

PROJECT RISK MANAGEMENT IN R&D ORGANIZATIONS: A SURVEY ON RISK REGISTER FROM KOREAN COMPANIES

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ABSTRACT

This study surveyed over 200 Korean R&D organizations—enterprises, institutions, and universities—on perceptions of risk management; their risk management policies; the usability of Risk Registers; factors behind declines in Risk Register usage; the perception of Risk Registers by users; and a strategy to improve the usability of Risk Registers. The main premise is that risk management rests on the balance between probability and impact. Based on this premise, the study analyzes the components of Risk Registers used in Korean enterprises and foreign enterprises; from these findings, a Risk Register Template is proposed for the use of Korean R&D organizations.

1. Introduction

Background and Purpose of the Study

Corporate enterprises encounter many uncertainties and obstacles as they implement business strategies designed to create value. In order to identify these factors in advance and mitigate their adverse affects, enterprises may opt

for risk management(Cummins, Phillips, & Smith, 1998). While the world's leading enterprises already implement effective risk management systems to minimize loss and maximize profit in the global enterprise environment with its diverse issues and opportunities, Korean enterprises have not yet done so(Benton, 2004; Chapman & Ward, 2003; Choi, 2004). Recently, with a growth in demand for risk management from Korean government organizations and the market, Korea is making efforts to

implement more systematic risk management and to undertake research on strategies for Enterprise Risk Management (ERM hereafter)(Chiles & McMackin, 1996). Compared with advanced countries, where risk management systems have been widely developed and applied, the Risk Management Systems (RMSs hereafter) mentioned in previous studies in Korea are generally focused on financial management(Cummins et al., 1998). Most business strategists understand that the success of

R&D projects is directly related to risk management(Ding, Litz, Malaka, & Pfisterer, 2003). Moreover, with the increasing complexity of R&D projects, there has been a proliferation of risks that need to be managed. The success of projects requires risk management that clearly identifies risks and utilizes a systematic Risk Register; it is thus necessary to obtain statistics on the extent to which Korean enterprises have implemented systematic risk management and utilize Risk Registers. In this way, systematic risk management is implemented within successful R&D projects in a variety of fields. In order to recognize, classify, document, analyze, and record probable risk factors, it is crucial to create and manage a Risk Register(Dyer, 1995).

The present study intends to survey various R&D enterprises that utilize a Risk Register as to their risk management strategies, analyze the limitations that need to be overcome, and present directions for future research. In addition, the study intends to examine previous cases in which a Risk Register was utilized; conduct a comparative analysis of Risk Registers utilized by various enterprises and research institutes to identify the components of each; and create a Risk Register Template that Korean R&D organizations can use. Through an analysis of the usability of Risk Registers and the issues they raise, the present study aims to set directions for future research.

Method and Structure of the Study

This research is centered on the risk management staff of over 200 Korean R&D organizations (enterprises, insti-

tutions, universities) that either have already implemented or will implement ERM and RMS. The study conducted a survey of this target population's perception of risk management, Korean organizations' risk management policies, Risk Register utilization, factors behind the decline of Risk Register usage, and strategies to improve Risk Register usability, as well as the perceptions of Risk Registers by the organizations that manage risks through their use. Under the premise that risk management rests on the balance between probability and impact, the present study intends to analyze the Risk Registers of major organizations and present a Risk Register Template to systematize the functions of such registers, in order to propose a strategy for effective project risk management.

First of all, in order to identify the index items of a functional Risk Register, we established the definition and scope of an essential crisis through reference to the Project Management Body of Knowledge (PMBOK) Guide from the U.S. Project Management Institute (PMI)(PMI, 2013). While each of the world's renowned project management institutions presents its own standards for project management, PMI's PMBOK is the one of the most widely recognized project management standards in the world. PMBOK defines the domain of project management across nine functions: integration, scope, time, cost, quality, human resources, communication, risk, and procurement. The present study intends to examine the risk domain in depth. The risk management process consists of risk management planning, risk identification, risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control.

Introduction	Background and purpose of the study Method and structure of the study
Theoretical background and case studies	Definition of Risk Register History of risk management Previous studies on risk management Cases utilizing risk management programs
Survey on Risk Register Utilization Status / Analysis	Analysis of survey data: - Selecting sample for analysis - Basic analysis of samples - Survey analysis of perceptions on meaning of risk management - Current condition of risk management policy - Current condition of utilizing risk analysis tools and techniques - Current condition of utilizing mature Risk Register - Testing the reliability of the survey Comprehensive opinion on survey results
Proposed Risk Register Template	Mandatory components of the template: - Identifying the common input components in Korean R&D organizations' Risk Registers - Identifying the common input components in foreign R&D organizations' Risk Registers Proposed Risk Register Template Strategies to promote the usability of Risk Register Template
Conclusion	Implications Limitations of the study and future tasks

TABLE 1. Structure of the study

As shown in **Figure 1**, the Risk Register is created at the risk identification stage and is repeatedly revised or updated in the following stage.

The goals and methodology of this study are as follows. Although the assumption is made that the majority of Korean companies' Risk Registers are developed and applied by their own R&D departments, the study aims to derive implications by conducting a survey that targets the leaders who manage and control their enterprise's overall R&D projects; analyzing the conditions of risk management, based on the data collected; and analyzing the various impact relationships, in light of the special nature of a set of diverse R&D projects.

2. Theoretical Background

This section covers the definition of Risk Register, the history of risk management, previous studies on risk management, and an analysis of cases utilizing risk management programs.

Definition of Risk Register

Before defining Risk Registers, we need to define what risk is. The term "risk" is used in many industries with a variety of different meanings. To make clear distinctions

among these, the definition of risk by organizations can be outlined as follows.

- ISO Guide 73:2009: Effect of uncertainty on objectives. In other words, risks include all elements that affect the achievement of goals set by organizations or individuals.(ISO, 2010)
- COSO: Risk is the probability that an incident will occur and negatively influence the achievement of the goal. (COSO, 2004)
- PMBOK Guide®: Risk management increases the impact and probability of positive events and decreases the impact and probability of negative events concerning projects.(PMI, 2013)

The concept of risk encompasses two aspects: the aspect of hazard, such as corruption, error, and mishap; and the aspect of opportunity, which entails the loss of a probable increase in the enterprise value(Gleim, 2002; Jung, 2004). Risks can be sub-classified into loss and profit, depending on their causes and effects(J. K. Kim & Kim, 2002). All risk-related adjustment activities that are conducted in the management and direction of an organization are defined as risk management. The risk management process refers to the series of steps that an organization takes to implement risk management. The term Risk Register refers to organized documents that contain the data results from risk identification, qualitative risk analyses, quantitative risk analyses, and risk response planning; it includes detailed information such as descriptions of all identified risks and their category, cause, occurrence probability, impact on objectives, suggest-

ed coping methods, risk holder, and current condition(J. K. Kim & Um, 2002).

History of Risk Management

Methods of risk management have progressed over the decades from the defensive management approach of the 1970s and 1980s to more modern enterprise management techniques. The techniques used to manage risks from such integrated perspectives comprise enterprise risk management (ERM). Currently, the interconnectivity and integration of business systems makes it possible to calculate the cost of losses related to particular risks and to manage risks more systematically.

Previous Studies on Risk Management

Traditionally, risk management in enterprises was focused on the prevention of any elements that might bring financial loss or impair enterprises' profits. However, with the rapid transformation of the business management environment, strategies with regard to enterprise risk management have recently begun to change(J. K. Kim & Kim, 2002; S. C. Kim & Lee, 2010; Kwak, 2000). The following table shows the definitions of risk management by author mentioned in previous studies on risk, from the 1990s to present day.

A review of previous studies shows that risk represents the negative consequences that arise from future uncertainties. Dangers that occur in daily life and risks that occur in enterprises can be categorized by the financial entities involved. Dangers and risks both bring financial loss to individuals or enterprises; and economic entities need to make strenuous efforts to avoid them.

Existing Risk Management Programs

As of 2016, there are about nine leading risk management software companies in the market. These companies offer individual products and the present study excluded the ERP

system's risk management function. **Table 4** provides a list of risk management-related products and companies in foreign countries. Although there are many other risk management software companies and software products, the present study selected the most well-known products in the market.

The characteristics of the nine company products listed in **Table 4** can be summarized as follows. The main functions are the key risk indicator tracking function and the corporate risk register reporting function. First, with regard to the key risk indication tracking function, these programs create performance indicators to manage and monitor a company's main risks. When critical values are reached, an automatic alarm goes off, which allows the user to trace the risk measurement items and critical values. Second, ERM software products automatically possess a corporate risk register reporting function and can print reports in the form of a Risk Register so that clients and supervisors can see the results. Traditionally, since ERP systems were first introduced in the financial industry, most applications of this software have an integrated financial transaction system as a basic platform, with various industries now using it as a risk management tool.

3. Survey and Analysis of Risk Register Utilization Status

The questionnaire used (see appendix for details) contained questions on organization size, type of industry, understanding of risk management, the organization's risk management policy, Risk Register usability, factors in the decline of Risk Register usage, and strategies to improve Risk Register usability. At the bottom of the questionnaire, the survey participants were asked to provide their contact information so that the completed research paper could be

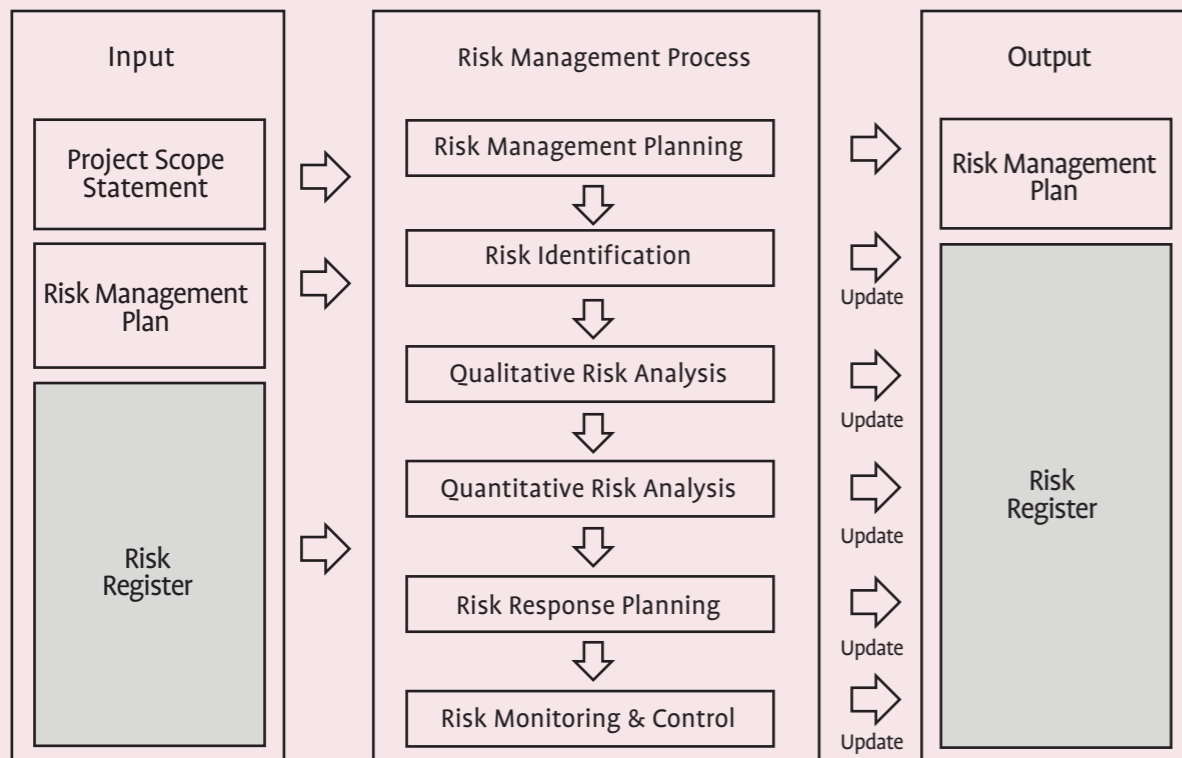


FIGURE 1. Risk Management Process Flow Diagram(PMI, 2013). Note: Not all interactions and data flows among the processes are shown

Defensive management period	Control-oriented management period	Enterprise management period	Global management period
(1970s-'80s)	(1990s)	(2000s)	Present
* Defensive risk management: – Focused on the prevention or shifting of loss – Established credit control, investment, & liquidity policies, audit procedures, etc.	* Control-oriented, volatility-centered risk management: – Focused on the management of volatility related to business and financial outcomes – Improved financial risk management methods – Increased the significance of risk management centered on internally controlled systems	* Enterprise management orientation: – Pursued optimal business outcomes with more aggressive and integrated risk management – Supported decision making related to business such as pricing and resource distribution – Improved accounting transparency through business risk management	* Interconnection and adjustment between risk management and business strategies: – Expects increased need for integrated risk response at enterprise level – Increases the need for more prompt and precise enterprise management

TABLE 2. Progression of risk management(Althonayan, 2011)

(Chapman & Ward, 2003)	It is necessary systematically to recognize, evaluate, and manage business-related risks in order to improve business performance.
(Cummins et al., 1998)	Risk mitigation is a preventive approach that increases potential opportunities; or reduces, absorbs, and shifts those risk factors that may bring any loss to enterprise during the business cycle.
(Pfleeger, 2000)	Risk represents uncertain situations that may bring decisive change and loss and events that bring negative consequences.

TABLE 3. Definitions of risk management

Product name	Company name	Characteristics
Enterprise risk management	SaS http://www.sas.com/solutions/riskmgmt/	Company has risk management platforms that target many industries, including insurance, energy, and information technology.
Enterprise risk management	IBM http://www-01.ibm.com/software/analytics/cognos/enterprise-risk-management.html	Based on Cognos business intelligence, the company's software offers management report, dashboard, decision, warning, and notice functions.
Risk Suite	Symbiant http://www.symbiant.co.uk/Risk-Suite/	Product is used to handle diverse risks within business initiatives, including new product development; and for risk identification, assessment, and change management, as well as for customer projects.
ERA	Methodwar http://www.methodware.com/era/	Companies can use this tool to integrate risk assessment, internal audit, compliance strategy, and enterprise governance structures; they also can produce reports and analyses.
Impact ERM	Syntex http://www.syntexsolutions.com/	Enterprises such as ExxonMobil, Schlumberger and Royal Dutch Shell use this program in order to improve operation, quality, environment, health, stability, and security risks.
Active Risk Manager	Strategic http://www.activerisk.com/	This product started as a project risk management program in the ERM product group; it now offers not only risk management functions, but also covers business continuity and governance compliance.
Risk Vision	Misys http://www.misys.com/	An integrated financial transaction system used by the world's major banks. The key focus of the product is risk management.
MX Risk Manager	Murex http://www.murex.com/	An integrated financial transaction system used by the world's major banks. The key to this product is a platform that incorporates risk management functions.
Calypso Solution	Calypso http://www.calypso.com/solutions/	A financial transaction system with financial risk management functions based on module-type Java.

TABLE 4. Major risk management software companies and their characteristics

sent to them via email. The survey was also used to request an enterprise Risk Register template from participants who had reported that they utilized a Risk Register.

Survey Data Analysis

Selecting Samples for Analysis

The survey was conducted over 20 days and targeted major Korean R&D institutions and enterprises through email,

online surveys, visits, and written forms. As a result, a total of 235 questionnaires were collected; after the exclusion of two responses that lacked sincerity, 233 selected samples were analyzed, based on industry type and size.

Basic Analysis of Samples

The samples used in this study can be categorized by industry type. Most participants were in manufacturing industry (48.1%), followed by IT and web communication (16.2%) and service industry (8.9%). The distribution of par-

ticipants by industry type is shown in Table 5. With regard to the enterprise size, enterprises with fewer than 100 employees were the majority (38.7%), followed by "Under 300 employees" (22.1%), and "Under 1000 employees" (14%). The distribution of enterprise sizes is shown in Table 5.

TABLE 5. Distribution of sample by enterprise size

	Under 100	100-299	300-999	1,000-9,999	10,000 and over	Total
Frequency	91	52	33	32	27	235

With regard to the status of R&D departments within these organizations, 181 (77%) out of 235 enterprises had their own R&D departments, which shows that the majority of participants were significantly engaged in R&D activities.

Awareness of Significance of Risk Management

The analysis of the awareness of risk management is shown in Table 6. The results indicate that most participants perceived risk management as activities intended to avoid tangible and intangible losses (average of 3.82). On the other hand, the perception of risk management as being "up to the individual's judgment" was 2.37 on average, which was the lowest. The results thus indicate that these enterprises generally understand risk management to be an activity that needs to be undertaken systematically within organizations, as opposed to something that is done according to an individual's judgment or by a related department. As shown in Table 6 below, the top three questions are positive questions on risk management and the bottom two questions are negative questions. Considering the fact that the average on the 5-point scale is 2.5, the awareness of risk management was identified to be very positive.

TABLE 6. Meaning of risk management

Meaning of risk management	Average
It is for avoiding tangible/intangible loss.	3.82
It is an essential item on the checklist for optimal results.	3.73
It is an official control system that identifies, manages, and reports risks.	3.27
It is meticulously managed by a related department.	2.54
It is solely up to the individual's judgment.	2.37

Current Condition of Risk Management Policy

The current condition of enterprise risk management policy is shown in Table 7. Compared with the perceptions of risk management shown above, the majority of organizations did not conduct formal risk management. Only 31.3% of the participant organizations had a special department for

risk management; with regard to risk management reports, 41.3% and 43.0% of the participants were identified as having written forms or official procedures, respectively. This indicates that risk management was not utilized by more than half of the participants, despite the efforts being made to promote risk management in Korea. The sample total here is 230, because some participants did not know whether their organizations had written forms or official reporting procedures at the time of survey and left the answer blank.

TABLE 7. Current condition of risk management policy

	Yes	No	Total
Existence of risk management team:	72 (31.3%)	158 (68.7%)	230
Existence of official procedure for risk management report:	99 (43.0%)	131 (57.0%)	230
Existence of written forms for risk management:	95 (41.3%)	135 (58.7%)	230

Current Condition of Use of Risk Analysis Tools and Technology

The average number of analysis tools and techniques that Korean enterprise use to reduce project risk was 2.57 (standard deviation of 1.82); 80% of the participants were using 4 analysis tools or fewer and only 6% of the participants were not utilizing any analysis tools. This shows that most organizations used between 1 and 4 risk analysis tools and techniques. In Table 8, the total is not 100%, because there were 3 missing values (1.3%); three participants did not answer this question at the time of survey.

TABLE 8. Current condition of use of risk analysis tools and techniques

Number of tools	0	1	2	3	4	5	6	7	8	9	10	Total
Frequency	14	59	51	59	23	9	5	7	3	1	1	232
%	6.0	25.1	21.7	25.1	9.8	3.8	2.1	3.0	1.3	0.4	0.4	98.7

The most frequently used analysis tool or technique was "meetings to discuss risks," followed by "reviewing documents" for risk analysis. The number of participants who reported that they used a Risk Register was 54 (23.0%), which indicates that only some of these enterprises use Risk Registers.

Condition of Risk Register Use Maturity

The condition of Risk Register use is shown in Table 9. The percentage of participants that did not use a Risk Register at all reached 47.8%, showing that almost half of participants did not use such a resource. The percentage of participants who used a Risk Register without utilizing it systematically was 35%, which is also high. The percentage of participants who used such a register systematically was

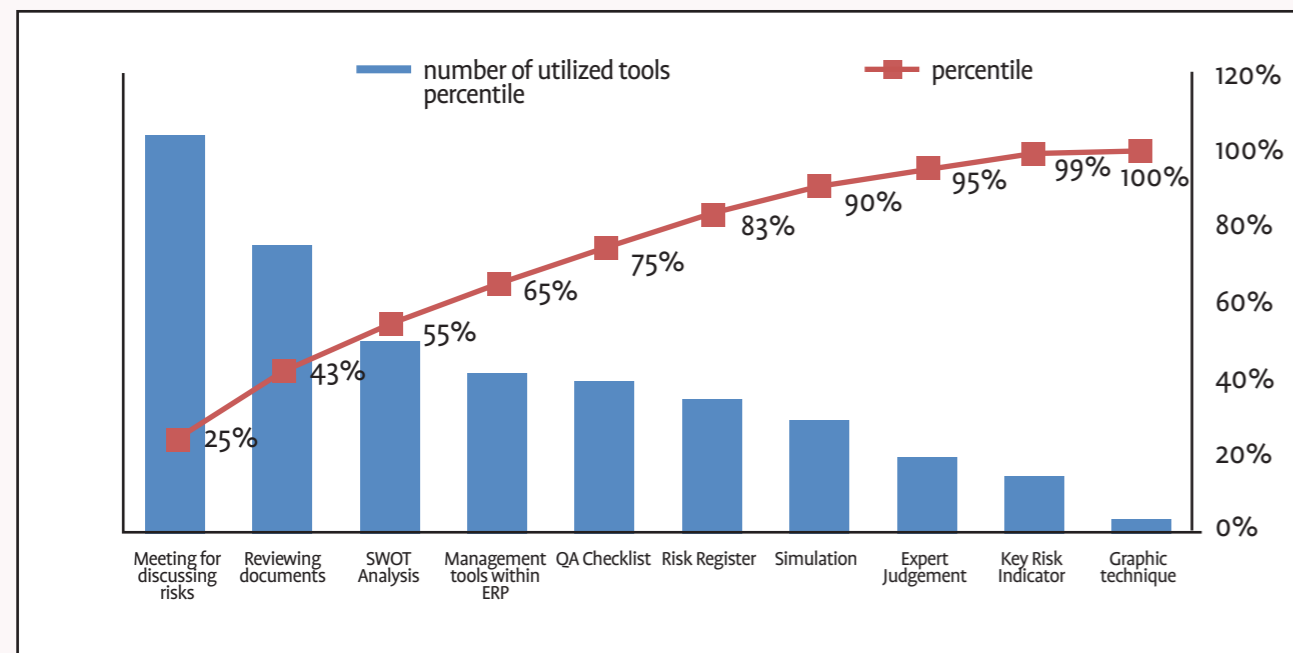


FIGURE 2. Current condition of use of risk analysis tools and techniques

13.7%, while only 3.6% of the participants either entered accurate figures or used previous data. The total number of responses is 226, because some participants did not mark their answers at the time of survey.

TABLE 9. Condition of Risk Register use

Status of Risk Register Use Maturity	Frequency	Percentage (%)
Risk Register is not used at all.	108	47.8
Risk Register is used, but not systematically.	79	35.0
Risk Register is used systematically.	31	13.7
Risk Register is used systematically and accurate figures are entered.	4	1.8
Risk Register is used systematically and previous Risk Register is used.	4	1.8
Total	226	100

As the main reason for low Risk Register usage, most participants (51.3%) responded that they did not have time to manage a Risk Register due to heavy workloads and busy schedules. The second most common reason was the perception of a Risk Register as a managerial and unnecessary element (33.7%). However, only 6.1% responded that there was a concern at being disadvantaged by revealing risks. The reasons for the low utilization of Risk Registers (multiple items selected) are shown in Table 10.

TABLE 10. Reasons for low utilization of Risk Register

Reason for low utilization of Risk Register (multiple items selected)	Frequency	Percentage (%)
There is no time to manage Risk Register due to heavy workload and busy work schedule.	134	51.3
Risk Register is burdensome because it is needed only in the managerial aspect of the organization.	88	33.7
Risk Register's form (or system) is not appropriate.	23	8.8
There is concern at being disadvantaged by revealing risks.	16	6.1
Total	261	100

With regard to solutions to increase Risk Register usability, 37.7% of the participants responded that education and training about Risk Register use should be reinforced. Other participants selected "computerization of Risk Register system" (27.4%), followed by "batch management by a management expert" (18.2%) and "revising the forms accordingly to fit the industry" (16.7%). Considering that the current Risk Register is gradually being integrated within an organization's ERP system or management configuration, the direction for future development is evidently the same as the direction for user demand (Markowitz, 1952; Meyers & Holusha, 1987).

TABLE 11. Solution to increase Risk Register usability

Solution to increase Risk Register usability (multiple items selected)	Frequency	Percentage (%)
Employees should be educated and trained regarding Risk Registers.	120	37.7
The Risk Register should become a computerized system (or connected to other systems)	87	27.4
It should be managed en bloc by a manager (or specialist).	58	18.2
The form should be revised accordingly to fit the industry group.	53	16.7
Total	318	100

With regard to the status of a quality assurance (QA) list as a replacement for their Risk Register, 56.4% of the participants responded that they did not use a QA list, while 22.7% of the participants responded that they used a QA list without replacing the Risk Register, which indicates that most enterprises did not replace their Risk Register with a QA list. The participants who responded that a QA list replaced the Risk Register were identified to be in the group of IT, web, and communications industries. Given that the product of IT industry groups is software, project risk management can be done with a QA list. In addition, risk management was identified to be partially replaced by a QA list now that QA activities have been reinforced by Capability Maturity Model Integration (CMMI: work performance and maturity assessment) assessments.

TABLE 12. Status of QA lists as replacements for Risk Registers

Status of QA list replacing Risk Register	Frequency	Percentage (%)
We are not using a QA list.	127	56.4
We are using a QA list, but it does not replace the Risk Register.	51	22.7
We are using a QA list and it partially replaces the Risk Register.	45	20.0
We are using a QA list and it completely replaces the Risk Register.	2	0.9
Total	225	100

Testing the Reliability of the Survey

The reliability of the survey was tested using Chronbach's alpha value.

Part 1 of the organizational survey covers industry type, size, status of R&D department, and budget; it is not appropriate to test these items' reliability with Chronbach's alpha value.

Question 9 in Part 2 of the survey, "What does risk management mean in your organization?" had a low Chronbach's

alpha value (0.429). The reason for this low value is that the survey question did not contain sub-questions, which lowers the internal consistency between questions and indicates a low reliability. In the meantime, Chronbach's alpha value for Question 10 was 0.827 and indicates no problem in reliability. Lastly, Questions 11 through 15 allow selection of multiple items and are therefore not suitable to provide Chronbach's alpha values.

Comprehensive Opinion of Survey Results

The survey results indicated that there was a strong interest in risk management. Although there was no typical method of risk management, survey participants were engaged in risk management in different forms. Most organizations held meetings for risk analysis, reviewed documents, or conducted SWOT analyses. Some organizations managed risks through the use of management tools within ERP systems instead of a Risk Register. Other organizations used QA check lists or simulations to identify and manage risks, but they believed that this was not enough to manage risks systematically, since it is necessary to use a Risk Register for more systematic risk management in R&D organizations. A very small number of Korean R&D organizations used Risk Registers, while many large corporations used tools within the ERP system. When Risk Registers are applied in the future, it will be necessary to establish a system of organized risk management education and training, because the usage of documents or management tools is very low, even where a special department within an organization implements risk management through official procedures.

4. Proposed Risk Register Template

First, in order to standardize Risk Registers, examples of such registers used in South Korea were analyzed. Among 233 selected responses from the 235 survey participants, after the exclusion of two in-

sincere responses, 54 participants responded that they used a Risk Register. When we asked the organizations to provide their Risk Register templates, 13 enterprises provided their Risk Registers for academic research purposes on condition of confidentiality, while most organizations could not provide this information due to their security protocols. The templates the organizations used were generally framed in similar ways, but there were discrepancies in their contents. After the common components were combined and revised, a new Risk Register Template was created.

Mandatory Components of the Template

Identifying Common Components in Korean R&D Organizations' Risk Registers

Among Korean enterprises, we identified common components in the Risk Registers provided by 13 enterprises for academic research. The Risk Register templates were generally very similar; their common components were put in a group and duplicated content was deleted. To identify the common components, each Risk Register content was scored. The contents with higher scores were determined to be common elements.

TABLE 13. Identifying common input components of Risk Registers in Korean enterprises

Common input components in Korean enterprise Risk Registers	ID	Reported by	Date of report	Description of risk	Risk type
Risk impact	13	9	8	10	7
		Severity rating	Probability of Occurrence	Risk rating	Preventive action
	11	11	11	10	7
Action taken by		Risk Priority Number	Date of action taken	Date of action completed	Notes
	6	5	8	5	4

Identifying Common Input Components in Foreign R&D Organizations' Risk Registers

We identified common components in Risk Register templates that we received from 10 foreign R&D enterprises. The Risk Registers from foreign organizations did not show much difference from Korean Risk Registers. Korean enterprises likely referred to the Risk Register Templates utilized by foreign enterprises since the 1970s.

TABLE 14. Common input components of foreign Risk Registers

Common input components in foreign enterprises' Risk Registers	ID	Raised By	Received By	Description of Risk	Description of impact
	10	8	6	10	9
		Severity Rating	Occurrence Rating	Detection Rating	RPN Rating
	8	8	8	8	8
		Action Resource	Action Date	Contingency Actions	Action Resource
	6	9	5	6	8

Proposed Risk Register Template

After scoring the data from the compilation of Risk Registers obtained from Korean enterprises that were analyzed earlier, mandatory elements and unnecessary elements were identified and separated to produce a Risk Register Template.

The analysis indicated that the components of Risk Registers used in Korea and in foreign countries did not show many differences. The components identified in case studies of Risk Registers in foreign enterprises were selected to test and verify the Korean versions. In other words, of the components that did not appear in Korean enterprises' Risk Registers, those components that were used by foreign enterprises were tested first. The results showed that the components of Korean enterprises' Risk Registers are not much different from those of foreign enterprises, as reported in theses and publications.

R&D PROJECT RISK REGISTER														
* Project title:														
* Documented by:														
* Revised date:														
Risk identification					Risk analysis			Risk resolution						
ID	Reported by	Date of report (D/M/Y)	Description of risk	Risk type	Description of risk impact	Severity rating	Occurrence rating	Risk rating	Preventive action	Action taken by	Risk priority number	Date of action taken	Date of action completed	Note

TABLE 15. Proposed Korean Risk Register Template

Table 15 below provides a proposed Risk Register Template.

The first step in this template is risk identification to check what type of risks exist. Risks are identified through various methods that include the analysis of previous project data, check lists, and interviews; however, due to the specialist nature of R&D projects, the template was designed for project participants themselves to identify the signs of risks. The ID number in the risk identification step is given to manage each individual risk and consists of the following information: project title; type of development (*preliminary research, mass production*); rating, in this order. The risk reporter is the first person who raises the issue; the date of the report is also entered. In the risk description section, project participants should describe their perception of the risk; under risk category, they should classify the risk as a technical risk or a non-technical risk.

The second step in the template process is to perform a qualitative risk analysis. When the probability of occurrence is high and its impact level on the project goal is high, the risk is very severe; on the other hand, when the probability of occurrence is low and the impact level on the project is low, the risk is insignificant. The descriptions "high severity," "normal severity," and "low severity" are not quantitative, but qualitative terms. When the severity of a risk is not known, it is impossible to establish a tailored strategy for the risk. When risks of high severity are managed intensely, the probability for a project to succeed becomes higher. In the risk analysis section, the description of risk impact is the explanation of the possible impact should the risk become a reality. To analyze the impact, a probability and impact matrix (*P-I matrix*) is usually used, but it is not easy to identify the impact level accurately during the risk analysis process. Therefore, the study did not adopt a P-I matrix and rather classified risks into 9 ranks; when the severity and probability of occurrence are entered, a risk rating is automatically created.

The final step is risk resolution, which aims to establish preventive action plans before the risk becomes an issue. At this point, the risk has been identified and analyzed qualitatively. This is the time to create plans for risk prevention. In the risk resolution step, resolution methods describe a sequence of actions to avoid the risk. For "Action taken by," one should write the name of a person who can manage the risk; when it is not clear who will take an action, one should write in the name of the project manager. To obtain a risk priority number, write in the estimated priority rating for

risk resolution in each case. Finally, write in the dates of the start and completion of the action. If there are other issues, record them in the "Notes" section.

Strategy to Improve the Use of Risk Register Templates

The survey results indicate that the main reason for the neglect of risk management is a lack of time for this activity. As large corporations have recently introduced ERP for risk management, people perceive that all responsibilities for risk management are carried out by the ERP system, with a special team in charge of risk management. This approach may be effective in certain fields such as the financial or construction industries; however, in the case of R&D organizations, each researcher is an expert in the respective field and knows the project risks best. In addition, risks are often intermittent rather than continuous. Therefore, individual researchers need to use the template as an assessment tool to evaluate their own performance throughout the research process. This implies that risk management should become a part of daily routine and take root in the organizational culture through continuing education. In addition, if risks can be managed through the construction of a database of repeated risk items, with the database organically interlinked with other project management systems or enterprise portals, then by the identification of risk items in the current project that are similar to previous risks in the database, a more efficient risk management process may be achieved.

5. Conclusion

Implications of the Study

The purpose of the present study is to inspect the risk management tools used in Korean R&D organizations, analyze their usability, and provide a Korean Risk Register model that can perform systematic risk management. The results of the analysis have the following implications. First, the survey results on the current condition of Risk Register utilization showed that small and medium size enterprises are hardly using this tool and that these registers are generally used in large enterprises with a minimum of 300 employees. Small and medium size enterprises have advantages in that they can quickly adapt to market changes; thus, the prediction of probable future risks appears to be crucial for them. Therefore, it

is essential for small and medium size enterprises to develop the capacity to cope with predictable risks through the adoption of the Korean Risk Register template that this study proposes, because such operations rarely use any enterprise resource management programs. Second, in order to improve the usability of Risk Register, organizations should make an effort to manage risks effectively through close attention to systematic management, while also conducting education and training. Finally, in order to identify, analyze, and cope with the risks that accompany R&D projects, it is crucial for organizations to implement other suitable strategies and tools that will complement Risk Registers and consider the relevant issues from multiple angles.

Limitations of the Study and Future Tasks

The number of questions in the survey was small, which creates challenges in satisfying the overall objective of this study. Given that there were many errors caused by participant misunderstandings, the present study serves as

a reference that infers the perceptions of most participants.

The present study has the following additional limitations. Although the survey targeted executives, heads of department, and project managers, some questionnaires were filled out by lower level employees such as managers and assistant managers. When there was a serious mismatch between a particular participant's response and those provided by colleagues, the response was excluded from the analysis. Although these excluded data did not affect the analytical results and the inferred conclusions, they can be seen as a limitation in reflecting the survey results clearly.

Moreover, when the Risk Register Template is created, Risk Registers should be analyzed across a wide range of industry sectors; however, only Risk Registers used in particular fields (*such as the IT, pharmaceutical, machinery, construction, and automobile industries*) were analyzed. A further in-depth analysis of other Risk Registers that were not included in this study should be carried out in future, using the present study as a reference.

APPENDIX 1. QUESTIONNAIRE

SURVEY ON R&D PROJECT RISK MANAGEMENT

How do you do? Thank you for taking your precious time for this survey.

This questionnaire is designed to make a diagnosis of R&D project risk factors in major Korean organizations (institutions and enterprises) and provide baseline data for future research on more systematic management strategies. The questionnaire will be used to provide analysis data for developing tools and building a database for future R&D project risk management.

This questionnaire consists of the following components:

[Part 1] General information on your organization

[Part 2] Analysis of tools and usability of R&D project risk management

Your response will be used only as precious research data for R&D project risk management.

·Survey period: April 25, 2015 ~ May 15, 2015 (20 days)

·Survey institution: Hanyang University Graduate School of Technology and Innovation Management (mot.hanyang.ac.kr)

[PART 1] THE FOLLOWING QUESTIONS ARE CONCERNED WITH GENERAL INFORMATION ON YOUR ORGANIZATION.

1. What type of industry is your organization in?

- ① Service industry
- ② Manufacturing industry
- ③ Medical, pharmaceutical
- ④ Sales, Distribution
- ⑤ Education
- ⑥ Construction industry
- ⑦ IT, Web, Communication
- ⑧ Media, Design
- ⑨ Financial industry
- ⑩ Institution, Association
- ⑪ Other ()

2. What is the size of your organization (total number of employees)? (According to the Statistics Act, this information will remain confidential.)
 ① Below 100 ② Below 300 ③ Below 1000 ④ Below 10,000 ⑤ 10,000 and above

3. Does your organization have an R&D department?
 ① Yes ② No (Please go to Part 2)

4. If you answered "Yes" to the above question on R&D department, how much budget is given to the R&D department?
 ① There is no set budget / Budget is allocated as needed. ② Below 3% ③ 3~7% ④ 7~13% ⑤ 13~20% ⑥ Over 20%

9. What does risk management mean in your organization?	Strongly disagree		Neither agree nor disagree		Strongly agree
(1) It is for avoiding tangible/intangible loss.	①	②	③	④	⑤
(2) It is an essential item on the checklist for optimal results.	①	②	③	④	⑤
(3) Risk management is solely up to an individual's judgment.	①	②	③	④	⑤
(4) Risk management is an official control system that identifies, manages, and report risks.	①	②	③	④	⑤
(5) Risk management is meticulously managed solely by a related department.	①	②	③	④	⑤

[PART 2] THE FOLLOWING QUESTIONS ARE CONCERNED WITH THE USABILITY OF THE RISK REGISTER, A TOOL FOR R&D PROJECT RISK MANAGEMENT.

10. This concerns the risk management policy of your organization.	Yes	No
(1) Does your organization have a designated team or department that manages risks?	①	②
(2) Does your organization have an official procedure for reporting risks?	①	②
(3) Does your organization have a written form to manage risks?	①	②

11. Select all risk analysis tools that your organization uses in order to minimize R&D project risks.

- ① Risk Register
- ② Management tools within ERP system
- ③ Key Risk Indicator
- ④ QA checklist
- ⑤ SWOT analysis
- ⑥ Expert judgment
- ⑦ Simulation
- ⑧ Graphic techniques
- ⑨ Reviewing documents
- ⑩ Meetings to discuss risks
- ⑪ Others ()

12. How much does your organization use a Risk Register? (Select all the items that apply.)

- ① Risk Register is not utilized at all.
- ② Risk Register is used, but not utilized systematically.
- ③ Risk Register is used systematically.
- ④ Risk Register is used systematically and is updated by entering accurate figures.
- ⑤ Risk Register is used systematically and the previous Risk Register is used.

13. If the Risk Register's usability is declining, or when you encounter a co-worker or team who cannot utilize Risk Register well, what do you think is the reason? (Select all the items that apply.)

- ① There is no time to manage the Risk Register due to a heavy workload and busy work schedule.
- ② The Risk Register is burdensome because it is only needed in the managerial aspect of the organization.
- ③ The Risk Register's form (or system) is not appropriate.
- ④ There is concern at being disadvantaged by revealing risks.

<p>14. What do you think is a solution to increase the Risk Register's usability?</p> <p>① The Risk Register should become a computerized system (or be connected to other systems)</p> <p>② The form should be revised appropriately to fit the industry group.</p> <p>③ The Risk Register should be managed en bloc by a manager (or specialist).</p> <p>④ Employees should be educated and trained in Risk Register use.</p>
<p>15. Is your organization using a QA list instead of a Risk Register?</p> <p>① We are not using a QA List.</p> <p>② We are using QA list, but it does not replace the Risk Register.</p> <p>③ We are using a QA list and it partially replaces the Risk Register.</p> <p>④ We are using a QA list and it completely replaces the Risk Register.</p>
<p>16. Please share your overall opinion on R&D risk management and Risk Register usage.</p>

APPENDIX 2. LIST OF ENTERPRISES THAT PARTICIPATED IN THE SURVEY

Alpinion Medical Systems	Hyundai IHL	NHN
Applied Materials Korea	Hyundai Motor	NICEDEB
ATEC	Hyundai Steel	NXP
AUTOMAX System Engineering	IBM Korea	P&G
Avellinolab	IMU Korea	PINS Information Technology
Bioleaders	Inchon Iron Steel Co	Ploom
Biz Doctor Center	Infobis	pllab
C&D Corporation	Innolife	Poongsan Co
CDS	Institute of Energy Technology Evaluation and Planning	PSIONDSP
Celltrion Chem	Intel Mobile Communication	R&D Patent Center
Chungnam Techno Park	IPT research	Republic of Korea Air Force
Cizion	Jeonbuk Technology Holdings	Republic of Korea Army
CKD Pharm	Jungmac energy	Rinnai
Corentec	KEPCO KDN	ROHDE&SCHWARZ
CPRO	KIAT	Ryann&Co
DACC	KIDECO	Samsung Advanced Institution of Technology
Daewoo Electronics	Kleannara	Samsung Corning Precision Materials
Daeyangplant	Korea Aerospace Research Institute	Samsung ELECTRO-MECHANICS
Delphi Korea	Korea Creative Content Agency	Samsung Electronics
Design Park	Korea Electronics Technology Institute	Samsung Heavy Industries
DFOCUS	Korea Evaluation Institute Of Industrial Technology	Samsung Medison
Digital Imaging Technology DH-M	Korea Information Society Development Institute	Samyang
Doosan Ecobiznet	Korea Institute of Machinery & Materials	Satrexi
Ecosian	Korea Institute of Patent Information	Sblimotive
Electronics and Telecommunications Research Institute	Korea Land & Housing Co.	SNU: Advanced Institutes of Convergence Technology
eTEC E&C	KOREA RAIL NETWORK AUTHORITY	SG servo
Excelab	KITECH	Siliconworks
FC Industry	Korea Strategic Trade Institute	Simens
FITI Testing & Research Institute	KoreanAir	SK Hynix
FLOWTECH	KTNET	SK telecom
Fusionelectronics Co	LG Chem	SSCP
H&C System	LG CNS	Sun & Shield
Hanall Biopharma	LG Electronics	Sunstat
HANDYSOFT	LIG Nex1	TC
HANIL GREEN TECH Co	Lotte Eng. & Construction	Telecommunications Technology Association
Hansol PNS	LSIS Co.	TES Co
Hanyang Industry-University Cooperation Foundation	Markpro	Catholic University: Industry-Academic Cooperation Foundation
Hanyang Management of Technology	Modelsim	UIN Edunics
Hanyang Semitech Co.	Naravision	UV PLUS
Hanyang University	National Education Information System	Valeo
Hot MOLD Eng	National Science & Technology Council	Wareco
Humanray	NCSOFT	WS precision
Hyundai Autoever	NEOWIZ GAMES	Yeonhab Precision Co
Hyundai Autron	Neung-In Solution	



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references

Althonayan, A. (2011). Aligning Enterprise Risk Management With. Information Systems, 2011, 109-129. Retrieved from <http://v-scheiner.brunel.ac.uk/handle/2438/8474>

Benton, W. D. (2004). Implementing and managing risk across the enterprise: A practical guide to ERM. GARP Risk Review, 21-33.

Chapman, C., & Ward, S. (2003). Project Risk Management: Processes, Techniques and Insights. <http://doi.org/10.1007/s13398-014-0173-7.2>

Chiles, T. H., & McMackin, J. F. (1996). INTEGRATING VARIABLE RISK PREFERENCES, TRUST, AND TRANSACTION COST ECONOMICS. Academy of Management Review, 21(1), 73-99. Retrieved from <http://amr.aom.org/content/21/1/73.short>

Choi, B. H. (2004). A case study on the integrated management of performance and risk. Management Accounting Association of Korea, (1), 89-107.

COSO. (2004). COSO Enterprise Risk Management-Integrated Framework: Application Techniques. Committee of sponsoring organizations of the treadway commission.

Cummins, J. D., Phillips, R. D., & Smith, S. D. (1998). The Rise of Risk Management. Economic Review-Federal. Retrieved from <http://search.proquest.com/openview/326d25c874d22f-9399c4aa803430666b/1?pq-origsite=gscholar>

Ding, Y., Litz, H., Malaka, R., & Pfisterer, D. (2003). On programming information agent systems an integrated hotel reservation service as case study. In Lecture Notes in Artificial Intelligence (Subseries of Lecture Notes in Computer Science) (Vol. 2831, pp. 50-61). Retrieved from http://link.springer.com/chapter/10.1007/978-3-540-39869-1_5

Dyer, S. C. (1995). Getting People into the Crisis Communication Plan. Public Relations Quarterly, 40(3), 38-41. Retrieved from <http://search.proquest.com/openview/7eb6d321279f89d-6d90215dec3d92356/1?pq-origsite=gscholar>

Gleim, I. N. (2002). Certified internal auditor process. The Institute of Internal Auditors, 22(1), 23-42.

ISO. (2010). ISO 31000:2009--The new international standard on risk management. Risk analysis : an official publication of the Society for Risk Analysis (Vol. 30). <http://doi.org/10.1111/j.1539-6924.2010.01397.x>

Jung, H. . (2004). Risk management practices of Korean Federation of Community credit Cooperatives(KFCC) with a Asset liability Management(ALM). Dong-eui University.

Kim, J. K., & Kim, C. S. (2002). An Integrated Model of QMS and RMS. Korean Institute of Industrial Engineers, (14), 800-807.

Kim, J. K., & Um, S. . (2002). An investigation study on risk management systems. Korean Institute of Industrial Engineers, (14), 780-786.

Kim, S. C., & Lee, J. C. (2010). Global standard project management. Hankyungsa Book.

Kwak, Y. (2000). The Effects of Risk Recognition and Characteristics of Risk Management on the Business Performance. Hanvat University.

Markowitz, H. (1952). Portfolio selection. J Finance, 7, 77-91. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1111/j.1540-6261.1952.tb01525.x/full>

Meyers, G. C., & Holusha, J. (1987). When it hits the fan: Managing the nine crises of business. Signet.

Pfleger, S. (2000). Risky business: what we have yet to learn about risk management. Journal of Systems and Software, 53, 265-273. Retrieved from <http://www.sciencedirect.com/science/article/pii/S016412120000170>

PMI. (2013). A Guide to the PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK® GUIDE). Project Management Journal. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1002/pmj.21345/abstract>