The Method of Risk Management for Scientific Research Projects

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***Abstract*—This paper discusses the composition of risks, methods for risk assessment and risk management for scientific research projects. Aiming at four type of research field: product development, software development, fundamental research and natural science research, elaborates on the main elements of technical risk and conditional risk, presents three methods of the risk assessment, one is veto method, the second is factor method, and the third is item method. Through three method, give the qualitative risk degree under the result for each method. In the end, provides three suggestions for coping with the risks.**

Keywords-scientific research project, risk, assessment method, suggestion

I. INTRODUCTION

Risk refers to the uncertainty in future events and outcomes. There are risks of different sizes, degrees and manifestations to do anything. In some high-risk industries, people have deeper understanding of risk and formulate corresponding measures and plans. In fact, without even knowing it, all social organizations have risks to deal with. In a sense, the rules and regulations of an organization are methods for reducing and coping with the risks.

There are also a lot of risks in scientific research. The definition, identification, assessment and management of risk vary in different scientific research fields and management styles. Most research institutes, researchers and managerial staff are more concerned with technical success, financial guarantee and research period, and are less aware of the risks. Any provision of risk management is contained in *GB/T19001B Quality management systems—Requirements*. But the risk management requirement is clearly put forward in *GJB9001B Quality management systems requirements*. It is indicated that the organization should develop a risk management plan and do risk analysis and assessment at all stages of the product realization to form risk analysis documents so that they can be provided to the customer if necessary. Obviously, risk management must be carried out if military products are developed and produced. And risk management is indispensable if GJB9001B quality management system certification is applied. In practice, risk management is not only an important content of the management, but also unavoidable work for researchers in research activities. The main contents, assessment methods and response measures of scientific risk are discussed in the paper.

II. RISK FACTOR IDENTIFICATION IN SCIENTIFIC RESEARCH

Risks run through the whole process of research activities. There are different forms of risk in different types of researches and stages. Some believe that scientific risk is the degree of goal fulfillment under the constraints of regulation performance, cost and schedule, etc. Some believe that the constraints of regulation performance, cost, schedule and so on also has uncertainty, which is also a risk. In the author's opinion, scientific risk runs throughout the entire process of research project from project approval to the end. Some constraints themselves are major risks.

According to the research objectives and the achievement form, scientific research can be divided into four categories, including product development, software development, fundamental research and natural science research. Product development forms a kind of new product, including stages of design, prototype, test, trial, improvement, stereotypes, etc. Software development form a kind of new software, including stages of functional planning, programming, testing, improving, publishing, etc. Natural science research forms a kind of new theory, draws valid conclusions or explores new methods, including stages of analysis, induction, verification, etc. Risk exists in the research activities above. Scientific risk can be divided into two categories, including technical risk and conditional risk. There are technical risk, conditional risk and business risk in the research activities of clientage, which the rights and obligations are stipulated by contract. Business risk is not discussed in the paper.

A. Technical Risk

Technical risk refers to the risk of technical failure. It is an inherent risk in research activities, which does not depend on the environmental conditions. Technical risk is objective, which can't be avoided. But it can be effectively controlled by good security conditions. It should be noted that "technical" should not be taken as only the technologies in the research. All the conditions that can't be obtained or used directly, including material, process and equipment, should be classified as technical content and cannot be simply regarded as necessary conditions.

1) Technical Risk of Product Development: Technical risk in product development can be divided into target risk, design risk, key technical risk, material risk, technology

risk, manufacturing risk, verification risk, trial risk, etc. Target risk refers to the risk of the target in scientificity, rationality and feasibility. Design risk refers to the risk whether the intended function can be realized by feature set, structure design and technology selection. Key technical risk refers to the risk whether the key technology, including Technical improvement, integrated innovation, etc, can be realized. Material risk refers to the risk whether the material and device can be obtained and matching. Technology risk refers to the risk whether the technology is mature and feasible. Manufacturing risk refers to the risk whether there are suitable facilities for manufacturing and whether there are specific hazards such as toxic and blasting caused by the product in the process of manufacturing. Verification risk refers to the possible danger and harm in the process of the sample function verification. Trial risk refers to the possible danger and harm in the process of trial.

2) Technical Risk of Software Development: Technical risk in software development contains target risk, function planning risk, data risk, programming risk, transmission risk, runtime environment risk and disaster recovery risk. Target risk refers to the risk of the target in scientificity, rationality and feasibility. Function planning risk refers to the risk whether the function designed can be realized and whether the demand can be met. Data risk refers to the risk of basic data and user data in rationality of structure design and reliability of data storage and processing. Programming risk refers to the risk whether the intended function can be realized by the programming language chosen and whether it can stably operate. Transmission risk refers to the risk whether the hardware condition and transport mechanism can ensure the safety, accuracy, timeliness and stability of data transmission. Transmission contains not only network but also underlying hardware that other data exchange way uses. Runtime environment risk refers to the risk whether the hardware and software environment is satisfied for software running and the risk in reliability and stability. Disaster recovery risk refers to the risk of the security and integrity of basic data and user data when the system crashes or a fatal software error occurs.

3) Technical Risk of Fundmental Reaearch: Technical risk of fundamental research mainly contains target risk, method risk and verification risk. The scientificity and rationality are not easy to judge because the target of the fundamental research is approached in constant exploration. Target risk refers to the degree of implementation success. The greater the degree is, the smaller the risk is, and vice versa. Method risk refers to the feasibility of method and the correlation of it with the research content. Verification risk refers to the feasibility and fits of the models, samples and means used for verifying the conclusions.

4) Technical Risk of Natural Science Research: Natural Science Research has the characteristics of both product development and fundamental research. It is similar with product development in the object of study, which is often material objects or natural phenomenon, and the research result, which may material objects or methods and laws. It is similar with fundamental research in the research method and verification mode, which contains tracking, analysis, induction and comparison. Technical risk of natural science research contains target risk, method risk and verification risk.

It should be noted that the four studies are not completely isolated. They cross each other, and each has its own characteristics. These are essentially same for risk identification. Technical risk can be effectively identified if the content, requirement, method and approach of the research are understood.

Technical risk is shown in table 1.

TABLE I. TECHNICAL RISK

Category	Risk Item	Description
Product Development	Target Risk	The scientificity, rationality and feasibility of the target.
	Design Risk	Whether the intended function can be realized by feature set, structure design and s technology election.
	Key Technical Risk	Whether the key technology needed can be realized.
	Material Risk	Whether the material and device can be obtained and matching.
	Technology Risk	Whether the technology is Mature and feasible.
	Manufacturing Risk	Specific hazards caused by the product in the process of manufacturing.
	Verification Risk	The possible danger and harm in the process of the sample function verification.
	Trial Risk	The possible danger and harm in the process of trial.
Software Development	Target Risk	The scientificity, rationality and feasibility of the target.
	Function Planning Risk	Whether the function designed can be realized and whether the demand can be meet
	Data Risk	The risk of basic data and user data in rationality of structure design and reliability of data storage and processing.
	Programming Risk	Whether the intended function can be realized by the programming language chosen and whether it can stably operate.
	Transmission Risk	Whether the hardware condition and transport mechanism can ensure the safety, accuracy, timeliness and stability of data transmission.
	Runtime Environment Risk	Whether the hardware and software environment is satisfied for software running and the risk in reliability and stability.
	Disaster Recovery Risk	Whether the Security and integrity of basic data and user data can be guaranteed when the system crashes or a fatal software error occurs.
Fundamental Research and Natural Science Research	Target Risk	The fits degree of implementation
	Method Risk	The feasibility of method and the correlation of it with the research content.
	Verification Risk	The feasibility and fits of the models, samples and means used for verifying the conclusions.

B. *Conditional Risk*

Conditional risk refers to the risk of whether the necessary guarantee demand of scientific research can be met. The risk is often determined by external factors. It is

an external risk. Compared with technical risk, conditional risk of all the science researches are almost the same. These risks are reflected in the contract for two sides in commissioned research. Along with the other risk appointed in the contract, it is called contrast risk. It can be considered as conditional risk for contractor.

1) Regulatory Risk: Regulatory risk refers to the risk whether the scientific research is allowed by laws and regulations and the unit regulations. Regulatory risk should be considered in research content, methodological approach, result and intellectual property rights.

2) Business Compliance Risk: Business Compliance Risk refers to the uncertainty whether the research is in accordance with the business direction of the unit. The risk was not considered when all disciplines were relatively independent. Business Compliance Risk is not ignored at present in Interdisciplinary intersection era that a product may involve multiple professional fields.

3) Human Resources Risk: Human resources risk is that whether the human resources needed in scientific research is satisfied. The human resources refer to the researchers directly engaged in the research and also those assisting personnel participated in the trial and testing links. It must be satisfied in terms of staff number, expertise and skills.

4) Capital Risk: Capital Risk is that the funds needed in scientific research are effectively and timely guaranteed. The total amount should be considered. For the funds allocated by stages, whether each stage is adequately founded should also be taken into consideration.

5) Cycle Risk: Cycle risk is that whether all the research work can be completed in the prescribed period, including the satisfaction degree of the total time limit and that whether periodic time limits can be achieved.

6) Built-on Risk: Built-on Risk refers to the risk that the special investment to complete research work brings, including risks in the investment of facilities increase and transformation, environmental management, toxic substance handling and Labor protection.

7) Commitment Risk: Commitment risk exists in the attention and support of the decision-maker and the client. Quality management system emphasizes an important principle of leadership. Whether the decision-maker and the client attach continuous importance to the research plays an important role in the success of the work. "Leadership" is very critical in scientific researches. Special attention should be paid to this kind of risk in those highly-difficult researches which have high risks and long research period.

8) Application Prospect Risk: Application prospect risk refers to the risk in the popularization and application of the research result. Unless the responsibilities of popularization and application are appointed by both contracting parties in the contract, otherwise, the risk can be ignored for commissioned research project. And it is an important content to which we must attach great importance for the scientific research project from our own coffers.

Conditional risk is shown in table 2.

C. Identification Principle

The various types of risks mentioned above are not all the risks, neither could they be found in every activity of scientific researches. The principles of combining practice, full consideration and selective analysis should be persisted in scientific risk identification. In view of the research content, features and requirements, the uncertainties of all the stages and links must be systematically analyzed in combination with the reality of manpower and financial resources, analyze and deal with the decisive factor and the key factor. Only in this way, the risks assessed are more targeted and more meaningful.

TABLE II. CONDITIONAL RISK

Risk Item	Description
Regulatory Risk	Whether the scientific research is allowed by laws and regulations and the unit regulations.
Business Compliance Risk	The uncertainty whether the research is in accordance with the business direction of the unit.
Human Resources Risk	Satisfaction of human resource in staff number, professional and skill.
Capital Risk	The funds needed in scientific research are effectively and timely guaranteed.
Cycle Risk	Whether all the research work can be completed in the prescribed period.
Built-on Risk	The risk that the special investment to complete research work brings, including risks in the investment of facilities increase and transformation, environmental management, toxic substance handling and Labor protection.
Commitment Risk	The attention and support of the executive and principal.
Application Prospect Risk	The popularization and application of the research result.

III. SCIENTIFIC RISK ASSESSMENT METHODS

On the basis of effective identification of scientific risks, they should be assessed with appropriate methods for objective conclusion: whether the research should be carried out or not? If it is decided that the research should still go on, then what measures should be taken to reduce the risk shall also be considered.

The concept of risk degree is used in scientific risk assessment. Risk degree is expressed as a percentage. According to the size of risk degree, Risks can be qualitatively classified into four levels, including fatal risk, serious risk, moderate risk and low risk.

Risk assessment methods mainly include veto method, factor method, and item method.

A. Veto Method

The veto method refers to the assessment method that the veto conclusion can be drawn as long as a factor is restricted and in risk.

The risk degree is calculated as shown in (1).

$$Rd = \max(r_i) \tag{1}$$

Rd -Risk Degree，%。

r_i -Veto Risk Item, if the item is in risk, r_i is 1, otherwise,0.

The veto method is mainly used for the risk assessment of the project with the risk item which has a huge impact on the project and can't be controlled. The risk item is called veto risk item. The veto risk item is either technical category or condition category. The technical risk that the

research objectives and the research method are contrary to justice, common sense or prohibited by state laws and regulations is veto risk item. The conditional risk that the requirements and the methods can't be satisfied is also veto risk item.

As long as there is one veto risk item, the risk degree is 1. It is a fatal risk. The project must be voted down.

The veto risk items could be easily identified and the conclusions can be easily obtained in product development and software development. The veto risk items in fundamental research and natural science research could not be easily indentified because the targets of the researches are exploratory.Therefore, the veto risk items of the researches should be indentified in conditional risk.

B. Factor Method

The factor Method refers to the assessment method that the whole risk degree is obtained by the weight of each risk item involved multiplied by the corresponding risk coefficient.

The risk degree is calculated as shown in (2).

$$Rd = \sum (V_i \quad D_i) \max(r_i) \tag{2}$$

Rd -Risk Degree, %.

V_i - Risk Item Weight, $\sum V_i = 1$.

D_i -Risk Coefficient, <1.

The factor method is mainly used for the risk assessment of the project without veto risk item. The weight and the risk coefficient of each risk item need to be confirmed. The risk degree of each item is obtained by multiplying them. And the sum of all the risk degrees is the risk degree of the whole project.

The weight and the risk coefficient of each risk item are often put forward by experienced management and technical personnel through careful analysis in view of the project details. The assessment conclusion is more valuable if the key links and major support conditions are found out and given proper weight and risk coefficient in the assessment.

A risk whose risk degree is above 50% is a serious risk. Risk whose risk degree is between 30% and 50% is a moderate risk. Risk whose risk degree is under 30% is a low risk.

C. Item Method

The item method refers to the assessment method that the risk degree is obtained with the number of the elements of risk divided by the number of all elements.

The risk degree is calculated as shown in (3).

$$Rd = S/T \tag{3}$$

Rd - Risk Degree, %.

S -Number of the Elements of Risk.

T - Number of all Elements.

The item method is a simple risk assessment method. It is often used for general research project risk assessment, such as projects with good foundations, the project which risk factors can be easily controlled, etc.

The risk degree is obtained as long as the numbers of the risk elements and all the elements are confirmed in item method. The total elements can be counted by the items shown in table 1 and table 2. And the elements of risk are counted on the basis of the specific circumstances of the project. Thus, the tedious work of confirming the weight and the risk coefficient of each risk item can be avoided.

A risk whose risk degree is above 60% is a serious risk. A risk whose risk degree is between 40% and 60% is a moderate risk. Risk whose risk degree is under 40% is a low risk.

The risk levels which the risk degrees by the assessment methods are in correspondence with are shown in table 3.

TABLE III. THE RISK LEVEL

Assessment Method	Fatal Risk	Serious Risk	Moderate Risk	Low Risk
Veto Method	Risk Degree=1	-	-	-
Factor Method	-	Risk Degree >50%	51%> Risk Degree >30%	Risk Degree <30%
Item Method	-	Risk Degree >60%	61%> Risk Degree >40%	Risk Degree <40%

IV. SCIENTIFIC RISK ASSESSMENT ORGANIZING AND RISK RESPONSE

A. Assessment Organizing

Scientific risk assessments are generally organized by the research management department. The assessment team is composed of the skilled management and technical personnel. Management personnel should be familiar with the policies and regulations, industry development trends and actual situation of the unit. They mainly analyze and assess the related conditional risk. The technical personnel should be familiar with the technical fields involved. They should effectively identify key technology, foresee uncertainty of technology, manufacture and test and analyze and assess technical risk. The assessment team should also absorb the financial personnel to participate in for the project of large funding and complex cost structure. The assessment team can seek advice from relevant legal professionals about the laws and regulations. And people familiar with the law can be absorbed in the assessment team. Avoidance system should be adopted in assessment of major project. People have an interest in the project can not be absorbed in the assessment team. For contract project, a third party can also be hired for risk assessment before delivery.

The proper assessment method should be taken on the basis of the specific circumstances of the project after the personnel is confirmed. The veto method should be taken first. If there is a veto risk item, the project is directly voted down. For the projects without veto risk item, the risk degree of simple projects can be obtained by the item method and that of should be obtained by the factor method. The risk degree and the risk level should be provided to the decision makers in time when they are obtained.

B. Risk Response

The risk management must be taken as an important content of scientific research. The technician must change

the habit of not attaching importance to risk and management personnel must put risk management into scientific research management so that the passive situation that the measures are taken only after the problem occurs can be avoided. Practice shows that effective project management can't be done if we do not prevent the possible risk in the project development and take necessary measures.

The risks of the scientific research connect to each other and influence each other. And they will vary with the research process. But only one or two factors may play leading roles. Seizing these main factors and controlling the key risk is the premise to reduce risk. Otherwise, the efficiency and benefit of scientific research may be reduced and the research costs may be increased.

Countermeasures must be adopted in advance. The risks which belong to the conditional risk are solved or reduced through providing corresponding conditions, improving conditions, reducing requirements, drawing support from external conditions and other methods. Management departments and researchers need to deal with together. The researchers are in charge of the risks which belong to the technical risk. The risk factor should be considered in advance and specific measures should be taken in to avoid risks. In short, measures to deal with the risk should be considered in advance. According to specific conditions, we must put forward a foresight, reply or plan.

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