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Public R&D Risk and Risk Management Policy

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***Abstract*—**R&D risk management has been suggested as one of the management approaches for accomplishing the goals of public R&D investment. The investment in basic science and core technology development is the essential roles of government for securing the social base needed for continuous economic growth. And, it is also an important role of the science and technology policy sectors to generate a positive environment in which the outcomes of public R&D can be diffused in a stable fashion by controlling the uncertainties and risk factors in advance that may arise during the application of such achievements to society and industry. Various policies have already been implemented to manage uncertainties and variables that may have negative impact on accomplishing public R& investment goals. But we may derive new policy measures for complementing the existing policies and for exploring progress direction by analyzing them in a policy package from the viewpoint of R&D risk management.

***Keywords*—**Risk management, Public R&D policy, Science and technology policy, Performance management.

I. Introduction

INTEREST and investment in R&D that consists of the essential elements of science and technology policy have been steadily increasing as the social and economic issues it can contribute to are expanded.

But it is true that the instability of the R&D environment is also increasing when science and technology levels improve based on such growing investment. For example, recent years, investment in ICT fields has increased because many governments selected them as key science and technology domains. But in the perspective of developing countries, the stability inherent in technology-pursuit model has become reduced as R&BD has emerged as the 4th-generation R&D paradigm and the technology innovation system is going to be switched rapidly to technology-leading model.

Furthermore, the demand for enhanced policy accountability of public sector regarding R&D policy has increased as the eventual goal of public R&D policies have been extended from the successful implementation of R&D project to the domain of economic growth and socio-cultural innovation.

Accordingly, the public sector has strengthened its efforts to increase the efficiency of R&D investment by concentrating on fewer selected larger-scale R&D tasks. However, the probability of R&D investment failures by a certain erroneous policy decision has also become increased under such policy environment.

This paper suggests the needs to strengthen R&D risk management and the direction this approach should take as a new public R&D role model for actively countering various changes arising in the R&D policy environment.

The increase of public investment in basic science and core technology development is an essential element for securing the social base needed for steady economic growth. In addition, it is an important role of the science and technology policy to generate an environment in which the achievements of public R&D investment can be diffused in a stable fashion through preemptively controlling uncertainties and risk factors that may arise in the application of such achievements to society and the industry.

It is true that diverse policies have already been implemented to manage uncertainties and variables that may have negative impact on accomplishing public R&D investment goals, even though they were not officially referred to as R&D risk management. But we are going to derive new policy measures for complementing potential deficiencies of the existing policies and progress direction by analyzing them in a policy package from the viewpoint of R&D risk management.

II. Applying the Risk Management Concept to R&D

A. Risk Management in R&D

The concept of risk refers to an event that can result in an undesirable or negative outcome [1]. Risk can be divided into two elements – the probability of such events, and the impact they may bring about as their result. The risk management concept has been widely accepted for many years in area such as insurance and finance and has started attracting the attention of national backbone facilities with regard to the need for emergency preparedness [2] - [4]. In recent years, this concept has begun to be applied to the field of innovation [5].

"Risk" in public R&D may be construed to the meaning of potential obstructive factors in the perspective of policy, technology, market, society, law and morality that may have a negative impact on the accomplishment of R&D goals, including the attainment of excellent scientific and technological advance and their application to industry and social challenge.

"R&D risk management" refers to the system of designing a series of policy countermeasures in advance to control uncertainties that may have negative impact on achieving public R&D investment goals and the mechanism to apply

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these measures to R&D process

R&D risk management may be viewed as a concept of "preparedness" and "insurance" to preemptively control such risk factors while reducing the uncertainties inherent in R&D activities, rather than as a concept of countering or resolving problems that have arisen [6].

Table I shows the examples of risks that arise in public R&D sector. The policy risk factors consist mainly of those related to decisions about public sector R&D investment and the selection of investment domains. Irrational resource distribution and crowding-out effect arising from business R&D investment may appear as one of the negative impact of administrative risk factors. The technology factors are those risk types relating to the failure of innovative technology development. The impact may include sunk costs and increased development costs. Market, social and legal factors are risk types that may arise in the application or diffusion of public R&D achievements to society and the market. The impact may include the delay in industrializing new technology, the formation of an inefficient market competition structure among new technologies and the dying of one of the new technologies. Moral factors are those risk types which pertain to certain immoral behaviors of researcher or support personnel participating in R&D programs. Negative impact may appear in the form of the suspension of promising research programs and a loss of confidence in research programs.

B. Risk Management Compared with R&D Performance Management

The concept of risk management differs substantially from that of performance management. But the two may be employed complementarily in order to minimize the uncertainty related to diffusion of R&D performance. In other words, we can strengthen the foundation for creating and diffusing R&D outcome by combining R&D risk management with the performance management system. Performance management is a concept that focuses on an efficient or effective attainment of target outcome, whereas risk management is a concept that focuses on the stable attainment of target outcome or the creation of a preventive environment.

III. Status of Public Sector R&D Risk Management

Diverse risk management programs already have been implemented to address the uncertainties related to technology development and to generate a positive outcome under changing R&D environment. For example, strategic activities such as technology demand survey, technology forecast, technology capability survey, innovation capacity survey, and economic feasibility analysis are being conducted in many public sectors at the planning stage of public sector R&D programs. These may be regarded as specific policy efforts designed to minimize the R&D risks that may arise from selecting a wrong investment target by deciding optimum

TABLE I
EXAMPLES OF PUBLIC SECTOR R&D RISKS

Category	Probability	Impact
Policy factors	Over- or under-estimation of economic feasibility. Over- or under-estimation capabilities of private sector. Defective forecasting on market and technology trends. Overlap with private sector in investment area. Lack of reasonable resource allocation criteria.	- Wrong decision on R&D project selection - Increase of sunk cost - Reduction of private sector R&D investment - Unrest caused by policy changes in the market.
Technology factors	Upgrade of science or technology capabilities of competing countries. Emergence of substitute technology or knowledge. Delay or failure of developing targeted technology Failure to obtain intellectual property rights or secure international standards.	- Increase of development cost and period. - Increase of sunk costs. - Loss of technology and market initiatives - Dying of new technology.
Marekt & Social factors	Release of new product or service R&D ahead of social demand. Conflict among new product or service. Failure to reach a social consensus on the scope of usage of new scientific technologies. Occurrence of international trade disputes.	- Formation of inefficient market competition. - Delay in the industrialization of new product. - Loss of market initiatives. - Dying of new technology.
Legal factors	Incomplete legal preparedness on new product or service Conflict between new product or service and existing regulations	- Delay in the release of new product or service. - Failure to industrialize new technology - Loss of market initiatives
Moral factors	Inappropriate use of research funds. Leakage of research secrets or other confidential information. Outflow of research workforce. Presentation of exaggerated or false research achievements.	- Stoppage of promising research projects. - Increase of administrative expenses. - Loss of confidence.

projects based on the principle of selection and concentration that are expected to produce superior social or economic achievements.

The evaluation system, which is designed to cut budget or drop non-performing projects during the course of R&D project implementation, may also be interpreted as a series of R&D risk management efforts intended to minimize sunk costs from the viewpoint of risk management.

Public policies for acquiring international standard initiatives are being actively implemented in many public sectors, especially in such areas as ICT where international standards can provide a key source of business competitiveness.

Policy for the protection of intellectual property rights are also being expanded to all R&D processes. Though such efforts are not made under the title of R&D risk management, these diverse activities are performed under public R&D policies that are designed to generate and diffuse R&D outcome steadily.

IV. Direction of Strengthening Public Sector R&D Risk Management

A. Risk Management Focusing on Technology Development → Strengthening the Management of Policy Institutional, Social and Market Risks

As discussed above, R&D risk management in many fields of scientific technology is currently performed centered on "technology development risk" with regard to the exploration, selection or management of R&D projects. Risk management focusing on technology development can be limited in its ability to address such non-technology development risks as market, social and legal factors [7].

If the legal system or state of preparedness is lacking in its application of new technologies to social service or business activities, however good they may be, it could take a long time for the ultimate achievement of public R&D efforts to become visible. As to policy aspects, if countermeasures are not fixed in advance to monitor the probable errors in policy decisions and to address such errors when they are noticed, it will be difficult to prevent sunk costs or minimize negative symptoms that can be impediments to business R&D activities.

Therefore, we should inclusively manage the policy, market, social and legal risks that may arise during or after technology development by treating them as inherent factors of technology development rather than external factors of technology development. For example, we can minimize such adverse effects as undue delays of diffusion of public R&D outcomes coming from legislative deficiencies, only if we diagnose potential conflicts between new technology and the current laws and regulations at the early stage of R&D planning in parallel with the preparation of the R&D road map and the selection of investment targets.

B. Risk Management from the Research Personnel's Perspective → Strengthening Risk Management from the Perspective of the People and Businesses

At present, risk management is focused on those efforts required for attaining superior research achievements from the viewpoint of those who perform the research, including researchers and research administrators. From the viewpoint of performance-oriented R&D management, the success of an R&D project may depend more on the question of whether a new technology will be accommodated by the people - the end-users, rather than whether or not the R&D outcome offers technological superiority.

The effective diffusion or application of R&D achievements may be limited if the individuals or the society that actually use them are not ready to accommodate new technologies or if their social application has a potentially negative influence on society, even if an R&D project successfully develops a technology that is outstanding from both the academic and theoretical perspectives.

As for the technological aspect, if a similar R&D outcomes - each of them has a distinct difference in terms of its source and theory but do not have difference from the perspective of the general end-user, that is, substitutes - appears at the same time, companies that intend to apply these new technologies to its business domain may experience difficulties in formulating investment portfolio. Or, a new technology may be abandoned without being fully applied to society because of fierce competition in the market.

Therefore, it is necessary to address the public R&D risk inclusively from the viewpoint of society and businesses in addition to established risk management from the viewpoint of researchers.

C. Unit Service-Based Risk Management → Strengthening Total Life Cycle Integrated Risk Managements

R&D risk has an omni-directional continuing property. However, most current risk management is performed to address individual problems at the level of a unit service or department [8].

In other words, current risk management is optimized from the viewpoint of a part rather than the total R&D processes. Risk management optimized from the viewpoint of a part may address risks at the level of unit service somewhat sufficiently: however, it can hardly be said that the risk management is performed from the viewpoint of the entire processes if potential risks that are not controlled in a earlier process arise in the current process, or if risks that are not controlled in the current process arise in a subsequent process.

Therefore, joint responsibility and an integrated approach are required for all risks which are latent in the entire processes of public R&D projects, including R&D planning, development and management, and the transfer of technology.

In certain instances, private businesses strengthen joint responsibility for performance, namely sales, and induce active cooperation in R&D processes by placing product planning, R&D and marketing departments within one business unit.

Such cases may also be analyzed in a similar context from the viewpoint of a total life-cycle integrated risk management.

D. Potential Risk management → Formal Systematic Risk Management

R&D risk management system is tends to relatively less formalized, whereas performance management is carried out in a formal, visible manner. In order to carry out preparedness-oriented risk management, we need to foster an affirmative culture where internal or external communication on the risks can be reinvigorated. Private businesses in advanced countries have widely employed the ERM (Enterprise Risk Management) concept, having realized that risk management capabilities are one of the core strategic elements in the securing of a competitive advantage [9]. A lot of public sectors such as national infrastructure management and natural disaster management already set up formal risk management procedures, including the preparation of a risk manual. Such formalized risk management procedures should also be widely adopted in the R&D areas. For example, the introduction of a CRO (Chief R&D Risk Management Officer) system may represent the first step in formalizing R&D risk management procedures.

V. Conclusion

We have so far reviewed the concept, practice and future policy directions of public R&D risk management. Someone may have the opinion that the public sector should take greater risk in carrying out R&D projects than that of the private sector. But such opinion does not differ greatly from the purport of this paper that it is necessary to strengthen R&D risk management. It is appropriate for public sectors to input the necessary resources in High-Risk High-Return areas where market failures may take place. Yet, it is also necessary for public sectors to actively carry out policies that can diagnose and counter probable risks to the maximum extent. In particular, it is necessary to thoroughly counter those risks that may arise because of non-technological factors such as market, social, and legal factors. It is not desirable - from the perspective of the prevailing science and technology innovation policies - for an R&D project into which massive resources and time have been invested to fail to achieve its expected outcome because of factors other than technological superiority.

In fact, the risk management concept has not yet been officially promoted in public R&D policy. This may be attributed in part to the fact that R&D is not a domain where visible damage is not incurred in terms of human and physical resources when an accident or failure takes place, as is the case with national backbone infrastructure facilities. However, the need to secure policy accountability to the people by maximizing return on R&D investment has been recognized as one of the critical elements as government in many countries invest substantial public resources in R&D projects. In such a context, it is necessary to actively introduce the risk management concept into the public R&D management.

This paper has a meaning in that it has reviewed the public role of R&D by re-interpreting public R&D policies using a risk management approach. From now on, additional research should be carried out based on case studies to more systemize and concretize R&D risk factors and the impact of these R&D risk factors that may arise in diverse fields, including the specifically moral R&D factors that this paper does not handle because further reviews are still required from diverse perspectives.

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