of the development process (Keil et al. 1998). Each of the ISD phase involves unique

objectives, tasks, activities, and different stakeholders; hence, the types and the degree of influences of each risk factor are different. The knowledge of how the risk factors evolve, as well as the changes in influential factors over time, is valuable. Thus, the dynamics of risk influences must be analyzed in terms of development phases to ensure and improve evaluation accuracy. Utilizing the decision making trial and evaluation laboratory (DEMATEL), this study measures the interrelationships among the risk factors, acknowledges the risk factors with greater influences, and systematically analyzes the variation of the influence levels of risk factors among the main phases of the IS project management process, including initiation, planning, execution, monitoring and control.

The contributions of this research are twofold. First, DEMATEL is applied to quantitatively assess the interdependences among project risks. Second, by revealing the influential risk factors at various phases of the project management process, the insights about how the strength and type of risk influences dynamically evolve throughout the project are provided.

The remainder of the paper is organized as follows. In Section 2, an extensive literature review on information system risk identification and assessment is performed to summarize a relevant list of risk factors for ISD projects. Section 3 introduces the DEMATEL methodology, and illustrates how the interrelationships among risk factors are measured in various ISD project phases. An empirical case study, conducted in a private university in Taiwan, is detailed to demonstrate the applicability of DEMATEL in Section 4, followed by the findings and discussion from the case in Section 5. Finally, the conclusion is presented in Section 6.

2. INFORMATION SYSTEM DEVELOPMENT PROJECT RISK ASSESSMENT

The term “project risk”, in accordance with the PMBOK guide (2008), is described as “*an uncertain event or condition that, if it occurs, has a positive or negative effect on the project objectives.*” That is, risks will have downside threats and upside opportunities on projects. Effective risk management alleviates the loss and threats with risks, and also creates a proactive environment of information system development to increase business profits and competitive advantages.

2.1 Risk Factors of Information System Development Project

Identifying the risks associated with an ISD development project can be a major challenge for project managers in organizations because various ways are available for interpreting or categorizing these risks. Several significant and well-known studies have supplied an extensive list of risks or uncertainties faced by ISD projects.

Alter and Ginzberg (1978) identified eight risk factors, mainly from designers and users in their implementation risk model, including lack of experience, nonexistent or unwilling users,

multiple users and designers, turnover of related stakeholders, lack of support, inability to specify the purpose or usage pattern, inability to predict and cushion the impact of risk, and technical or cost-effectiveness problems. McFarlan (1981) identified project size, technology experience, and project structure as the main risk dimensions inherent in software projects. Davis (1982) argued that the difficulties of requirement determination lead to poor project performance. Barki et al. (1993) developed a generally accepted risk assessment instrument through thorough literature reviews. The instrument consists of 23 risk variables that are categorized into five groups: technological newness, application size, expertise, application complexity, and organizational environment. Keil et al. (1998) and Schmidt, Lyytinen, Keil & Cule (2001) employed a “ranking type” Delphi survey with three panels of experts in Hong Kong, Finland, and the United States. The survey produced a rank-order list of top 11 risk factors that deserves the project managers’ attentions during project development. These risk factors include the lack of top management commitment to the project, failure to gain user commitment, misunderstanding the requirements, lack of adequate user involvement, lack of required knowledge/skills of the project personnel, lack of frozen requirements, changes in the scope/objectives, introduction of new technologies, failure to manage end user expectations, insufficient/inappropriate staffing, and conflict between user departments. Chua (2009) adopted a meta-case analysis approach to explore the risk factors in eight well-documented and high-profile failed ISD projects. A list of 13 common risk factors was uncovered and classified into four main categories: people-related, process-related, technical, and extra-project risk factors. To examine the impacts of software development risks on project performance, Wallace et al. (2004a) built a theoretical model with six dimensions that characterize the software risk factors, including user, requirement, project complexity, planning and control, team, and organization environment. This model provides an overall view to assess the risks of ISD projects.

Synthesizing prior studies (e.g., Wallace et al., 2004a) on information system development risks, a list of 25 risk factors classified into six dimensions is summarized in Table 1. The present study utilizes the list of risk factors in the subsequent risk assessment procedures.

Risk Dimensions	Risk Factors
Organization (O)	Top management commitment (O ₁)
	Organizational changes (O ₂)
	Organizational politics (O ₃)
	Environmental changes (O ₄)
User (U)	Users’ attitude (U ₁)
	Users’ conflict (U ₂)
	Users’ involvement (U ₃)
	Computer literacy (U ₄)
Requirement (R)	Requirement stability (R ₁)
	Requirement completeness (R ₂)
	Requirement validity (R ₃)
	Requirement clarity (R ₄)

Project Complexity (C)	New technology (C ₁)
	Task complexity (C ₂)
	Technical complexity (C ₃)
	Prior experience with the similar technology (C ₄)
Team (T)	Development expertise (T ₁)
	Application know-how (T ₂)
	development experience (T ₃)
	roles and responsibility (T ₄)
Management and Control(P)	Project management methodology (P ₁)
	Progress tracking and Monitoring (P ₂)
	Project managers' competence (P ₃)
	Project planning (P ₄)
	Communication and coordination (P ₅)

Table 1. List of risk factors for information system development projects

2.2 Information System Risk Assessment Methods

The purpose of risk assessment is to analyze the effects of risks on project outcome and determine the priorities of which threats or problems require more attention or urgent response. A common approach to rank risks comprises two basic elements: the likelihood of the particular risk occurring and the magnitude of the consequences (Charette 1989; Ward 1999). Various tools and techniques have been provided in previous studies. Boehm (1991) recommended a mathematical formula for the concept “risk exposure” as the multiplication of probability of unsatisfactory outcome with associated loss if the certain risk really occurred. Although this concept is popularly accepted by the discipline of information system risk management, some researchers recognize that many people have little knowledge of probabilistic notions and are unable to express themselves clearly with the mathematical equations (Anderson & Narasimhan 1979; Kangari & Boyer 1989, Barki et al. 1993). In 1993, the Software Engineering Institute (SEI) delivered a software risk management tool named “Taxonomy-Based Risk Identification”, in which the risks are assessed by linguistic scales (Carr, Suresh & Ira 1993). Due to the complex and diverse aspects of risk factors facing an IS project, some studies adopted more advanced assessment methods to perform prioritizing procedure, such as multi-criteria decision making methodologies (Huang, Chang, Li & Lin 2004; Aloini, Dulmin & Mininno 2012) and data mining techniques (Huang & Han 2008; Wallace et al. 2004b).

Although the various assessment methods are acknowledged as a basis to manage risk factors, many of existing assessment models ignor the mutual influences among risk factors and do not measure the project risks from a holistic viewpoint. Modern ISD projects, characterized by large scale, integration, globalization, and unpredictability, are fraught with more risks than before. Dedicating efforts to every risk within limited resouces is impractical (Ward 1999). Previous studies suggest that risks are managed in terms of relative importance or risk ranking. However, the risks inherent in complex ISD projects are interdependent and exert domino effects over each other (Aloini et al. 2012). Therefore, the interrelationship among risk factors

should be readily illustrated before any attempts to evaluate importance of risk factors (Aloini et al. 2012; Ward 1999)

Furthermore, risk factors are changing dynamically along the progress of project development (Carr et al. 1993; Wallace et al. 2004a; Keil et al. 1998; Chua 2009). Each phase of ISD process has unique objectives, tasks, and activities; hence, the risks involved should be assessed and controlled respectively in each phase. Previous studies also addressed the needs of investigating key risk incidents at each phase throughout the software development lifecycle and devising response strategies to increase the likelihood of project success (Alter & Ginzberg 1978; Dey et al. 2007). Gemino, Reich, and Sauer (2008) proposed the temporal model of information technology performance. They suggested that temporal differences in risk factors exist. The understanding of how various risk factors affect the project performance can be improved by separating the risk factors into earlier factors and later factors. Chua (2009) constructed a model for identifying IT project risk factors, in which various risk factors are mapped to specific phases of project lifecycle, namely, initiation, development, and implementation, to help practitioners preempt or manage the risks as the projects progress.

According to the foregoing discussion, this study therefore adopts an alternative technique to dynamically assess the intertwined influences among risk factors against the project development phases so that appropriate risk resolution strategies can be devised in a cost-effective way and at the right stage.

3. DEMATEL METHODS

DEMATEL quantifies the type and the strength of interdependence among factors by organizing complex problems into structured and distinct matrix-type questionnaires, specifying the degree of the mutual influences of the elements in pairs, and employing matrix operations and mathematical algorithms (Lee, Huang, Chang, & Cheng 2011). The knowledge of experts is solicited and analyzed. Thus, DEMATEL offers the ability to extract mutually impressible and effective relations of elements. The final result of the DEMATEL analysis illustrates the interrelationships among the factors, and summarizes all the factors into a cause group or an effect group so that the central factors of the complex problem and a priority list of actions can be determined (Lin & Wu 2008; Tzeng et al. 2007). This method was originally developed to solve globally complex issues in economic, scientific, and political areas (e.g., Fontela & Gabus 1974; 1976; Warfield 1976). In recent years, the DEMATEL technique has been recognized as a better approach for identifying the interdependencies of factors. DEMATEL has evolved and widely applied to evaluate the interrelationships between criteria in various research areas, such as marketing strategy generation (Chiu, Chen & Shyu 2006), e-learning program evaluations (Tzeng et al. 2007), airline safety measurements (Liou, Tzeng & Chang 2007), competence development of global managers (Wu & Lee 2007), assessment of information security risk control (Ou Yang et al. 2008), group decision-making under fuzzy

environments (Lin & Wu 2008), service quality assessment models (Tsai & Chou 2009; Tseng 2009), knowledge management strategies (Wu 2008), and causal effects of competences of the IC design service company (Lin, Yang, Chang & Cheng 2011).

To apply DEMATEL, a matrix-type questionnaire is developed based on a list of criteria. Respondents are asked to score the degree of mutual influences among the criteria in pairs with a scale from 0 to 4, where 0 means no influence, 1 means low influence, 2 means medium influence, 3 means high influence, and 4 means very high influence. Through a series of matrix operations, the total influence matrix is derived with four influence coefficients presented for each criterion. Details of the steps can be referred to previous studies (Liou et al. 2007; Tzeng et al. 2007).

d^p : the total of direct and indirect influences of each criterion are given to the others in phase p .

r^p : the total of direct and indirect influences of each criterion are received from the others in phase p .

$(d^p + r^p)$: the total effect of the criterion played in the problem in phase p , named as “Prominence”

$(d^p - r^p)$: the net effect of the criterion that contributes to the problem in phase p , named “Relation”.

The causal diagram can be constructed with $(d^p + r^p)$ as the horizontal axis and $(d^p - r^p)$ as the vertical axis. All criteria can be divided into the cause group or the effect group in each phase. The factor is classified into the cause group if $(d^p - r^p)$ is positive and into the effect group when $(d^p - r^p)$ is negative. The risk factors in the cause group influence other risk factors, while those in the effect group are influenced by the others. The concept and meaning of prominence $(d^p + r^p)$ and relation $(d^p - r^p)$ are summarized in Table 2.

Prominence	Relation	Description
High	Positive	This category of criteria is critical and creates more dynamics on other criteria and on the problem. Any actions taken on this type of criteria have wide-range impact on the other effect criteria. The high priority of management intervention is required to attain higher level of improvement.
High	Negative	This category of criteria is highly affected by other criteria and requires more attention. However, it is not an urgent priority to be dealt with.
Low	Positive	This category of criteria is somewhat independent with some influence on the criteria, but cannot be influenced easily.
Low	Negative	This category of criteria is kind of independent. It affects and is affected by few of the other criteria.

Table 2. Descriptions of dataset ($D+R$, $D-R$)

4. EMPIRICAL STUDY

4.1 Case Description

The empirical study was conducted in a private, medium-scale university in Taiwan. The university has over 15,000 students in 31 departments, as well as 1,200 faculties and administrative staff. This university started the first-generation computerization of school management and administration in the late 1980s. Most of the application systems were implemented according to the requirements specific to particular organizational units in an uncoordinated way. Although the information systems have evolved through several stages of growth in response to the revolution of information technologies and the increasing needs of the university, the university was still faced with some major problems, including difficulties in data exchange among the heterogeneous hardware platforms across standalone, client-server, and, to date, web-based architecture, as well as small integration and incomplete support of the administrative process for the disjointedly developed systems. As a result, the university decided to initiate an integrated project following the spirit of ERP to more effectively integrate the data and processes of university academic, research, and administration activities. The new university information system development (UISD) project was expected to take advantage of emergent information technologies in innovatively and interactively pedagogical ways and offer flexibility for future expansion.

4.2 Data Collection

To investigate the influential risk factors under different project management processes, this research adopted a longitudinal method for collecting data along the progress of the project. To analyze the interrelationship between the UISD project risk factors, a matrix-type questionnaire was designed based on the list of risk factors proposed in Section 2.1 and utilizing the DEMATEL method for each phase, as outlined in Section 3.

The knowledge of professionals and experts on project risk management is important for this study to determine the relationships among the influential factors of the UISD development project. Therefore, the core team members of the UISD project were invited to verify the project risk factors and fill out the survey. Table 3 summarizes the composition of the respondents at each phase of the ISD process.

	Initialization	Planning	Execution	Monitoring and Control
IT director	1	1	1	1
Project manager	1	1	1	1
Analysts	2	2	2	2
System Developer	0	4	4	4
IT Steering member	2	2	2	2
User representative	0	2	2	2

Table 3. *Composition of respondents*

4.3 Data Analysis

Based on the results of the survey, this section analyzes the relationship structure of the twenty five risk factors and identifies the dominant risk factors having greater influences during the different phases of the project management process. For each project management process phase P , four influencing coefficients are presented including (1) d^P : the total of direct and indirect influences over the other risk factors in phase P ; (2) r^P : the total of direct and indirect influences received from the risk factors in phase P ; (3) $(d^P + r^P)$: the prominence, representing the strength that the factor exhibited in the project performance in phase P ; (4) $(d^P - r^P)$: the relation, representing the direction (cause or effect) of the factor displayed in the project performance in phase P . In addition, a causal diagram was prepared, with $(d^P + r^P)$ as the horizontal axis and $(d^P - r^P)$ as the vertical axis, to display clearly the degree and direction of influences among the risk factors in phase P . Based on Table 2, the higher the prominence $(d^P + r^P)$ value is, the more critical the risk factor. The average of $(d^P + r^P)$ was calculated and used as a baseline threshold value so that all the risk factors can be classified into high prominence group and low prominence group. According to the value of $(d^P - r^P)$, the risks were divided into the cause group when $(d^P - r^P) > 0$ and the effect group when $(d^P - r^P) < 0$. For the combination of $(d^P + r^P)$ and $(d^P - r^P)$, risk factors are mapped into the four quadrants of a causal diagram.

The casual diagrams of the project risk factors of the four phases are shown in Figures 1 to 4. The results of the initialization phase were obtained to interpret the classifications of the risk factors. The average of the prominence $d^i + r^i$ of all risk factors is 5.14 in the project initialization phase. As shown in Figure 1, twelve risk factors exceed the average and belong to the high prominence group. Among these factors, only P3 (Project Manager's competence), U1 (Users' attitude), and U4 (Users' Computer literacy) are cause factors, which are the dominant risk factors during initialization process, and necessitate immediate and appropriate management action to generate greater improvement on project performance. The remaining nine higher prominent factors are positioned in the effect group, including most of the factors in the dimension of planning and control, such as P1 (project management methodology), P2 (progress tracking and monitoring), P4 (project planning), P5 (communication and coordination), as well as all factors in the dimension of teams, such as T1 (development expertise), T2 (application know-how), T3 (development experience), and T4 (roles and responsibilities) and R1 (requirement stability). These factors are considered important but not the top priority to be tackled. They may be resolved or mitigated in terms of the management interventions on the factors of the cause group with high prominence. The factors with low prominence consist of organization-related risks, project complexity related risks, and most of the requirement related risks, which are more independent and have little cause and effect influence upon the other factors in this stage.

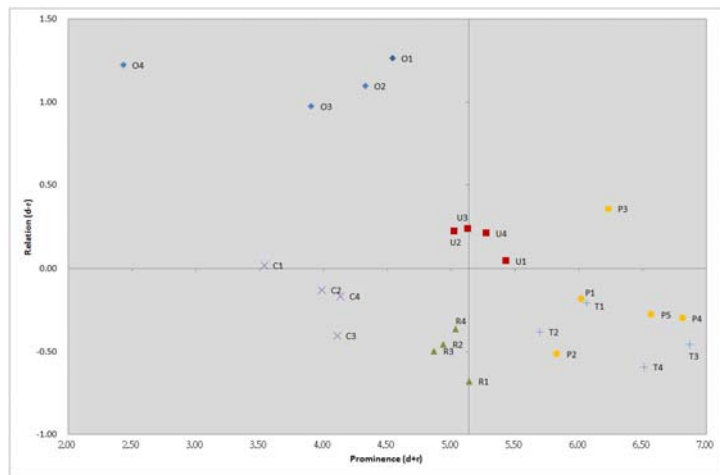


Figure 1. Causal diagram of risk factors in the project initialization phase

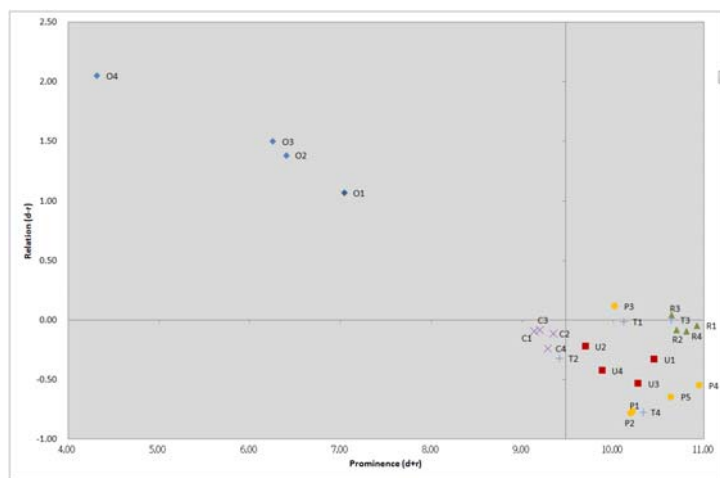


Figure 2. Causal diagram of risk factors in the Project planning phase

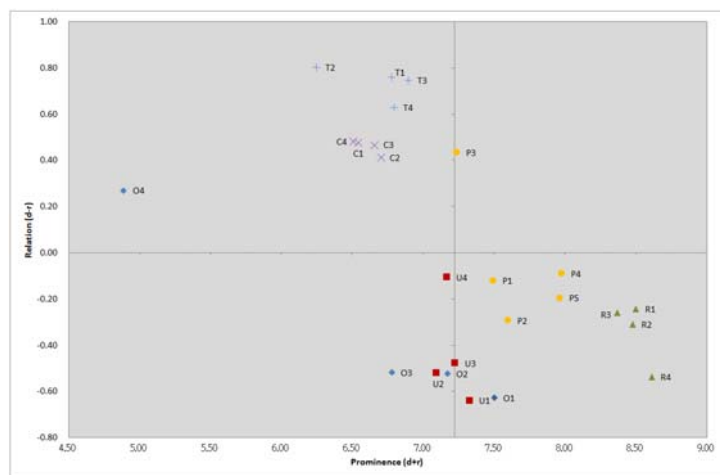


Figure 3. Causal diagram of risk factors in the project Execution phase

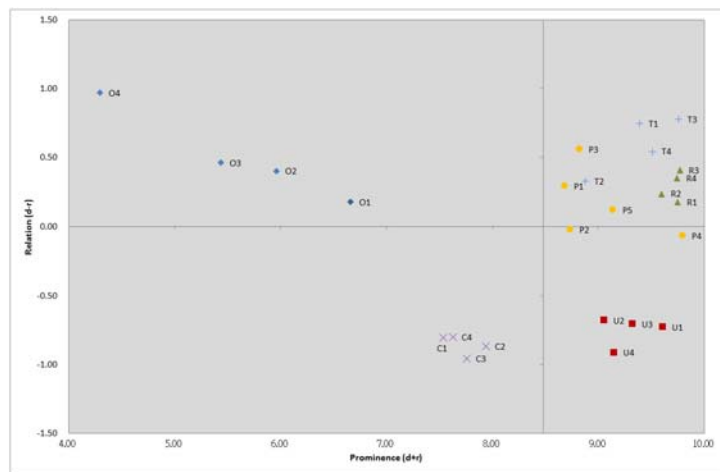


Figure 4. Causal diagrams of risk factors in the project monitoring and control phase

5. DISCUSSION

Instead of probing the risk factors at an overall project level, more in-depth understanding about the intrinsic features of the risk factors is revealed with multiple observations during the ISD process. Some risk factors may remain on the prominent positions throughout the life of the projects. Such risk factors necessitate immediate and continuous attentions from the inception of project to the end. Nevertheless, the strength or direction of influences are more likely to be varied during the course of project development process for most of the risk factors (i.e., change from cause group to effect group or from high prominence to low prominence).

As shown on the empirical results, project manager's competence (P3) is the only prominent risk factor through the whole project development process. This finding reaffirms the vital role played by the project manager in the introduction and implementation of the ISD project. Especially for UISD projects, the university organization is known with quick turnover of administrators and less profound computer knowledge and skills among the administrative staff (Telem, 1996). The project manager should lead the project implementation and take the responsibilities and accountability for the project success. As indicated by Zimmerer and Yasin (1998), 76% of successful projects are attributed to the positive leadership of the project managers.

Top management commitment and clear requirements are the top two risk factors of the rank-ordered list in a cross-cultural study (Schmidt et al., 2001). Their importance is well documented from the viewpoints of both academic studies and industry practices. The current research intends to examine the risk factors from the angle of their interrelationship with other factors and observe the changes of the influences of these risk factors along the project progress.

Top management commitment signals how serious they think about the project in terms of resource allocation, project priority, trust, and respect. The attitude of top management greatly

affects the behavior of the users, the morale of the project team and the communication among stakeholders. As perceived by project managers, this risk factor does have significant impact on the other risks, as well as on the project activities, but is outside the direct control of the project managers and is influenced by few risk factors (Keil et al., 1998). However, the said situation is not unalterable. In our case, the aforementioned statement can be applied to the project initialization phase and project planning phase. The said risk factor turns into the effect group and can be influenced by the others during the execution phase because systems are implemented step by step. The project team demonstrates something tangible and creates more visibility of the project to the top management. The project team can gain the trust and support from the top management via their performance. The changes on the influences of top management support along the project development are shown on Figure 5.

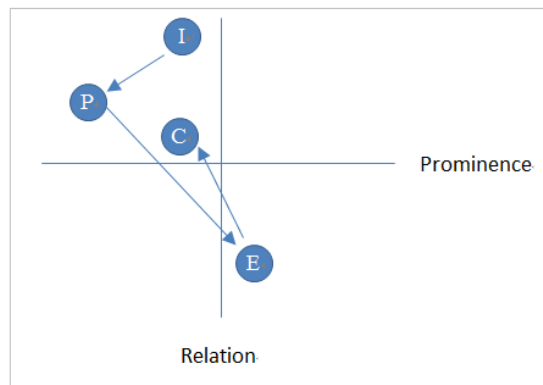


Figure 5. Changes of influences of top management support along project development phases.

The strength and direction of the requirement-related risk factors changes dynamically from phase to phase, as shown on Figure 6. These factors exert few influences during the phase of initialization and execution, but gain its prominent position in the phase of planning and monitoring and control. The key ingredients of the planning phase are clear, correct, and complete requirements. When the system requirements can be determined as detailed as possible, the system structure, interface among applications, and system scopes can be well-defined (Davis 1982). The project resources can also be estimated more accurately. As the project proceeds, the requirements are subjected to continuous change due to environmental factor or business needs. The performance of monitoring and control phase would be improved if the requirement changes are properly managed.

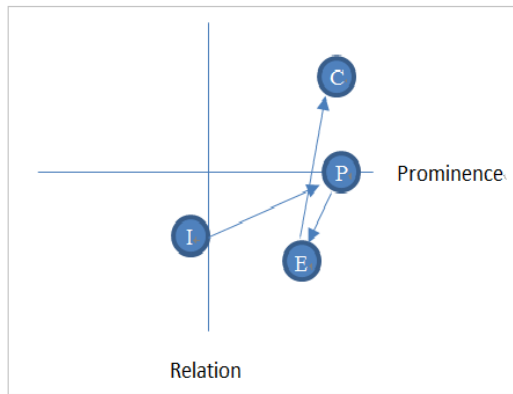


Figure 6. *Changes of influences of requirement-related factors along project development phases*

6. CONCLUSION AND REMARKS

Traditionally, risk assessment for information system projects is used to analyze the possibilities and magnitude of loss for each risk factor, and then produce a ranked-order list of risks in terms of relative importance. This study provides evidence that better understanding of interrelationship among risk factors provides additional information to enhance the risk assessment procedure. In addition, a multi-phased analysis of the risk influence could be a more suitable alternative than a single-phased analysis in the risk management of the ISD projects. However, the present study has certain limitations. First, the importance or non-importance of the risk factors is not considered. Second, the uncertainties from the competition and markets are excluded from the analysis in this study, which may affect the results of the project risk influences. Although the results of this study provide interesting insights on ISD project risk management, further the findings could be involved in the above issues.

ACKNOWLEDGEMENTS

The authors would like to thank the anonymous referees for their valuable comments and suggestions. Their comments helped improve the quality of the paper immensely. This research is sponsored by the National Science Council of Taiwan, under project number NSC 101-2410-H-309-017.

References

- Aloini, D.; Dulmin, R. and Mininno, V. (2012). Risk assessment in ERP projects. *Information Systems*, 37, 183-199.
- Alter, S. and Ginzberg, M. (1978). Managing uncertainty in MIS implementation. *Sloan Management Review*, 20(1), 23-31.

- Anderson, J. and Narasimhan, R. (1979). Assessing implementation risk: a methodological approach. *Management Science*, 25(6), 512-521.
- Barki, H.; Rivard, S. and Talbot, J. (1993). Toward an assessment of software development risk. *Journal of Management Information Systems*, 10(2), 203-225.
- Boehm, B.W. (1991). *Software Risk management: principles and practices*. IEEE Software, 8(1), 32-41.
- Carr, M.J.; Suresh, L.K. and Ira, M.F. (1993). Taxonomy based risk identification (CMUISEI-93-TR-6). Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA, USA.
- Charette, R.N. (1989). *Software Engineering Risk Analysis and Management*. McGraw-Hill, New York.
- Chiu, Y.; Chen, H. and Shyu, J. (2006). Marketing strategy based on customer behavior for the LCD-TV. *International Journal of Management and Decision Making*, 7(2), 143-165.
- Chua, A.Y.K. (2009). Exhuming IT projects from their graves: an analysis of eight failure cases and their risk factors. *Journal of Computer Information Systems*, 49(3), 31-39.
- Davis, G.B. (1982). Strategies for Information Requirements Determination. *IBM Systems Journal*, 21(1), 4-30.
- Dey, P.K.; Kinch, J. and Ogunlana, S.O. (2007). Managing risk in software development projects: a case study. *Industrial Management & Data Systems*, 107(2), 284-303.
- Fontela, E. and Gabus, A. (1974). DEMATEL, innovative methods, Report no. 2, Structural analysis of the world problematique. Bettelle Institute, Geneva Research Center.
- Fontela, E. and Gabus, A. (1976). The DEMATEL Observer. Bettelle Institute, Geneva Research Center.
- Gemino, A.; Reich, B.H. and Sauer, C. (2008). A Temporal Model of Information Technology Project Performance. *Journal of Management Information Systems*, 24(3), 9-44.
- Han, W.M. and Huang, S. J. (2007). An empirical analysis of risk components and performance on software projects. *Journal of Systems and Software*, 80(1), 42-50.
- Houston, D.X.; Mackulak, G.T. and Collofello, J.S. (2001). Stochastic simulation of risk factor potential effects for software development risk management. *Journal of Systems and Software*, 59(3), 247-257.
- Huang, S.J. and Han, W.M. (2008). Exploring the relationship between software project duration and risk exposure: a cluster analysis. *Information and Management*, 45(3), 175-182.
- Huang, S.M.; Chang, I.C.; Li, S.H. and Lin, M.T. (2004). Assessing risk in ERP projects: identify and prioritize the factors. *Industrial Management and Data Systems*, 104(8), 681-688.
- Jiang, J. J. and Klein, G. (2000). Software development risks to project effectiveness. *Journal of Systems and Software*, 52(1), 3-10.

- Kangari, R. and Boyer, L.T. (1989). Risk management by expert systems. *Project Management Journal*, 20(1), 40-48.
- Keil, M.; Cule, P.; Lyytinen, K. and Schmidt, R. (1998). A framework for identifying software project risks. *Communications of the ACM*, 41, 76-83.
- Lee, W.; Huang, Y.; Chang, Y. and Cheng, C. (2011). Analysis of decision making factors for equity investment by DEMATEL and analytic Network process. *Expert Systems with Applications*, 38, 8375-8383.
- Lin, C. J. and Wu, W. W. (2008). A causal analytical method for group decision-making under fuzzy environment. *Expert Systems with Applications*, 34, 205-213.
- Lin, Y.; Yang, Y.; Kang, J. and Yu, H. (2011). Using DEMATEL method to explore the core competences and causal effect of the IC design service company: An empirical case study. *Expert Systems with Applications*, 38, 6262-6268.
- Liou, J. J. H.; Tzeng, G. H. and Chang, H.C. (2007). Airline safety measurement using a hybrid model. *Journal of Air Transport Management*, 13(4), 243-249.
- McFarlan, F. W. (1981). Portfolio approach to information systems. *Harvard Business Review*, 59(5), 142-150.
- Ou Yang, Y. P.; Shieh, H. M.; Leu, J. D. and Tzeng, G. (2008). A novel hybrid MCDM model combined with DEMATEL and ANP with applications. *International Journal of Operations Research*, 5(3), 160-168.
- PMBOK Guide (2008). A guide to the project management body of knowledge. 4th edition. Project Management Institute.
- Schmidt, R.; Lyytinen, K.; Keil, M. and Cule, P. (2001). Identifying software project risks: and international Delphi study. *Journal of Management Information Systems*, 17(4), 5-36.
- Tsai, W. H. and Chou, W. C. (2009). Selecting management systems for sustainable development in SMEs: A novel hybrid model based on DEMATEL, ANP, and ZOGP. *Expert Systems with Applications*, 36, 1444-1458.
- Telem, M. (1996). MIS implementation in schools: a systems socio-technical framework. *Computers & Education*, 27(2), 85-93.
- Tzeng, G. H.; Chiang, C. H., and Li, C. W. (2007). Evaluating intertwined effects in e-learning programs: A Novel Hybrid MCDM Model Based on Factor Analysis and DEMATEL. *Expert Systems with Applications*, 32(4), 1028-1044.
- Tseng, M. L. (2009). A causal and effect decision making model of service quality expectation using grey-fuzzy DEMATEL approach. *Expert System with. Application*. 36: 7738-7748.
- Wallace, L.; Keil, M. and Rai, A. (2004a). How software project risk affects project performance: an investigation of the dimensions of risk and an exploratory model. *Decision Sciences*, 35(2), 289-322.
- Wallace, L.; Keil, M. and Rai, A. (2004b). Understanding software project risk: A cluster analysis. *Information and Management*, 42(1), 115-125.

- Ward, S. C. (1999). Assessing and managing important risks. *International Journal of Project Management*, 17(6), 331-336.
- Warfield, J. N. (1976). *Societal Systems, Planning, Policy and Complexity*. John Wiley & Sons, New York.
- Wu, W. W. (2008). Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. *Expert Systems with Applications*. 35(3), 828–835.
- Wu, W. W. and Lee, Y. T. (2007). Developing global managers' competencies using the fuzzy DEMATEL method. *Expert Systems with Applications*. 32, 499–507.
- Zimmerer, T. and Yasin, M. (1998). The leadership profile of American project managers. *Project Management Journal*, 29(1), 31-38.