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Prediction of IS Project Escalation Based on Software Development Risk Management

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Abstract. Information system project failure is described as a common phenomenon. Escalation occurs when there are continued commitments for a troubled project and has been observed as one pattern of failure. The main purpose of this research was to investigate whether software development risks were the factors to discriminate between escalated projects and non-escalated projects. Thirty critical risks were selected and classified into nine risk categories under three dimensions such as product, people, and process. Probability and loss in each nine risk category were measured on the basis of 247 survey cases from IS professionals. The results show that the risk probability in the people dimension and the process dimension with management aspects was more important to predict escalation than the risk loss in those dimensions and the risk impact in the product dimension with technical aspects. The results imply that managerial factors are more critical than technical factors in predicting IS development project escalation. Additionally, it was noticed that the CMM level of an organisation was very significant to predict successful projects.

Keywords: Information system development project; risk; project escalation.

1. Introduction

Information system (IS) project failure is described as a common phenomenon by both academic researchers and industrial practitioners, and many researchers have studied actively about success/failure factors of IS project, IS project management and IS itself. The definitions of the terms such as IS project, IS project management and IS are slightly different, but there are common factors which are cost, time and quality to affect the success/failure critically.

Escalation occurs when there are continued commitments for a troubled project. Escalation has been observed as one pattern of failure (Keil, 1995). Various theories explain escalation phenomenon in social science. Self-justification theory, prospect theory, agency theory and approach avoidance theory are representative of escalation theory. In these theories, psychological self-justification, social self-justification, sunk cost effect, goal incongruency, information asymmetry and completion effect are considered. These theories focus on the escalation behaviour. Recently, researchers have studied IS project escalation. According to Keil and Mann, escalation occurs in 30–40% of IS projects, and the escalated projects have more significant problems than non-escalated projects have (Keil and Mann, 2000). In addition, it is proposed that factors of project management could predict escalation in IS development project (Keil *et al.*, 2003; Zhang *et al.*, 2003).

Many IS researchers have studied individual IS project risk identification as a major source of IS development problem and IS success as impacted by risks. The purpose of this research was to discriminate between escalated projects and non-escalated projects in IS development using risk measures. First, critical risks in IS development projects were selected from previous IS literatures and classified into multiple risk categories. Then, risk in each category was measured respectively and the measures were used to predict escalation. This research was based on 247 survey cases from IS experts in Korea.

The rest of the paper is organised as follows: The background section gives a brief review of the literature

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on escalation and software development risk, research methodology section describes research design and data collection followed by analysis and results, and finally, results and limitations of this research are discussed in the conclusion section.

2. Background

2.1. *Escalation*

Escalation behaviour occurs in individual and group decision-making situations when people continue investing time, money and other valuable resources into a failing course of action despite negative feedback information (Staw, 1976). This phenomenon has been called entrapment (Fox and Staw, 1979) or sunk cost effect (Arkes and Blumer, 1985).

Staw and Ross (1989) described four forces such as project forces, organisational forces, social forces and psychological forces, and proposed three-stage escalation model. The four forces determine decisions to persist with failing projects of escalation behaviour. In the first phase of the three-stage escalation model, project forces initiate an individual/group decision to pursue the project and in the second phase, negative project results influence social forces and psychological forces to persist with the project. In the third phase, more negative project results such as sunk costs activate social, psychological and organisational forces pressuring the individuals to continue their escalation of committed resources to the project (Staw and Ross, 1989).

Several different theories have been proposed to explain the escalation behaviour including self-justification theory, prospect theory, agency theory and approach avoidance theory in the escalation literatures. First, self-justification theory explains that individuals seek to rationalise their previous behaviour against a perceived error in judgment (Staw and Fox, 1977). Second, prospect theory suggests that individuals exhibit risk seeking behaviour in choosing between two negative alternatives (Kahneman and Tversky, 1979; Tversky and Kahneman, 1981; Whyte, 1986). Sunk costs may influence decision makers to adopt a negative frame, thereby prompting risk seeking behaviour which can be observed as escalating commitment to a failing course of action (Whyte, 1986). Third, under agency theory, goal incongruency between principal and agent can create a situation in which the agent acts to maximise his or her own utility rather than acting in the best interests of the principal, and the agency problem that promotes escalation behaviour will exist within organisations because the principal cannot observe with certainty the actions and work effort of the agent (Baiman, 1990; Harrison and Harrel, 1993; Tuttle *et al.*, 1997). Finally, under approach avoidance theory, escalation is conceptualised as a behaviour that occurs when driving forces that encourage persistence seem to outweigh restraining forces that encourage abandonment (Brockner and Rubin, 1985).

Several researchers have applied the concept of escalation to the domain of software project management (Keil *et al.*, 1995; Drummand, 1996; Newman and Sabherwal, 1996). Escalation has been defined as continued commitment in the face of negative information about prior resource allocations coupled with uncertainty surrounding the likelihood of goal attainment. In the context of software project escalation, negative project status refers to significant performance problems in one or more the following areas: cost, schedule, functionality or quality (Brockner, 1992). Project escalation can be said to occur when there is continued commitment and negative information. The escalation theories provide a promising base for explaining IT failure (Keil, 1995). Keil and Mann suggested that from 30–40% of all IS projects exhibit some degree of escalation. Escalated projects had project outcomes that were significantly worse in terms of perceived implementation performance and perceived budget/schedule performance, as compared to project that did not escalate (Keil and Mann, 2000). In addition, it was proposed that project management factors in IS projects could discriminate between escalated project and non-escalated one (Keil *et al.*, 2003; Zhang *et al.*, 2003).

2.2. *Risk*

Previous IS risk studies can be categorised in terms of risk definition, risk factor identification and categorisation and risk management model or approach. The dictionary definition of risk is the possibility of loss or injury. Sometimes risk can be called risk impact or risk exposure. With reference to software risk management, Boehm (1991) defines risk impact or risk exposure as:

$$\mathrm{RE} = \mathrm{P(UO)} * \mathrm{L(UO)}$$

where RE is the risk exposure, P(UO) is the probability of an unsatisfactory outcome and L(UO) is the loss to the parties affected if the outcome is unsatisfactory. Barki *et al.* (1993) defines software development project risk by referring to the uncertainty surrounding a project and the magnitude of potential loss associated with project failure:

$$\begin{aligned}&\text{Software development risk}\\&\quad = (\text{project uncertainty}) * (\text{magnitude or potential}\\&\qquad \text{loss due to project failure})\end{aligned}$$

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Table 1. Examples of major software development risks.

Boehm (1991) Top 10 software risk items	SEI (1996) Major risk elements
Personnel shortfalls	Product engineering
Unrealistic schedules and budgets	Requirement
Developing the wrong functions and properties	Design
Developing the wrong user interface	Development environment
Gold plating	Management process
Continuing stream of requirements changes	Development system
Shortfalls in externally furnished components	Program constraints
Shortfalls in externally performed tasks	Resource
Real-time performance shortfalls	Customer
Straining computer-science capabilities	
Conrow and Shishido (1997) Key risk issues	**Kansala (1997) Top 15 software risk items**
Excessive, immature, unrealistic or unstable requirements	Volatility of requirements
Lack of user involvement	Availability of key staff
Underestimation of project complexity	Dependence of key staff
Performance shortfalls	Interfaces to other systems
Unrealistic cost of schedule estimates	Unnecessary features (gold plating)
Ineffective project management	Commitment of customer
Ineffective integration, assembly and test, quality control and so on	Capability of contract person
Unanticipated user interface difficulties	Analysis skills of staff
Immature or untried design, processes or technologies	Delivery reliability of subprojects
Inadequate work plans or configuration control	Complexity of functional model
Inappropriate methods or tool selection or inaccurate metrics	Commitment of staff
Poor training	Logical complexity of software
Inadequate or excessive documentation	Maintainability of software
Legal or contractual issues	Availability of project manager
Obsolescence	Complexity of data model
Unanticipated difficulties and subcontracted items	

Software Engineering Institute (SEI, 1993) designed taxonomy-based questionnaire and organised software development risks into three levels such as class, element and attribute. Most of other studies show empirical identification of the risks. Large number of risks have been discussed in IS literatures. Table 1 illustrates major software risks and Table 2 summarises categorisation of software development risks in previous literature.

The practice of software risk management involves two primary steps each with three subsidiary steps. The first primary step, risk assessment, involves risk identification, risk analysis and risk prioritisation. The second primary step, risk control, includes risk management planning, risk resolution and risk monitoring (Boehm, 1991). The SEI risk management paradigm is represented as a circle to emphasise that risk management is a continuous process. This risk management paradigm consists of six activities: identity, analyse, plan, track, control and communicate (SEI, 1993).

Linkage between software risks and other issues (e.g., system success, project effectiveness and decision-making to continue a project) have been explored. IS success (e.g., development process satisfaction, customer satisfaction, system quality satisfaction and impact of the system on the organisation) are related to different risk factors (Jiang *et al.*, 1999, 2001), and risks have a significant impact on project effectiveness (Jiang and Klein, 2000). Keil explored the relative influence of risk perception and risk propensity on the decision of whether or not to continue a software development project (Keil, 2000).

3. Research Design and Methodology

3.1. *Research design*

Figure 1 displays research design. Probability of unsatisfactory outcome and loss if the outcome is unsatisfied in each risk category were main variables to discriminate

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Table 2. Summary of software development risk category in IS literature.

Source	Risk grouping
Barki *et al.* (1993): Empirically identified	Technical newness, application size, expertise, application complexity, organisational environment
SEI (1993): Class-element-attribute structured	Product engineering, development environment, program constraints
Conrow and Shishido (1997): Based on correlations	Project level, project attributes, management, engineering, work environment, others
Kansala (1997): Based on previous studies	Client, contract, developer, project, project team, key person of team, initial baseline of project, deliverables of project, quality of project
Madachy (1997): Aligned with cost attribute of COCOMO	Schedule, product, platform, process, reuse
Ropponen and Lyytinen (2000): Empirically defined	Scheduling and timing, system functionality, subcontracting, requirement management, resource usage and performance, personnel management
Jiang *et al.* (2001): Empirically defined	Technological acquisitions, application size, team application expertise, user support, clarity of role definitions, user experiences
Wallace *et al.* (2004): Empirically defined	User, team, requirement, planning and control, complexity, organisational environment

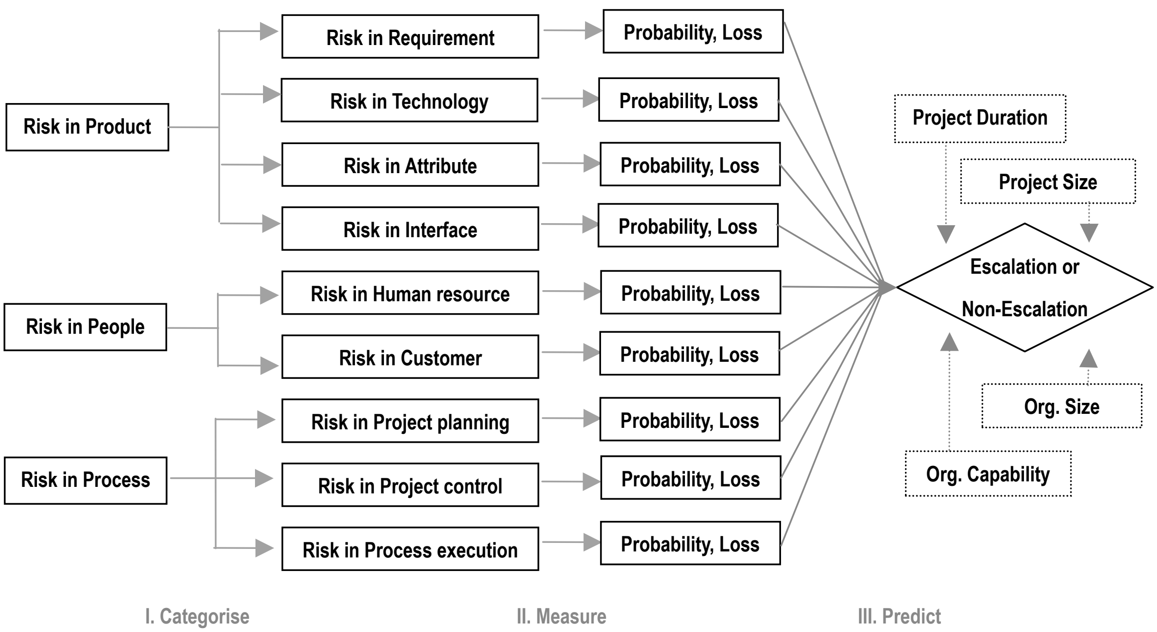

Fig. 1. Research design.

escalated projects and non-escalated projects in this research. Major 30 risk items extracted from IS literatures were grouped into three dimensions such as people, product and process and then categorised into multiple categories in each dimension.

Many researchers have studied identifications of software development risks, which are more than 100 in an IS development project. Several researchers suggested top risks which need more attention in IS development projects. We gathered these major risks from previous literatures and selected 30 risk items as critical risks.

Risk occurrence as an event can be focused on one of the three dimensions: product as an object of an event, people as a subject of an event and process as a group of activities related to an event. We used the three dimensions to group risk items. The 30 risk items were classified into three dimensions and then the three dimensions were divided into multiple risk categories. The product dimension has technical aspects and includes several risk categories related to system development such as requirement, system attribute, external or user interface and technology. Customer and human resources belong to the people

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Table 3. Categorisation of major software development risks.

Dimension	Category	Items	Source
Product	Requirement	Incomplete requirement	Conrow and Shishido (1997)
		Volatility of requirement	Boehm (1991), Kansala (1997)
		Unnecessary requirement	Boehm (1991), SEI (1996), Kansala (1997)
	Technology	Technology newness	Barki *et al.* (1993)
	Attribute	High complexity of DB/function model	Barki *et al.* (1993), Kansala (1997), Madachy (1997)
		Wrong function	Boehm (1991)
		Low performance (e.g., throughput, response time and recovery time)	Boehm (1991), SEI (1996), Conrow and Shishido (1997)
	Interface	Shortfalls in Interface to other systems	Boehm (1991)
		Shortfalls in external systems	Boehm (1991)
		Unanticipated user interface difficulties	Conrow and Shishido (1997)
		Wong user interface	Boehm (1991)
People	Human resource	Personnel shortfalls	Boehm (1991), Barki *et al.* (1993), SEI (1996), Madachy (1997)
		Poor training	SEI (1996), Conrow and Shishido (1997)
		Poor communication	Barki *et al.* (1993), SEI (1996)
		Ineffective project organisation	Barki *et al.* (1993), SEI (1996)
		Availability of key staff/project manager	Barki *et al.* (1993), SEI (1996), Kansala (1997)
		Dependence on key staff	Kansala (1997)
		Low commitment of staff	Conrow and Shishido (1997), Kansala (1997)
	Customer	Internal conflicts related to the project issues	SEI (1996)
		Disagreement with customer	SEI (1996)
		Low commitment of customer	Kansala (1997)
Process	Project planning	Underestimation of project complexity	Conrow and Shishido (1997), SEI (1996)
		Unrealistic schedule and budget	Boehm (1991), SEI (1996), Conrow and Shishido (1997), Madachy (1997)
		Inadequate work plans or WBS	Conrow and Shishido (1997)
		Inappropriate methods or tool selection	Conrow and Shishido (1997)
	Project control	Ineffective project control	Conrow and Shishido (1997), SEI (1996)
	Process execution	Undefined process	SEI (1996)
		Not following due to inadequate process	Conrow and Shishido (1997)

dimension. In the process dimension, there are project planning, project control and process execution. In summary, we had the three dimensions, the nine categories and the thirty risk items under three-level categorisation structure of the major software development risks. Table 3 presents the hierarchy.

Additionally, project duration, project size, organisation size and IS development capability as exogenous parameters were used to predict escalation. The average number of project members and the number of organisation employees were measured as proxy variables of the project size and the organisation size respectively. The CMM (Capability Maturity Model) level was used as a proxy variable of the organisation's IS development capability.

3.2. *Data collection*

For this study, 346 cases were collected from IS experts in Korea during June 2005. Survey questionnaire consisted of four parts such as personnel information, project information, organisation information and risk measurement.

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Questions in the project information and the risk measurement were about a respondent's latest involved IS project. In order to classify the cases into two groups such as escalation and non-escalation, we operationally defined "escalated project" as a project not finished within budget on schedule and continued to provide resources for example time and human resources and "non-escalated project" as a project completed within budget on schedule. According to these definitions, 112 escalated projects and 135 non-escalated projects were extracted from the total 346 cases while the rest 99 cases were not satisfied with the classification conditions. A summary of the demographic characteristics of the 247 cases is presented in Table 4.

The respondents work at the one of 57 companies of which main business area is system development service providing. The profiles of the respondents show that the average age of respondents is 35 years with the average 9.6 years of job experiences in system development. About half of them work in project management, and the rest in system development as a major role. The profiles of the respondents' latest involved information system development projects represent that the average project duration is about 13 months, and that the average number of project members is 38.6. About half of the respondents belong to companies with more than 1000 employees. In addition, organisations' CMM levels of more than half of the respondents were higher than level 2 when they worked at the latest project according to the survey.

3.3. *Data reliability*

In this research, probability and loss in each nine risk category were basically used as project escalation discriminators. The probability of unsatisfied outcome in each risk category was the average probability of multiple risk items which were classified into the same risk category. The loss due to the unsatisfied outcome in each risk category was measured with the same way to probability. Respective probability and loss in each risk item had five-point Likert scale from very low (1) to very high (5). Cronbach's alpha was calculated to assess measurement reliability of the categorisation. Table 5 shows that all alpha values are acceptable implying an adequate level of internal consistency.

4. Analysis and Results

Among nine probability variables and nine loss variables of risk categories there were significant correlations as results of correlation analysis. Multicollinearity refers to the correlation among three or more independent variables. The impact of multicollinearity is to reduce any

Table 4. Sample demographics.

Personnel		Project		Organisation	
Age (mean)	35.7	*Duration (mean)*	13.1	*No. of employees*	
Under 30 years old	92	Under 6 months	73	Under 100	81
31–40 years old	178	7–12 months	104	100–500	30
41–50 years old	33	13–18 months	33	500–1000	8
51 years or above	3	19–24 months	20	1000 or above	128
		25 or above	17		
IS work experience	9.6	*Averge no. of members*	38.6	*CMM level*	
(mean)	22	*(mean)*	110	Level 0 or 1	107
Under 4 years	114	Under 15 members	54	Level 2	18
5–9 years	70	16–30 members	23	Level 3	80
10–14 years	25	31–45 members	60	Level 4	15
15–19 years	12	46 or above		Level 5	17
20 years or above					
Position		*Escalated*	112	*No. of organisations*	57
Project management	120	*Non-escalated*	135		
PM	41				
PMO	19				
PL	44				
Others	16				
Development	114				
Architect	22				
Analyst	36				
Developer	46				
Others	10				
Others	13				

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Table 5. IS Project risk measures.

Product ($\alpha = 0.802$, 0.861)	People ($\alpha = 0.876$, 0.903)	Process ($\alpha = 0.845$, 0.859)
Requirement ($\alpha = 0.695$, 0.752)	*Human resource* ($\alpha = 0.839$, 0.873)	*Project planning* ($\alpha = 0.815$, 0.821)
Incomplete requirement	Personnel shortfalls	Underestimation of project complexity
Volatility of requirement	Poor training	Unrealistic schedule/budget
Unnecessary requirement	Non-active communication	Inadequate work plan/WBS
Technology	Ineffective project organisation	Inappropriate methods or tool selection
Technology newness	Availability of key staff/PM	*Project control*
Attribute ($\alpha = 0.622$, 0.735)	Dependence on key staff	Ineffective project control
High complexity of model	Low commitment of staff	*Process execution* ($\alpha = 0.719$, 0.735)
Wrong function	*Customer* ($\alpha = 0.755$, 0.800)	Undefined process
Low performance (i.e., throughput, response time, recovery time)	Internal conflicts related to project issues	Not following process due to inadequate process
Interface ($\alpha = 0.690$, 0.764)	Disagreement with customer Low commitment of customer	
Shortfalls in interface to other systems		
Shortfalls in external systems		
Unanticipated user interface difficulties		
Wong user interface		

(Cronbach's alpha $\alpha =$ for "probability of unsatisfied outcome", for "effected loss" in a risk category)

single independent variable's predictive power (Hair *et al.*, 1998) and to make several signs of estimates opposite to expected ones. In order to prevent the impact of the multicollinearity of the variable, factor analysis was performed with nine probability variables and nine loss variables of risk categories. Factor analysis provides direct insight into the interrelations among variable and empirical support for addressing conceptual issues relating to the underlying structure of the data (Hair *et al.*, 1998). Principal component extraction and varimax rotation method was used in the factor analysis. The value of each 18 variable's communality (i.e., total amount of variance an original variable shares with all other variables included in this analysis) from 0.647 to 0.814 implies sufficient explanation of the variance by the factor solution for each variable. Table 6 presents the summary of the factor analysis. From the results of this analysis, we obtained five risk components such as loss of risk in management, probability of risk in management, impact of risk in requirement, impact of risk in technology and impact of risk in system. The five components explained 73% of total variance.

Component 1 accounted for 42.6% of the total variance. Five variables such as human resource-loss, customer-loss, project planning-loss, project control-loss and process execution-loss represented the significant loadings of this component. It was composed of risk loss in the people dimension and the process dimension. Component 2 explained 8.9% of the total variance. Five variables such as human resource-probability, customer-probability, project planning-probability, project control-probability and process execution-probability showed the significant loadings of the second component. It consisted of risk probability in the people dimension and the process dimension. Components 1 and 2 can be named as risk loss in management and risk probability in management. Components 3–5 accounted for 7.6%, 7.1%, and 6.3% of the total variance respectively. Different from components 1 and 2, components 3–5 consisted of one or two pairs of probability and loss in one or two risk categories. Probability and loss in requirement risk category represented significant loadings of component 3 and probability and loss in technology risk category indicated significant loading of component 4. Probability and loss in attribute risk category and interface risk category exhibited significant loadings of component 5. Risk, risk impact or risk exposure expresses both probability of unsatisfied outcome and effected loss under the definition of risk by Boehm (1991). Therefore, components 3–5 can be named as risk impact in requirement, risk impact in technology and risk impact in system respectively.

Logistic regression is the principal technique in this research. This method of logistic regression was chosen because it has widespread application in situations in which the primary objective is to identify and to predict the group to which an object belongs. When the dependent variable has only two groups, logistic regression may be preferred (Hair *et al.*, 1998).

Let Y be a binary dependent variable, in this case $Y = 1$ if the project is escalated, and $Y = 0$ if the project is non-escalated. Suppose X is a vector of independent

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Table 6. Results of factor analysis.

Components	Risk loss in management (1)	Risk probability in management (2)	Risk impact in requirement (3)	Risk impact in technology (4)	Risk impact in system (5)
Human resource-loss	**0.795**	0.337	0.098	0.058	0.209
Customer-loss	**0.745**	0.199	0.272	0.104	0.182
Project planning-loss	**0.761**	0.311	0.165	0.157	0.064
Project control-loss	**0.581**	0.208	0.368	0.416	−0.209
Process execution-loss	**0.721**	0.328	−0.067	−0.010	0.124
Human resource-probability	0.296	**0.739**	0.143	0.058	0.305
Customer-probability	0.190	**0.692**	0.277	0.085	0.229
Project planning-probability	0.238	**0.733**	0.233	0.093	0.067
Project control-probability	0.165	**0.619**	0.246	0.456	−0.291
Process execution-probability	0.270	**0.745**	−0.071	0.089	0.093
Requirement-probability	−0.002	0.272	**0.843**	0.004	0.172
Requirement-loss	0.377	0.081	**0.788**	0.070	0.076
Technology-probability	−0.047	0.200	−0.013	**0.815**	0.211
Technology-loss	0.374	0.021	0.058	**0.750**	0.229
Attribute-probability	0.206	0.252	0.356	0.340	**0.542**
Attribute-loss	0.560	0.000	0.272	0.276	**0.475**
Interface-probability	0.096	0.495	0.080	0.195	**0.690**
Interface-loss	0.557	0.079	0.084	0.160	**0.639**
Percent of variance	42.6%	8.9%	7.6%	7.1%	6.3%

*Extraction method: Principal component analysis.

**Rotation method: Varimax with Kaiser normalisation.

***Value in bold is the highest loading for each variable (except "Attribute-loss").

Table 7. Selected variable from backward elimination logistic regression with five risk components and four exogenous variables.

Selected variables	B	SE	Wald	d.f.	Sig.	Exp(B)
CMM level	−0.304	0.106	8.212	1	**0.004**	0.738
Component 2 — Risk probability in management	0.390	0.143	7.434	1	**0.006**	1.477
Component 3 — Risk impact in requirement	0.228	0.137	2.747	1	0.097	1.256
Component 4 — Risk impact in technology	0.252	0.136	3.448	1	0.063	1.287
Intercept	0.429	0.254	2.845	1	0.092	1.535

variables, in this case the five risk components as the results of factor analysis and four exogenous variables such as project duration, average number of project members, number of organisation employees and CMM level of organisation, the logistic regression model relates the response probability to the explanatory variables in the following explicit form:

$$P(Y = 1|X) = \frac{1}{1 + \exp(\alpha + \beta' X)}$$

where α is a intercept constant and β is the vector of coefficients to predictor variables. This equation shows the probability that a subject in the interested group, in this case escalation group, is a logistic function of the predictor variables. This equation can be expressed as the following logit form:

$$\log\left(\frac{p}{1-p}\right) = \alpha + \beta' X$$

With the created five risk components and the four exogenous variables, backward elimination logistic regression was performed. Table 7 displays the selected variable at the final step of the backward elimination logistic regression. CMM level, component 2 — probability of risk in management, component 3 — risk in requirement, component 4 — risk in technology and intercept constant were selected at the final step of the backward elimination logistic regression. Among the finally selected parameters, CMM level and probability of risk in management were very significant to predict escalation

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Table 8. Descriptive statistics of escalation group and non-escalation group.

Independent variables	Dependent variable	Escalation group("1") Mean ($n = 112$)	Non-escalation group("0") Mean ($n = 134$)
Project	Duration (months)	13.22	13.05
	Average no. of members	45.94	32.56
Organisation	No. of employee (very small:1–large:4)	2.53	2.92
	CMM level (1–5)	1.83	2.37
Risk measures	(very low: (1)–very high: (5))		
Product	Requirement-probability	3.46	3.33
	Requirement-loss	3.63	3.33
	Technology-probability	2.81	2.70
	Technology-loss	3.15	2.96
	Attribute-probability	2.86	2.72
	Attribute-loss	2.98	2.87
	Interface-probability	2.86	2.59
	Interface-loss	2.86	2.78
People	Human resource-probability	2.87	2.64
	Human resource-loss	3.20	2.97
	Customer-probability	2.93	2.69
	Customer-loss	3.21	3.13
Process	Project planning-probability	3.14	2.79
	Project planning-loss	3.37	3.22
	Project control-probability	3.27	2.66
	Project control-loss	3.43	2.93
	Process execution-probability	2.72	2.44
	Process execution-loss	2.83	2.80

(i.e., $p < 0.004$ for CMM level and $p < 0.006$ for component 2 — probability of risk in management). In addition, Table 8 gives descriptive statistics of escalation group and non-escalation group, showing the differences between two groups.

5. Conclusions

Before discussing the results of our work, it is appropriate to mention its limitations. This research relied on IS development professionals and focused on risks as project forces to initiate project escalation. Loss of risk as predictor variable was measured as a quality variable not a quantity variable such as cost, risk, risk impact or risk exposure is defined the product of probability and loss (Boehm, 1991). In this research, however, we considered risk components reflecting probability and loss as results of factor analysis risk impact, instead of the product of probability and loss.

In this research, 30 major software development risks were used. On the basis of the risks, categorisation hierarchy was suggested and escalation group and non-escalation group was explained. In IS projects, hundreds of risks exists. The applicability of the categorisation structure and prediction of escalation proposed need validation using all software development risks. However, the 30 risks based on this research are very critical and referred frequently in IS literatures. Therefore, the results of this study would be acceptable by practitioners and researchers.

The main objective of this research was to investigate whether software development risks were the factors to discriminate between escalated projects and non-escalated projects. Risk occurrence probability and degree of loss in each nine risk category were measured on the basis of the survey. The nine risk categories were included in one of the three dimensions such as product, people and process. Risks in the product dimension include risks with system development technique aspect. On the other hand, risks in the people dimension and the process dimension are highly related in project management. We demonstrated that the five risk components were extracted from probability and loss of each nine risk category as the results of factor analysis in Table 7. The risk components showed technical aspect or managerial aspect. Three components related risks in requirement, technology and system represented system development side in IS projects. Each of the three components had probability and loss of risk as a pair and implied risk exposure or risk impact. Two risk components were related to project management. One component was almost about risk probability, and the other

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component was mainly related to loss of risk in the people dimension and process dimension.

Among the five risk components, the component about probability of unsatisfied outcome in project management was more important to discriminate between escalation group and non-escalation group than the component about loss due to unsatisfied outcome in project management and the components about risk impact in system development technology. The results suggest that project management factors are more critical than system development factors in predicting IS development project escalation.

Additionally, it was noticed that the CMM level of an organisation was the most significant variable to predict IS development project escalation. The CMM is a well-known comprehensive software process improvement model developed by the SEI at Carnegie Mellon University. The CMM describes an evolutionary improvement path for software organisations from an ad hoc, immature process to a mature, disciplined one. This path is encompassed by five levels of maturity. The CMM covers practices for planning, engineering and managing software development and maintenance (Paulk *et al.*, 1995). The results of this research can be added as a solid evidence of the benefits to use the CMM as the software development process improvement framework.

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