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Risk Management of Information Systems Development In Distributed Environment

Research-In-Progress

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ABSTRACT

Risk management has been recognized as an effective way to reduce system development failure. Information system development (ISD) is a highly complex and unpredictable activity associated with high risks. With more and more organizations outsource or offshore substantial resources in system development, organizations face up new challenges and risks not common to traditional development models. Classical risk management approaches have relied on tactical, bottom-up analysis, which do not readily scale to distributed environment. Therefore, risk management in distributed environment is becoming a critical area of concern. This paper uses a systemic approach developed by Software Engineering Institute to identify risks of ISD in distributed environment. Four key risk factors were identified from prior literature: objective, preparation, execution, and environment. In addition, the impact of these four risk factors on the success of information system development will also be examined.

Keywords

Risk, Information system development, Distributed environment, Survey, Impact.

INTRODUCTION

System development is a complex process due to technological issues, organizational factors, and user's involvement (Powell and Klein, 1996; Xia and Lee, 2005). The complexity has contributed to the high rate of system failure. For example, the Standish Group Report (2009) reports that only 32% software projects succeeded, 45% of projects overran costs, 63% of projects couldn't be delivered on time, and only 67% of functions were delivered (The Standish Group, 2009). Further, as it is shown in **Figure 1**, failures are *more* likely and successes are *less* over time. Even though the Standish Group's survey is overly pessimistic, it highlights a problem with economic consequences (Xia and Lee, 2005; Tiwana and Keil, 2006).

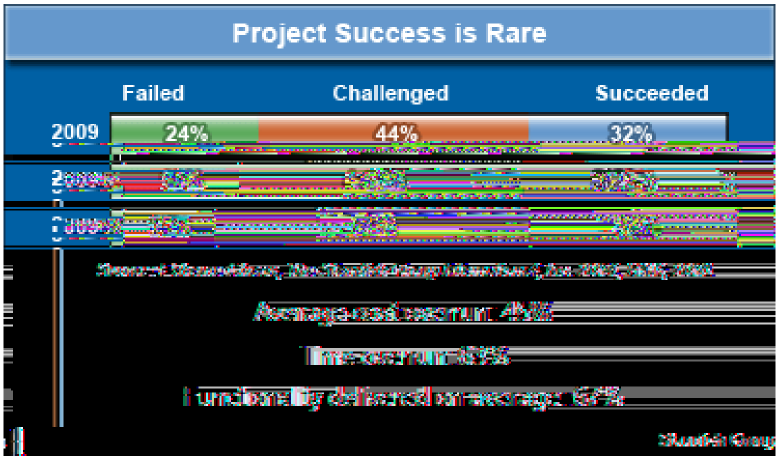

Figure 1: Project Success

One approach used over the past decades is to apply risk management principles to reduce the failure rate (Iversen, Mathiassen and Nielsen, 2004). Risk refers to a particular aspect of a development task, process, or environment, which, if ignored, will increase the probability of project failure (Barki, Rivard and Talbot, 1993; Lyytinen, Mathiassen and Ropponen, 1998). Empirical studies indicate that management of risk has improved system development considerably (e.g. Alter and Ginzberg, 1978; Boehm, 1991). The classical risk management focuses on intra-firm development and emphasizes methods including risk list (e.g. Barki et al., 1993), risk-action list (e.g. Alter and Ginzberg, 1978; Boehm, 1991), risk-strategy model (e.g. McFarlan, 1981), and risk-strategy analysis (e.g. Davis, 1982). However, since the globalization of business and the fast pace of business growth have led to an increase in outsourcing and partnering among organizations, a focus on risk management today must address the problems of project complexity in which multiple organizations work collaboratively in pursuit of a common goal (Albert and Dorofee, 2009).

This multi-organizational development is done in a *distributed, or multi-enterprise, environment* where the management of a program, process, or technology is shared by people from multiple organizations (Albert and Dorofee, 2009). This flexibility has provided strategic opportunities. For example, information can be shared quickly and transparently among people who are in different countries, and organizations can quickly form partnerships to access new markets. However, along with new opportunities, comes with new risks. Information system development success in these distributed environments demands collaborative management and risk management collaboration among all participating groups (Albert and Dorofee 2009). Clearly, the tactical, bottom-up analysis of traditional risk management is not appropriate.

Systemic risk management is an alternative approach to manage risks in distributed environment developed by Software Engineering Institute (SEI) (Albert and Dorofee 2009). It is a driver-based approach starting at the top, with the identification of a project's key objectives. Once the key objectives are articulated, the next step is to identify a set of risks which influence the achievement of key objectives. Then this set of risks can be used for subsequent risk analysis. This study uses the systemic risk management approach to identify information system development risks in distributed environment from prior literature and then will test the impact of these risks on ISD success. In summary, this paper aims at answering the following two research questions:

1. *What are the critical risk factors of system development in distributed environment?*
2. *How can these risk factors impact the information system development outcomes?*

Although there are articles investigating the impact of software risk management, there is almost no research in distributed environments. This paper is organized as follows: *first*, literature of related areas was reviewed. *Second*, research model and hypotheses were described. *Third*, the design, method, and data collection procedures were discussed. *Finally*, the limitations and significance of contributions was discussed.

LITERATURE REVIEW

This article focuses on the risks during information systems development, including analysis, design, development, testing and maintenance of IS applications/systems to support organizational activities and functions (Barki et al., 1993).

There are different approaches or perspectives to study existing risks, although they share a common core. Boehm (1991) was concerned with managing the expected risk exposure, as defined by the relationship by minimizing the product of the probability of unsatisfactory outcome, and the loss to the parties affected if the outcome is unsatisfactory, P(UO)*L(UO). His (1991) definition has been widely cited by academic research (e.g. Barki et al.,1993, Lyytinen et al., 1998). Barki et al. (1993) expanded software development risk as a product of *project* uncertainty and magnitude of potential loss due to project failure. In this article, we adapted Barki et al. (1993)'s definition: i*nformation system development risk = (project uncertainty)*(magnitude of potential loss due to project failure).* That is, the focus is on the *project* and how those risks can be minimized.

Traditional Risk Management Approaches in Information System Development

Information system development is a complex process that must manage uncertainties from organizational factors, technological factors, and behavior factors. In addition, changes in the business environment complicate the process of eliciting business requirements, contributing to the risk of failure (Xia and Lee, 2005). Understanding and managing the risks involved in information systems development can help in reducing the incidence of system failure.

Risk management deals with the identification, assessment, prioritization and mitigation of risks to reduce negative outcomes (Lyytinen et al., 2004, Iversen et al., 2004). Lyytinen et al. (1998) identified, and Iversen et al. (2004) later enhanced, four classical risk management approaches, including McFarlan's risk portofolio approach, Davis's contingency approach, Boehm's software risk approach, and Alter's and Ginzberg's implementation approach. Risk-strategy model is a contingency model that relates aggregate risk items to aggregate resolution actions (McFarlan, 1981). Risk-strategy analysis is a stepwise process that links a detailed understanding of risks to an overall risk managmeent strategy (Davis, 1982). Risk-action list is a list of prioritized risk items with related resolution actions (Boehm, 1991). Risk list is a list of prioritized risk items (e.g. Barki et al., 1993). **Table 1** shows the strengths and weaknesses for each approaches.

Approach	Easy to use	Easy to build	Easy to modify	Risk appreciation	Risk resolution	Strategic oversight
Risk-list	+	+	+	+	-	-
Risk-action list	+	+	+	+	+	-
Risk-strategy model	+	-	-	+	+	+
Risk-strategy analysis	-	-	+	+	+	+

Table 1: Comparison of Four Risk Management Approaches (source: Iverson et al. , 2004)

Information System Development in Distributed Environment

Historically, the responsibilities for managing software programs have aligned along organizational boundaries, but with new dynamic relationships, there is a trend toward adopting boundary spanning approaches to risk management (Levina and Vaast, 2005). In a distributed program, management control is shared by the people who are usually come from different internal or external organizations (Alberts and Dorofee, 2009). This includes users, development teams, technologies, and processes from multiple locations with many viewpoints (Mudumba and Lee, 2010). Yet, firms need to collaborate cohesively to achieve overall optimization. **Figure 2** shows an example of system development in distributed environment.

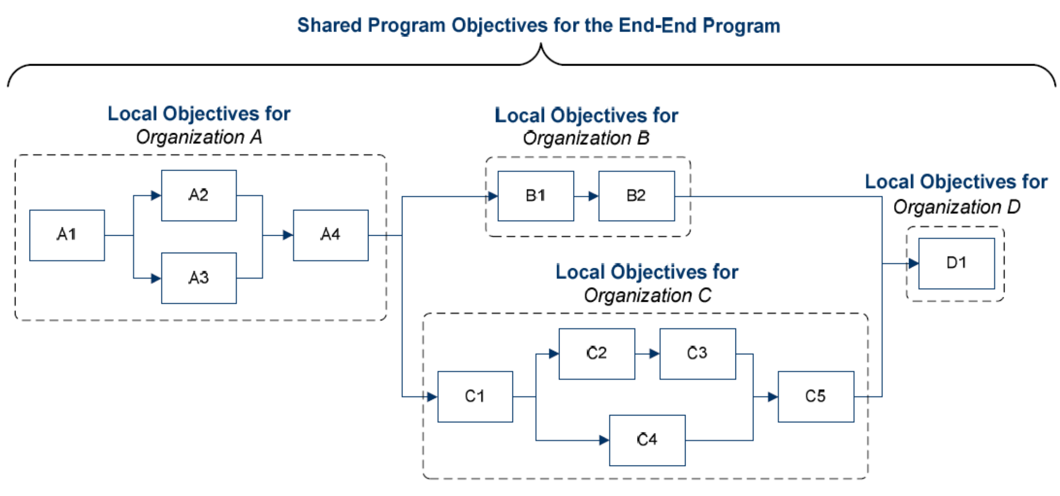

Figure 2: project spanning four organizations (Source: Alberts & Dorofee, 2009)

This simple example illustrates a large system that links four distinct sub-systems. Each group must adhere to the objectives of its parent organization, while also working collaboratively toward achieving a common set of overall objectives. This creates a virtual enterprise with its own unique mission that must be satisfied in spite of diverse components such as people, technologies, equipment, facilities, information, procedures, and work products (Alberts and Dorofee, 2009). These assets come from multiple organizations that are often geographically distributed, culturally diverse, and independently managed. Since management control is shared in multiple organizations, program planning, decision-making, and execution become complicated. In the distributed environment, decision makers must work collaboratively to strike a balance between achieveing their own objectives and the overall program objectives, which are often in conflict with each other. Therefore, the prevailing risk management paradigm needs to shift from traditional approaches such as those listed in Table 1 to those that employ a systemic focus.

Systemic Approach to Manage Risks in Distributed Environment

A Systemic Approach assumes a holistic view of key, shared, objectives by examing the aggregate effects of multiple conditions and events on those objectives (Alberts and Dorofee 2009). It starts at the top, with the identification of a project's key objectives, and the risks impacting those objectives, as shown in Figure 3.

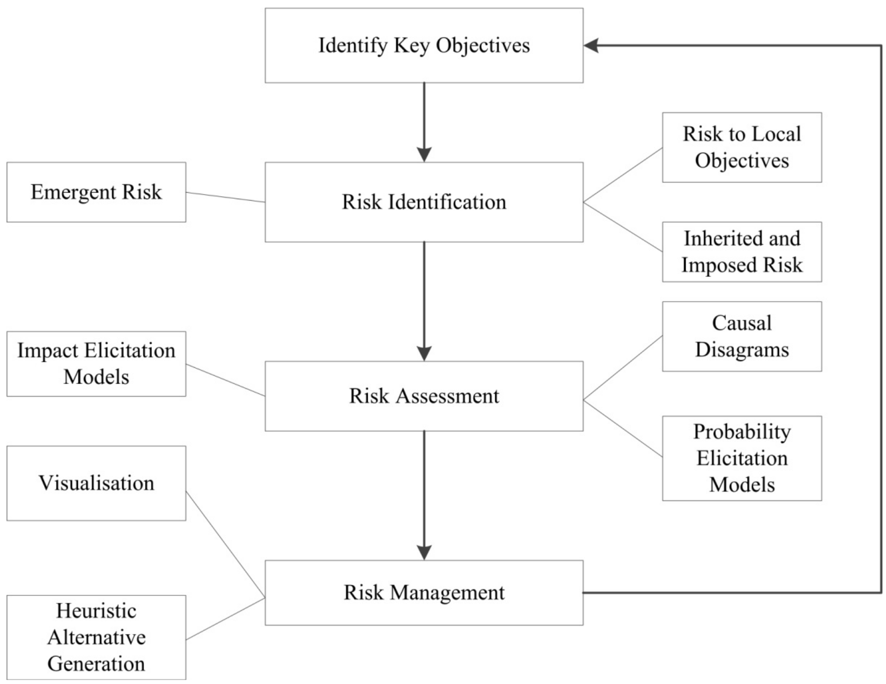

Figure 3: A Systemic Approach for Managing Risk in Distributed Environment
(Adapted from Powell and Klein (1996)and Alberts and Dorofee (2009))

Once the key objectives have been identified, risks can be determined. There are three types of risks exisiting in distributed ISD environment (Alberts and Dorofee, 2009). The simplest of the risks are local risks, which can impact each group's/organization's key objectives. The second type of risks are inherited from upstream activities or imposed because of required downstream activities. The third, and most complicated type of risks, are emergent risks, or those that arise from the interaction of groups/organizations in the distributed environment and are not observable or inherent in the groups/organizations separately. For example, Mudumba and Lee (2010) described seven categories of emergent risks are: (1) risks emergent from people-people interaction e.g. language barriers; (2) risks emergent from people-process interaction e.g. multi-task distribution and coordination; (3) risks emergent from people-technology interaction e.g. fear of multi-development platforms with different standards; (4) risks emergent from process-process interaction e.g. misalignment of business processes; (5) risks emergent from process-technology interaction e.g. task-technology misfit; (6) risks emergent from technology-technology interaction e.g. misalignment of IT strategies among distributed teams; and (7) risks emergent from internal environment and external environment interaction e.g. market positioning and time to market.

After identifying the risks, assessment of the seriousness of risks may be either qualitative or quantitative (Powell and Klein 1996). One standard quantitative risk assessment technique is to describe the magnitude of risk both in terms of a probability distribution, and the impact of risks on project success.

Therefore, this study uses the Systemic Approach depicted as above to identify key objectives and risk factors of ISD in distributed environment, and then will evaluate the impact of identified risks on the ISD success. Based on the results of impact model testing, this paper will eliminate factors that are not related to ISD success and refine the key objectives of ISD in distrubuted environment.

THEORY AND HYPOTHESES DEVELOPMENT

Key Objectives of ISD

An information system development project typically focuses on three key objectives: product, cost, and schedule (Alberts and Dorofee, 2009). These objectives specify what will be accomplished, how much it will cost, and when it will be finished, respectively. They can be operationalized to build a clearer picture of success. Harter, Krishnan, and Slaughter (2000) used the measures of product quality, cycle time, and development effort. Jiang, Klein, and Means (2000) measured outcomes in terms of team performance by adapting 6 items from Jones and Harrison (1996): staying within the budget, meeting time deadline, using technical expertise productively, working with other parts of organization well, achieving excellent results overall, and overall advantages of having teams. Lee and Xia (2010) used on-time completion, on-budget completion, and software functionality to measure software development performance. Sabherwal, Jeyeraj, and Chowa (2006), based on a comprehensive survey of prior literture, proposed 4 constructs representing IS success: system quality, perceived usefulness, user satisfaction, and system use. Ebert, Murthy, and Jha (2008) identified efficiency, presence, talent, and flexibility as key objectives of global software engineering. From these options, this study identified the key objectives of ISD in distributed environment as:

- Staying within the budget
- Meeting time deadline
- Meeting user requirements
- System integration with other systems when deployed
- Ease of use: barriers to adopt the system can be easily managed
- Operational support: the system is useful and can support operations effectively.

Risk Identification

Risk has been operationalized in a variety of ways in the literature. Jiang et al (2000) considered a traditional view by considering factors such as project size and complexity, top management support, team expertise, and user support. Tiwana and Keil (2006) considered functionality risk factors such as related technical knowledge, user involvement, requirement volatility, methodological fit and formal project management practices, as well as financial and political risk factors. Kayis et al (2007) considered similar technical factors as well as organizational risk factors (instabilities of management), communication issues, logistics, resources, and financial factors. Drake and Byrd (2006) looked at more conceptual risks, such as the stability of the development group, the culture and climate and strategic alignment between IS and the organization. Similarly Ebert et al (2008) considered efficiency, presence, talent and flexibility risks of the organization. Finally Mudumba and Lee (2010) separated the risks by people-related risks, process-related risks, technology-related risks and environmental risks. From these various operationalizations, we identified the following risks as influencing factors on ISD outcomes in distributed environement:

1. ***Objectives risk***: unrealistic or unachieveable objectives (product cost, schedule) (Kayis et al., 2007).
2. ***Preparation risk***: the plan and process for developing and deploying the system are insufficient (e.g. Mudumba and Lee, 2010).
3. ***Execution risk*:** risks in task execution, coordination, external interfaces, information management, technology, facilities and equipment (e.g. Jiang et al., 2000; Kayis et al., 2007).
4. ***Environment risk***: risks in organizaitonal conditions and compliance with relevant policies, laws, and regulations (e.g. Kayis et al., 2007; Tiwana and Keil, 2006).

The research model for this study is presented in Figure 4.

Research Model and Hypotheses

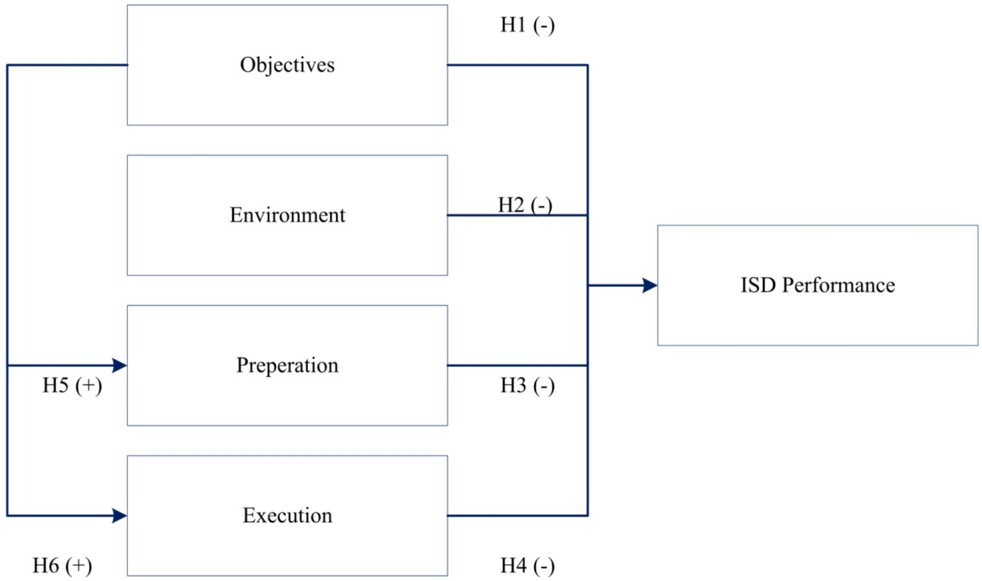

Figure 4: Research Model and Hypotheses

The literature on ISD has identified that unrealistic or unachievable objectives are negatively associated with project success (Kayis et al., 2007). Therefore, organizations need to align their technical, cost, and schedule objectives with their available resources. We hypothesize:

H1: The level of perceived objectives risk is negatively associated with information system development performance in distributed environment.

The construct of environment is defined as risks in organizational conditions, policies, laws, and regultions. Previous research has demonstrated a negative relationship between environmental risks and ISD performance (e.g. Tiwana and Keil 2006). Since ISD in distributed environment involves multi-organizations, multi-locations, or even multi-countires, the risks in environment are high. If an ISD project can not comply with all relevant policies, laws, and regulations, it may fail at the end. Thus, we hypothesize:

H2: The level of perceived environment risk is negatively associated with information system development performance in distributed environment.

Improving strategic planning within the realm of information system development is consistently identified by top management as a critical competitive issue (Segars and Grover, 1999). Poor planning is likely to be associated with inefficiencies in system development and, thus, lead to large budget and time variance (Liu, Wang, and Ma, 2011). Liu et al. (2011) empirically tested the effect of project planning and control on the process performance which was measured in terms of on time delivery and within budget. They found a significantly positive relationship between project planning and process performance. Therefore, risks in preparation can negatively affect ISD performance. We hypothesize:

H3: The level of perceived preparation risk is negatively associated with information system development performance in distributed environment.

The construct of execution integrates risks from multiple dimensions, including risks in task execution, coordination, information management, architecture, technology and etc. This approach is supported by previous research. For example, Jiang, Klein, and Ellis (2002) reduced the Barki et al. (1993)'s 11 multiple-item risk dimensions to a short form of risk measurement. They found that the dimensions are well integrated to a higher-order of overall risk, and risk is adversely related to project success. In addition, Janssen and Klievink (2012) found that architectures can be considered as an organizational shaping routine to reduce project failure. Thus, we hypothesize:

H4: The level of perceived execution risk is negatively associated with information system development performance in distributed environment.

In addition, this study will test the relationships among risk factors. Risk in objectives has been recognized as influencing factor on preparation risk and execution risk (Alberts and Dorofee, 2009). Unrealistic objectives can lead to insufficient planning and control of ISD, as well as lack of resources and capabilities to execute the project. Therefore, we also hypothesize:

H5: The level of perceived objective risk is positively associated with the level of perceived preparation risk.
H6: The level of perceived objective risk is positively associated with the level of perceived execution risk.

RESEARCH DESIGN AND DATA COLLECTION

Measurement of Variables

Each independent variable in the research model will be measured using a 5-point scale to indicate the probability of occurrence, and a 7-point scale to indicate its impact on the failure of ISD project. The risk score will be calculated by the formula of risk=probability*impact. Measurement items of ISD project outcomes are adapted from Liu et al. (2011). The survey questionnaire is shown in Appendix A.

Pilot Test

To ensure the survey instruments arecomprehensible, we will invite at least 50 MBA students who have experience of ISD in distributed environemnt to attempt the survey, and to provide comments on the questions. If they have any difficulty in comprehending the survey questions, we will ask them to point out the questions/phases they have difficulty with. Based on their feedback, we will revise or reword the survey questions. Then discuss the changes with the participatns again. If they can understand the survey questions after the changes, we will publish the survey online to collect data. The target number of usable sample is over 300 persons.

Subjects

This study focuses on the risk management in distributed environment. Therefore, the participants we are looking for are project managers who have experiences in distributed program. One reasonable source is memebers of the Project Managent Institute. We can put advertisment on the website (http://www.pmi-issig.org/) and invite project managers who have experience to participant in the survey. Another potential source of subjects is from members of International Association of Outsourcing Practitioners (IAOP). Members at IAOP are outsourcing clients and providers. The survey will be online survey because we may have participants outside US. Another option would be alumni or members of the IS Department's Advisory Board at a US midwest university.

Data Collection

IAOP has a research committee to support research with IAOP. The research committee has a meeting to determine supported projects periodically. A project supported by IAOP can have access to collect data from its members. IAOP is a global community of more than 120,000 members and affiliates worldwide. We will submit our proposal to IAOP to gain access to its members. Another data source is the members of Project Managent Institute. The online survey will last for four weeks.

DATA ANALYSIS

Factor analysis and structural equation modeling will be used to analyze data. First, the risk measurement items will be assessed via exploratory factor analyses (EFA) and confimatory factor analyses (CFA). Scale reliability and validity will also be assessed because risk scales in distributed environment have not been empirically tested. We will first perform principal components factor analysis (PCA). PCA is a data analysis technique to reduce the number of variables into fewer components, while retaining as much of the variation as possible (Jiang et al., 2000). A factor weight of 0.50 is the minimum cutoff value. We will also drop any item exhibiting cross-loading (the highest loading required to surpass the second highest by 0.30). Then the retaining items will be assessed by CFA using LISREL 8.3(Jöreskog and Sörbom, 1996). CFA can reveal if our measurement model has a good overall fit. Several methods can be applied to assess the convergent and discriminant validity. Convergent validity can be assessed by reviewing the t-tests for the factor loadings (Anderson and Gerbing, 1988). Discriminant validity can also be confirmed using the procedure Anderson and Gerbing (1988) recommended.

After confirming the total measurement model, the research model shown in Figure 2 can be estimated using LISREL.

LIMITATIONS

One limitation of this study is the self-reported data. Self-reported data provides a measure of perception about, not the actual variable itself, and thus introducing possible bias. Another potential limitation is the instrument. The instrument used in the survey is fosucing on high construct level. For example, program objective has three sub-constructs: cost, schedule, and functionality. It might be better to sperate them into three sub-constructs. One method to improve data validity is to use object data such stock-price, general accounting information to supplement self-report data.

SIGNIFICANCE OF THE STUDY

Risk management in distributed environment has received little attention in information system research. As the development of new technology, outsourcing, and colloboration activities in organizations, it is very important to investigate risks of information systems development in distributed environment. Second, this study tries to put information system research in practitioner's shoes. It uses instruments recently developed by SEI to investigate the relationships. Third, this study will examine the impacts of objective risks, environment risks, preparation risks, and execution risks on the ISD performance. This can provide insights for practitioners to adjust their risk management strategies.

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APPENDIX A: SUVERY QUESTIONNAIRE

Instructions: Please based on **One Project** you have completed in distributed environemnt to answer following questions.

I. Demorgraphics Questions:

1. Which industry are you in?
2. How many employees are in your organization?
3. How many employees are in your IT department?
4. How many projects have you done in distributed environment?
5. How many organizations were in this project?
6. How long have you been working in information system development?

II. Risk Factors: the first column is the risk statement may occur during information system development. The **Probability** column measures the probabilities that this risk occurred in your project. 1=less than 5% chance of occurrence, 2=around 25% chance of occurrence, 3=around 50% chance of occurrence, 4=around 75% chance of occurrence, 5=more than 95% chance of occurrence. The **Impact** column is measuring the loss of risk occurrence. 1=almost no loss, 7=significant loss.

Risk Statement	Probability					Impact						
Objective Risks												
Item 1. The project objectives (product, cost, schedule) were not realistic and achievable. Consider: alignment of technical, cost, and schedule objectives; inherent technical risk; technology maturity; resource variable.	1	2	3	4	5	1	2	3	4	5	6	7
Preparation Risk												
Item 1. The plan for developing and deploying the system was insufficient. Consider: acquisition or development strategy, program plan; resources; funding; schedule; roles and responsibilities	1	2	3	4	5	1	2	3	4	5	6	7
Item 2. The process being used to develop and deploy the system was insufficient Consider: process design; measurements and controls; process efficiency and effectiveness; acquisition and develop life cycles; training	1	2	3	4	5	1	2	3	4	5	6	7
Execution Risk												
Item 1. Tasks and activities performed were not effectively and efficiently. Consider: experience and expertise of management and staff; staff levels; experience with the acquisition and development life cycles.	1	2	3	4	5	1	2	3	4	5	6	7
Item 2. Activities within each team and across teams were not coordinated appropriately. Consider: communication; information sharing; dependencies; relationships; partners and collaborators	1	2	3	4	5	1	2	3	4	5	6	7
Item 3. Work products from suppliers, partners, or	1	2	3	4	5	1	2	3	4	5	6	7

collaborators didn't meet the quality and timeliness requirements. Consider: applications; software; systems or sub-systems; hardware												
Item 4. The project's information wasn't managed appropriately. Consider: usability, confidentiality; integrity; availability	1	2	3	4	5	1	2	3	4	5	6	7
Item 5. The project team didn't have the tools and technologies it needs to develop the system and transition it to operations. Consider: software applications; infrastructure; systems; database	1	2	3	4	5	1	2	3	4	5	6	7
Item 6. Facilities and equipment sufficient were not sufficient to support the project. Consider: building; physical work spaces; support equipment; supplies; other resources	1	2	3	4	5	1	2	3	4	5	6	7

Environment Risk

Item 1. Enterprise, organizational, and political conditions didn't facilitate completion of project activities. Consider: stakeholder sponsorship; actions of upper management; effect of laws, regulations, and policies	1	2	3	4	5	1	2	3	4	5	6	7
Item 2. The project didn't comply with all relevant policies, laws, and regulations. Consider: policies; laws; regulations; standards of care	1	2	3	4	5	1	2	3	4	5	6	7

III. ISD Project Performance: indicate the degree to which you agree with the following. 7=strongly agree, 5=moderately agree, 1=strongly disagree.

1. The project was completed within budget.	1	2	3	4	5	6	7
2. The project was completed within schedule.	1	2	3	4	5	6	7
3. The system met user's intended functional requirements.	1	2	3	4	5	6	7
4. The sytem was integrated well with other systems when deployed.	1	2	3	4	5	6	7
5. The system efficiently supportted operations.	1	2	3	4	5	6	7
6. The system was easy to use.	1	2	3	4	5	6	7
7. The overall quality of the developed system was high.	1	2	3	4	5	6	7