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Ex-ante Evaluation Process for Public R&D: Korean Case and its Implications for Indonesian R&D System

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Abstract A variety of approaches are being applied to improve the existing ex-ante evaluation by expert panels in publicly funded R&D. While the objective evaluation criteria are constantly being improved to screen and select the superior projects, alternative approaches such as random prioritization and logical modeling are also underway to overcome the conservative bias of reviewers and to secure disruptive innovation. This study intends to find critical implications for ex-ante evaluation of public R&D system from the comparison of Indonesia and Korea. For the comparative analysis, literature review and expert in-depth interviews are conducted on the national R&D system and the selection evaluation process. In Korea, the selection criteria of projects are legally promulgated for establishing an objective evaluation system, and at the program level, the major considerations in the planning process are specified by Presidential Decree. On the other hand, while Indonesia conducts R&D in 47 strategic fields largely by public research institutes (PRI) based on the non-competitive government contributions. This study draws out implications of institutionalizing the planning process at the level of program, and of increasing the ratio of contract-based competitive funding at the level of project in the national R&D portfolio.

Keywords National R&D Program, Indonesia, Ax-ante evaluation, Program, Project

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I. Introduction

As the share of innovative knowledge and technology in the creation of national security and wealth increases dramatically, the governments of modern advanced industrial countries are pouring a considerable amount of money into producing knowledge and technology. Policy resources are being put into building a system that can produce higher quality knowledge and skills more effectively. However, public funds have essentially always had spending limits due to the diversity of the fields that require it and the uncertainty of the external environment, so the government operates a management mechanism for public R&D investment. The R&D evaluation system is that management mechanism for fiscal input priorities and the distribution of limited resources, representing the view of how the state's governing system perceives its public R&D, along with the desire of securing its competitiveness through more innovative achievements.

Although the ex-ante evaluation of public R&D projects is certainly a means of screening out more innovative and profitable ones, it is vulnerable to the nation's financial conditions and tends to be affected by economic trends in the short term. Therefore, both the ex-ante evaluation as well as traditional ex-post evaluation are important concerning the accountability of public finances in public R&D projects, where the state's intervention is justified due to the market-failure in nature of R&D investment (Arrow, 1962; Duch-Brown et al., 2008; Klette et al., 2000). The ex-ante evaluation provides an important basis for securing national innovation by selecting more competitive research projects. Control for efficient use of limited finances and expectation for returns are the two main perspectives on public R&D.

The evaluation of public R&D is largely divided into program and project levels (Bulathsinhala, 2015). The purpose of this paper is to examine the selection process of programs and projects and how various criteria are codified in the public R&D system through literature review and case studies. The cases of Indonesia and Korea are compared, and implications are discussed by understanding the different contexts between the two countries (Figure 1).

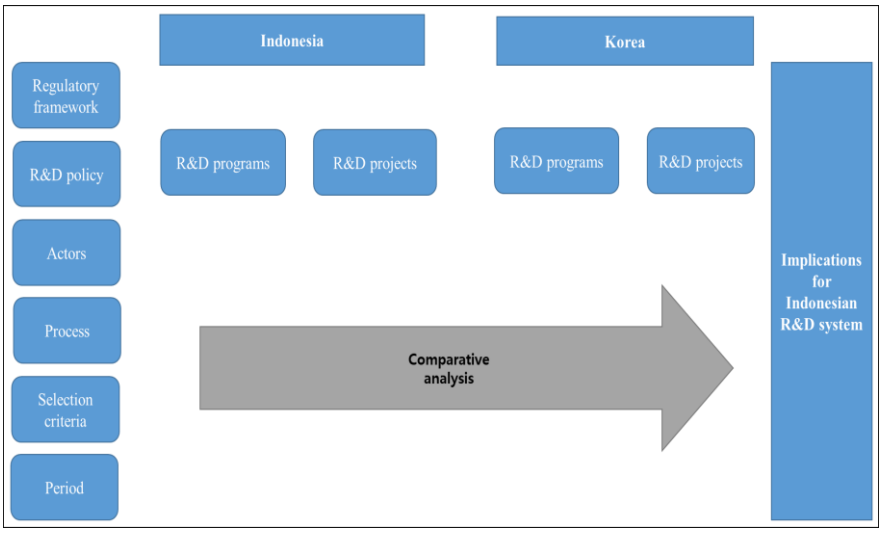


Figure 1 Research Framework

Although existing literature points to the importance of research on ex-ante review processes and evaluation criteria since the early 2000s, it seems that there are still insufficient empirical cases (Klenner et al., 2013; Roper et al., 2004). The reason for the lack of study on ex-ante evaluation is seemingly due to the difficulty in collecting data. According to Bulathsinhala (2015), (a) it is difficult to quantify the expected performance in ex-ante review compared to ex-post evaluation, which is evaluated after the research output is already available. (b) Since the evaluation process is often conducted in a relatively closed internal procedure by a small number of experts, there are not much available data about the process (Bulathsinhala, 2015; Roy, 1985). It is generally difficult to prove that a bias was involved because the evaluation of the referee is generally operated on a unanimous basis, and only the final report is accessible (Martin 1997).

Regarding the implications from a comparison between Korea and Indonesia, it is necessary to consider the economic development stage (e.g., adolescence or plateau) and industrial development model that influence the ex-ante evaluation from a macroscopic point of view. Korea is one of the representative countries that has taken a fast-follower strategy since the 1970s when it has increased public R&D investment. It was Japan that takes the lead in this path in East Asia, and China is now following the path. This is a traditional way for latecomers to quickly catch up with the leaders. South Korea has received great help in industrial development by implementing this strategy. The ex-ante evaluation process, currently settled in Korea's R&D system, is optimized to achieve this

incremental innovation. Whereas, it is another pair of shoes whether the system is suitable for securing radical and disruptive innovation. On the other hand, Indonesia was ever considered as one the Asian 'tiger economies' between the late 1980s and early 1990s that was predicted to progress through the flying geese pattern of development. However, the 1997-1998 Asian financial crisis has altered its development direction that has left its footprint until the present day.

The remainder of the paper is organized as follows. In Chapter 2, existing literature on the evaluation process and criteria were reviewed in the ex-ante process of publicly funded R&D. In Chapter 3, Indonesia's R&D policy and the ex-ante evaluation process at the program/project level were analyzed. In Chapter 4, Korea's current ex-ante process and historical transition of related decrees are studied. Chapter 5 concludes with the implications for the Indonesian R&D system.

II. Literature Review

While there has been scant research on the ex-ante evaluation process and criteria in public R&D, a few attempts have only begun in the late 1990s and 2000s (Klenner et al. 2013), based on the knowledge of ex-post evaluation that had been accumulating rapidly at that time (Bulathsinhala, 2015; Roper et al. 2004). In general, evaluation of certain projects tends to be carried out afterward; thus studies on ex-post evaluation have been conducted more systematically. The ex-ante evaluation has largely been based on the methodologies and experiences of the ex-post evaluation.

Bulathsinhala (2015) attempted to categorize the existing literature on ex-ante evaluation. According to his typology and other previous studies, the literature can be classified into the following types in terms of methodology.

(a) First of all, there is a methodological study on the expert panels, which is the most common type of ex-ante evaluation. There has been a relatively larger number of studies on the expert panel approach both in the ex-ante/ex-post process, as it is the most common method (Horrobin 1996; Rigby 2002). The evaluation by expert panels is a synonym for an evaluation method known as 'peer-review.' The term 'peer-review' is used in several different contexts, but it is widely used in the review process of the scientific treatise for publishing academic journals. The peer, being both a colleague of the academic community and a member of the evaluation committee, is considered a referee and editor of a submitted manuscript in the review process of academic journals (Martin 1997). As with the academic paper review, the evaluation of experts/peers exerts a key influence on the selection of R&D programs and projects, and this attribute

is criticized for being linked to a tendency of conservatism and risk-averse, making it difficult to find innovative research.

Rigby (2002) classified the expert review into various types. Pre-emptive review, one of those types, vests a sole right to experts in decision-making, but it is not currently widely used since the appointer (e.g., bodies of government) has no specific authority, even though the U.S. National Institutes of Health has conducted such an ex-ante evaluation before. Currently, a modified version of the traditional peer-review is largely being adopted, by asking experts to consider the social impact of research in a broader aspect. It is part of an effort in improving the limitations of the traditional peer-review to ask experts to use a series of evaluation criteria. The criteria of ex-ante evaluation include academic performance (also called a knowledge base) of basic/applied/ developmental research, R&D productivity, profits from commercialization, and knowledge transfer effects (Roper et al. 2004).

(b) The primary alternative is to use logic and mathematical modeling. Among the various studies, a few are listed as follows. There is a group of studies on Data Envelopment Analysis (DEA), which is a quantitative approach adopted mainly by private entrepreneurs (Duch-Brown., 2008; Linton et al., 2002). It is an evaluation method of organizational performance in business. There are also studies on the logic model that evaluates the outcome ex-post based on corporate financial data who participated in publicly funded R&D programs (Park et al., 2017). Some studies focus on the comparison of exiting mathematical approaches (Hwang and Yu, 1998).

(c) Another alternative to the peer-review is focal randomization. This approach means to adopt randomization when prioritizing among different projects to overcome the drawbacks of a conservative peer-review system. As an ex-ante evaluation method at the project level, the focal randomization regards unanimity of the review committee as a basic principle in the light of justification issues raised by the nature of random selection. The projects which all reviewers agree to be executed are adopted by priority, and the valueless projects deemed by all reviewers are eliminated. In this way, such cases where adoption and rejection are determined unanimously are excluded from randomization targets because there is no legitimacy issue. For the rest positioned in the middle, this is a study of how to adopt some of the projects randomly among them (Brezis, 2007).

The empirical studies except for methodology are as follows. There is a study on prioritization of projects in Danish energy program as an ex-ante process of publicly funded R&D (Bulathsinhala, 2015); categorization of evaluation indices for SMEs' R&D performance (Park et al., 2013); a process of strategic decision-making for product R&D by senior managers in business (Johnson, 1995). Klenner et al. (2013) also report typological findings of existing literature on how to detect disruptive innovation ex-ante in the field of private R&D.

On the contrary, as described above briefly, some studies focus on the drawbacks of the existing peer-review system from a critical perspective. The most representative is a group of studies on funding systems in the peer-review process (Heinze, 2008). These studies underline that the key issue in R&D management and policy is to unearth innovative research for expanding frontier and emphasize the importance of overcoming selection bias of referees. The funding system based on the expert panel is risk-averse and overfunds in mainstream research, thus having limitations to find unorthodox and ground-breaking projects (Brezis, 2007; Horrobin, 1996; Martin, 1997).

This is the question they raise. Is it possible to choose a *fundamentally* innovative research project or program under the current ex-ante process? Does the current peer-review system *structurally* enable such selection (Horrobin, 1996)? These skeptics recognize the existing peer-review system as elitism and a Kuhnian ruling paradigm and criticize its bias. These fundamental questions are beyond the scope of this study, but it is necessary to be mentioned as key issues in the ex-ante evaluation process.

III. The Ex-ante Process in Indonesian R&D System

1. R&D Policy and Regulatory Framework regarding Indonesia's R&D Programs and Projects

Current R&D programs and projects in Indonesia are based on two key R&D policy documents, which are the National Research Master Plan (2017-2045) (hereinafter RIRN) and the National Research Priority (2020-2024) (hereinafter PRN). RIRN provides long-term research and development (R&D) policy direction aimed at increasing Indonesia's national competitiveness. RIRN was prepared by taking account of other national development policies such as the Master Plan of National Industry Development (2015-2035) (RIPIN), the National Energy Policy (KEN), and the Master Plan of National Creative Economy) (RIEKN). RIRN takes a sectoral approach to R&D development, focusing on nine research areas. These areas include: Food and Agriculture, Health and Medicine, Transportation, Information and Communication Technology, Defense and Security, Advanced Materials, Maritime, Disasters, and Social and Humanities-Cultural Arts-Education (Ministry of Research, Technology and Higher Education, 2017). RIRN promulgates ambitious five-yearly targets, for example, increasing the contribution of R&D expenditure to Gross Domestic Expenditure from 0.20% in 2015, to 0.84% in 2020, and to 5.04% in 2045. A set of targets and budgets are laid out for each research focus area in the RIRN. However, the targets of RIRN may be difficult to realize due to

uncertainty over the sources of funding for R&D, something which was a concern in the institutionalization process of RIRN. The RIRN was intended to have a locked R&D budget, but the key clause related to the budget was finalized to include flexibility within the ceiling of budget allocation for R&D stakeholders from the public sector (Setiadarma, 2018). The COVID-19 pandemic could be another factor hindering the achievement of RIRN targets, as R&D resources have been refocused to support R&D activities in the Health and Medicine sector.

Before the establishment of RIRN, or between 2006 and 2017 in particular, Indonesia had no long-term R&D policy. The National Research Agenda (ARN), a five-year R&D plan, served as the basic guideline for R&D development in Indonesia. Under the ARN scheme, the National Research Council (DRN) had the main role in formulating and coordinating R&D policies, as stipulated by Law 18/2002 on the System of Research, Development, and Application of Science and Technology. However, the role of DRN has been later weakened by Law 19/2019 (the revision of Law 18/2002) on the National System of Science and Technology (Yim et al., forthcoming). On the other hand, the role of the Ministry of Research, Technology, and Higher Education (MORTHE)[1], has been reinforced.

PRN (2020-2024) is the operational plan of RIRN, and it currently serves as the operational guideline for R&D programs and projects in Indonesia. PRN was developed according to the procedures described in MORTHE Decree no. 36/2018 on the Development of Procedures for PRN and the Implementation, Monitoring and Evaluation Mechanism for RIRN. Later, PRN was finalized in MORTHE Decree no. 38/2019 on National Research Priority (or PRN) 2020-2024. However, it is found that these ministerial regulations do not specify the selection criteria for national R&D programs under PRN. Instead, monitoring and evaluation mechanism for long-term R&D policy was briefly mentioned in the MORTHE Decree no. 36/2018. Under the umbrella of the nine research areas of focus, PRN is implementing 30 research themes and 47 national flagship R&D programs for the next five-year period (2020-2024). In the formulation process of PRN, 80 themes and 416 programs were proposed through surveys involving related stakeholders - mainly public actors. The research themes and R&D programs in PRN were selected after inter-ministerial coordination meetings and consultations with public R&D institutions (PRIs) and other stakeholders. In the formulation process of PRN, instead of MORTHE, the Ministry of National Development Planning (MNDP/BAPPENAS) took the initiative to organize the coordination meetings. Given its main responsibility, MNDP also tried to align PRN with the Medium-term National Development

1 The name was changed to Ministry of Research and Technology (MORT) in 2019.

Plan (RPJMN) 2020-2024. Meanwhile, MORTHE was mainly responsible for collecting proposals for R&D programs.

The funding mechanism for the implementation of R&D programs under PRN is distinctive from that of the Republic of Korea. This mechanism is indeed one of the major challenges that Indonesian government should address. In the context of Indonesian R&D policy, there is no specific funding for the implementation of PRN, meaning that there is no open call for proposals for national R&D programs under PRN (Yim et al., forthcoming). Instead, funding opportunities are available on a competitive basis from national, such as the Indonesia Endowment Fund for Education (LPDP), and international funders. For the most part, however, public research institutions have to allocate their own research budgets in order to develop and implement R&D projects related to the national R&D programs under PRN. This type of funding scheme for national R&D programs under PRN makes the ex-ante process of national R&D programs and projects in Indonesia distinctive from that of the Republic of Korea.

2. The Ex-ante Process at the Program-level

2.1 Process and Selection Criteria

The process of determining research themes and programs in PRN was conducted through both top-down and bottom-up processes. The top-down process refers to the elaboration and synchronization of research themes and programs with the national strategic policy, while the bottom-up process aims to facilitate the perspectives of stakeholders, i.e., researchers, experts, and industries. However, little is known about the extent to which the stakeholders involved have fully recognized and addressed the most important issues in and the different geographical settings of the country. The last matter is important since Indonesia is a vast archipelagic country in which each province may have different development problems and issues that require more nuanced approaches.

In the first phase, the formulation process generated wide-ranging results with 80 themes and 416 research programs. In order to narrow down and make these more specific, a series of surveys and analyses, as well as expert judgment (top-down process), were performed. Based on the urgency level and its feasibility, the final PRN agenda consists of 30 themes and 47 research programs, targeting 49 outputs (also called National Flagship). The selection process of the National Flagships used the following criteria: 1) the excellence of ministry/non-ministerial institution; 2) economic impacts (market/demand-based); 3) the implementation of laws and regulations; 4) the conformity with national strategic policies; 5) improving national competitiveness; 6) the availability and

capacity of science and technology actors as well as the supporting facilities and infrastructures; 7) involving national/ international collaborations; and 8) downstream readiness.

It is intended that 70% of the national R&D budget is allocated to the National Flagship, while the rest is allocated to ministerial/non-ministerial institution flagships. This indicates how the national government puts a high priority on research related to PRN themes. However, up to recent, there is no clear mechanism from which source of budget this National Flagship will be funded. As discussed earlier, this implementation seems to be far from the initial intention because there is no specific research funding provided for PRN.

Regardless of this funding mechanism, the National Flagship is conducted in the form of a research consortium so as to promote collaboration among actors. One flagship is led by one ministry/non-ministerial institution and each consortium member works on one or more key technologies. The research budget is attached to each member institution, and the amount of this budget depends on the division of labor among the actors or the key technologies being / will be developed. Given its 'self-sufficient' nature of budget allocation, all (government) institutions involved must prioritize their (institution) research budgets to be allocated to the National Flagship. If an institution faces a budget shortage, MORT and the Ministry of Finance (MOF) may provide (indirect) funding assistance.

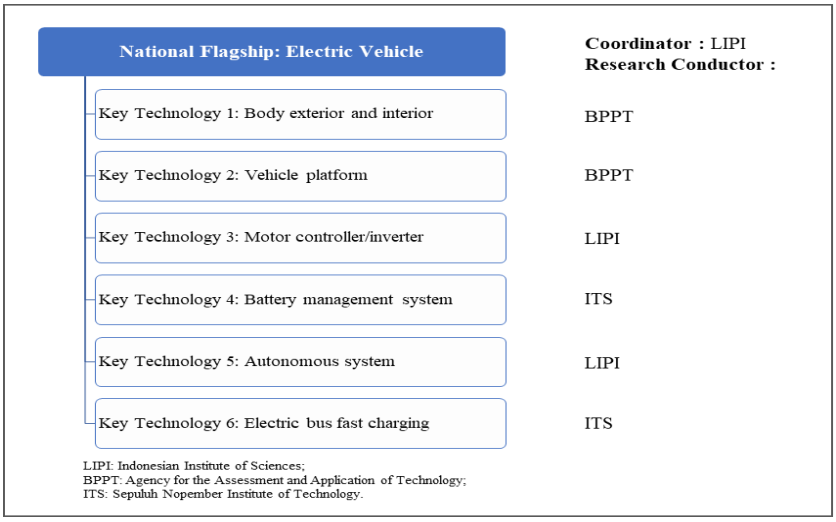


Figure 2 Example of National Flagship

Since PRN serves as the operational plan of RIRN and generated more concrete and detailed directions, it has a plausible initiative to encourage

research collaboration in Indonesia, thus decreasing the possibility of research overlaps and leading to product downstream. These two issues have been a fundamental problem of the R&D process in Indonesia for many years. In general, the selection process has tried to be carried out based on certain criteria. However, it seems that the ex-ante evaluation process was not carried out in-depth, especially the economic and social aspects of each program. As a case in point, the economic impact of the electric vehicles program has not been carried out in detail, such as gauging the economic feasibility of electric vehicles, cost and benefit analysis, environmental assessment, urban mobility implication, and other related socio-economic aspects. On the contrary, although some criteria have been considered, the final decision on the selected themes and programs was based more on the results of negotiations between the national government (MORT, MNDP, or other ministries) and implementing institutions (mostly public R&D institutions). Given this point, it is evident that the formulation and selection procedure of the R&D programs have been often conducted based on opportunity rather than a well-design assessment.

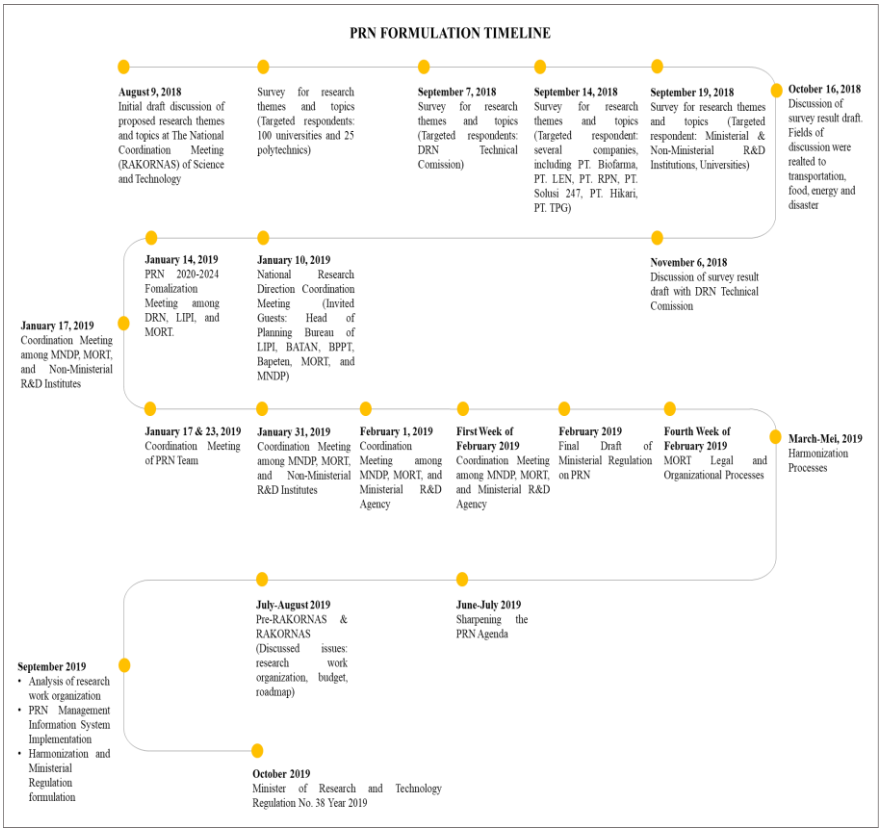
2.2 Actors / Stakeholders

There are at least four main parties involved in the formulation process of PRN. The Ministry of Research and Technology (MORT / BRIN) – playing a key role in R&D governance in Indonesia – coordinated the whole process of formulating PRN 2020-2024. Another ministry that also plays a strategic role in the formulation process of PRN is the National Development Agency (MNDP/ BAPPENAS), which is responsible for ensuring the conformity of PRN to the national research agenda, especially within the RPJMN framework. As discussed earlier, it was MNDP that took part in MORT's main responsibility when coordinating the formulation process of PRN. Meanwhile, budget allocation, monitoring, and evaluation of R&D are held by MOF. There is, however, no special body that wields specific responsibility in leading the formulation and implementation process of PRN. This situation is different compared to that of the Republic of Korea. Moreover, as mentioned above, the stipulation of PRN themes and topics (or research programs) also involved a number of experts, researchers, and industries. The involvement of the last stakeholder, however, was minimum.

The formulation process of PRN is complex in nature, entailing a long period of formulation and involving various parties with different roles and concerns. The nature of dominance and power relation between involving parties is different from one theme/program to another. This strongly depends on the different concerns, interests, and capacities of the parties. We will elaborate on this further by using two cases.

2.3 Time Horizon

The initial process of PRN formulation, starting from mid-2018, as shown in Figure 2, consisted of several meetings and surveys with related stakeholders. This series of discussions continued until 2019 and produced several themes and research programs that were later legalized into ministerial regulation (MORTHE Decree no. 38/2019). Although these programs have been stipulated in the ministerial regulation, the nature of research programs is quite dynamic: changes and iterations of the programs can still occur.



Source: Ministry of Research and Technology, Indonesia (2019)

Figure 3 PRN Formulation Timeline

3. The Ex-ante Process at the Project-level

The Ministry of National Development Planning (MNDP) invited public research institutions (PRIs) and universities to discuss and determine who does

what in what fields. The MNDP then determined which products/outputs are selected as PRN's products/outputs in each field. As mentioned earlier, in total, there are 49 products being generated within the next five years under the National Flagship of PRN. These products include superior plants and livestock, medicines and vaccines, seaplane, high-speed train, electric vehicle, etc. Institutions that have already had research projects on certain products and are seen to have the expertise in leading the projects were selected as the coordinators. Subsequently, a ministerial decree was issued regarding PRN 2020-2024 activities: MORTHE Decree no. 38/2019. This decree outlines the programs, outputs, and implementing institutions for each program. While the coordinator for each program is clearly stated, the implementing member institutions from universities and industries are not specifically identified.

In the project-level process, the actors involved are MORT/BRIN, the research program manager/coordinator, and implementing member institutions. Implementing members consist of PRIs, universities, and industrial actors in general. Members involved in each program differ from one program to another. One program may consist of one or several institutions and projects. A business actor is usually involved only in programs related to scale-up or commercialization. In the project-level process, there are no dominant actors because every implementing member carries out its own project (funded internally or externally). The coordinator's authority was not explicitly and clearly stated. Generally, the coordinator determines the number of projects and members involved.

In general, the program coordinator, together with the members, determines the research roadmap served to achieve the desired output(s)/product(s). As discussed above, each research program is detailed into several projects, and each project, if needed, can be further detailed into two or smaller projects, namely activities. However, the process of determining the roadmap (number of projects and actors involved) is different for each program. For example, in the "Processed Food Packaging Technology (Ready to Meal)" program (Figure 3), a roadmap was prepared by assessing the key technologies needed as well as the roles and capabilities of each member. Quite the contrary, in the "Electric Vehicle Technology (Small and Medium Bus)" program coordinator has difficulty in collaborating with other (potential) members and determine the roadmap. This is due to the dominant role of MORT / BRIN in this program so that this ministry can change the program output suddenly. Research program members (including coordinator), however, are still given rooms to negotiate the desired output. Unfortunately, several universities that have the core competencies in this particular field, and should be therefore part of the implementing members, have not received any detailed information about PRN and the existence of this program. As a result, the expected collaboration to

produce the desired product has been so far remaining an important issue that needs to be addressed.

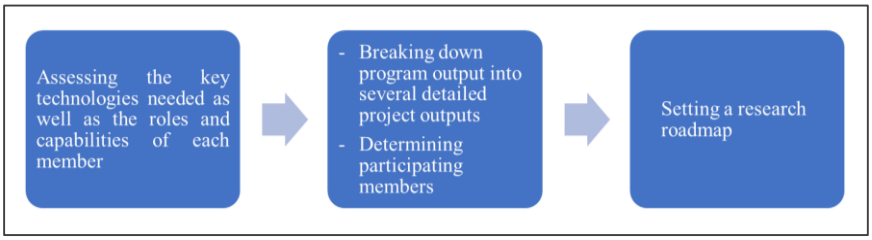


Figure 4 Process setting research roadmap in "Processed Food Packaging Technology (Ready to Meal)" program

As have been discussed earlier, no robust ex-ante evaluation for each research program and project has been carried out. This can be clearly seen through the time spent on project-level assessment. In particular, the time needed in the ex-ante project level process was approximately 1 month. The MORTHE Decree no. 38/2019 on PRN was issued on October 22 2019 and less than one month later (November 18, 2019) MORT / BRIN held socialization of PRN 2020-2024 at the National Coordination Meeting in which the research projects were already completed. MORT / BRIN does not provide any standard criteria to select a research project; accordingly, each program coordinator has the authority to do the selection process. The selection process is carried out by considering the specificities and capabilities of potential institutions (PRI, university, industry, non-governmental entity) as well as the compatibility between the research program's desired output and the potential output(s) generated by these institutions.

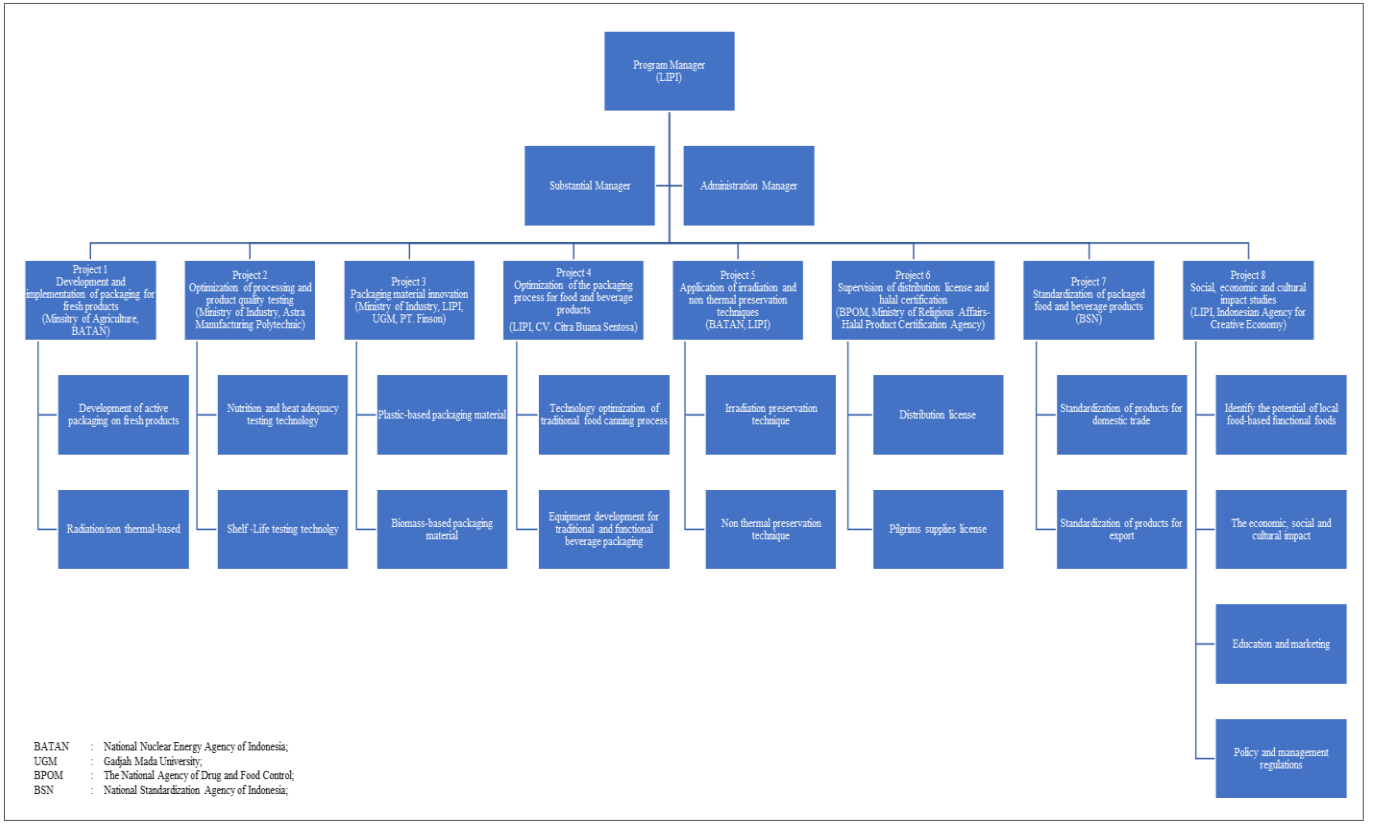


Figure 5 Example of "Processed Food Packaging Technology (Ready to Meal)" Program Structure

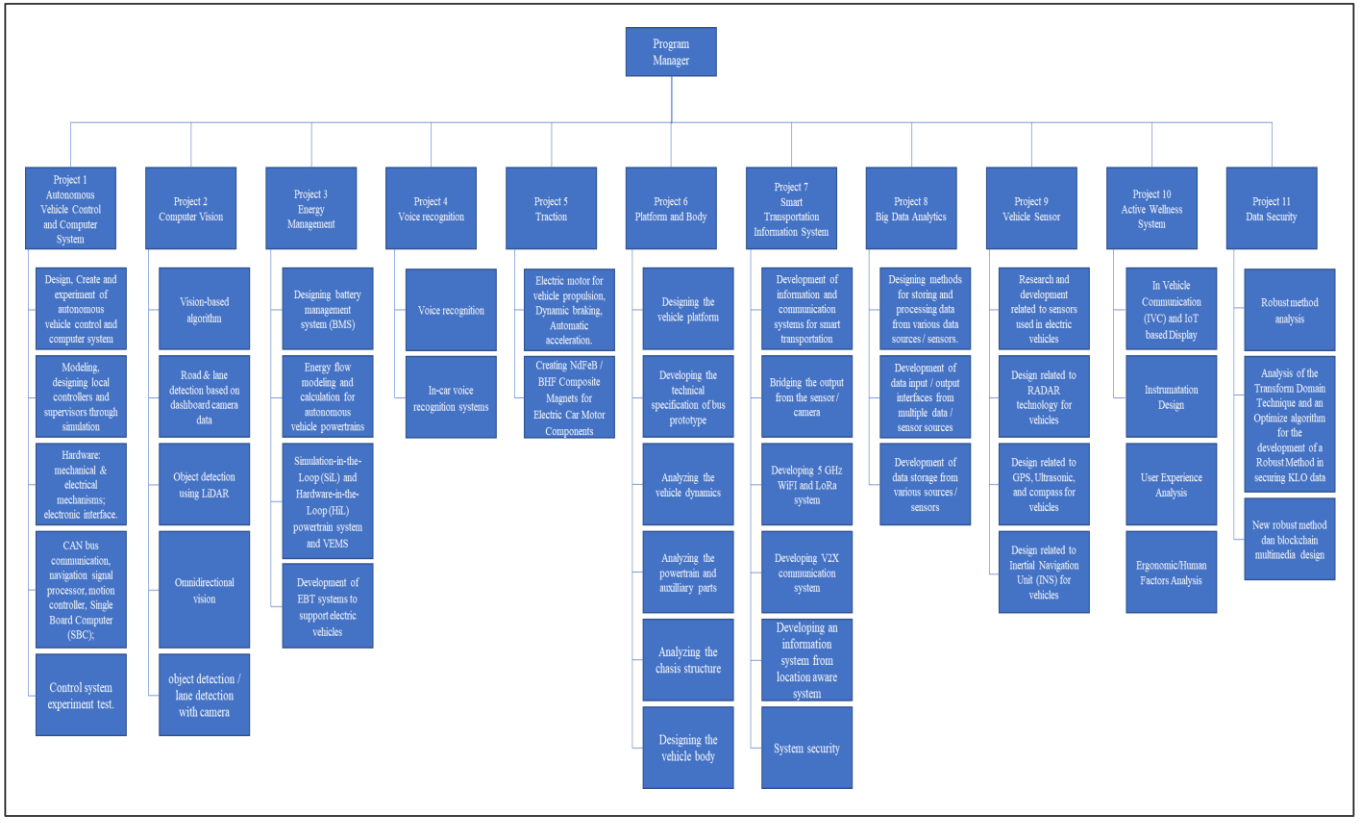


Figure 6 Example of "Electric Vehicle Technology (Small and Medium Bus)" Program Structure

IV. The Ex-ante Process in Korean R&D System

1. R&D Policy and Regulatory Framework regarding Korea's R&D Programs and Projects

There are also laws and strategic plans for the ex-ante evaluation of national R&D projects. The master plan for evaluation is contained in the 'Act on the Performance Evaluation and Management of National Research and Development Programs, etc.' as a law, and the 'Master Plan for National R&D Performance Evaluation' as a national initiative, but these mainly put a focus on the ex-post evaluation.

There are presidential decrees, 'Regulation on the Management, etc. of National Research and Development (R&D) Projects,' and the 'Enforcement Decree of The Framework Act on Science and Technology,' which give more concrete institutional mechanism of the ex-ante evaluation. As a more direct institutional mechanism for the ex-ante evaluation, there are a couple of presidential decrees such as (a) Regulations on the Management, Etc. of National Research and Development Projects, (b) Enforcement Decree of The Framework Act on Science and Technology. The Regulations on the Management, Etc. of National R&D Projects was enacted on December 19, 2001. It has been amended 41 times over the past two decades, and it has changed considerably in the scope and content covered by the regulation. The 2001 Regulations on The Management, etc. of National R&D Projects (Presidential Decree No. 17429) just regulated the ex-ante evaluation at the *project* level, and subsequently, the provisions regarding planning and evaluation at the program level were added. The evaluation criteria have also been refined.

While regulations on the Management, Etc. of National R&D Projects promulgates the planning process of general R&D projects, the Enforcement Decree of The Framework Act on Science and Technology regulates the large-scale programs particularly. The parent law of the Enforcement Decree of The Framework Act on Science and Technology is the 'Framework Act on Science and Technology,' which is corresponding to the S&T master plan in Korea. In article 12-3 of the Framework Act on Science and Technology, the large-scale program is defined based on the 'National Finance Act' (MSIT, 2018a).

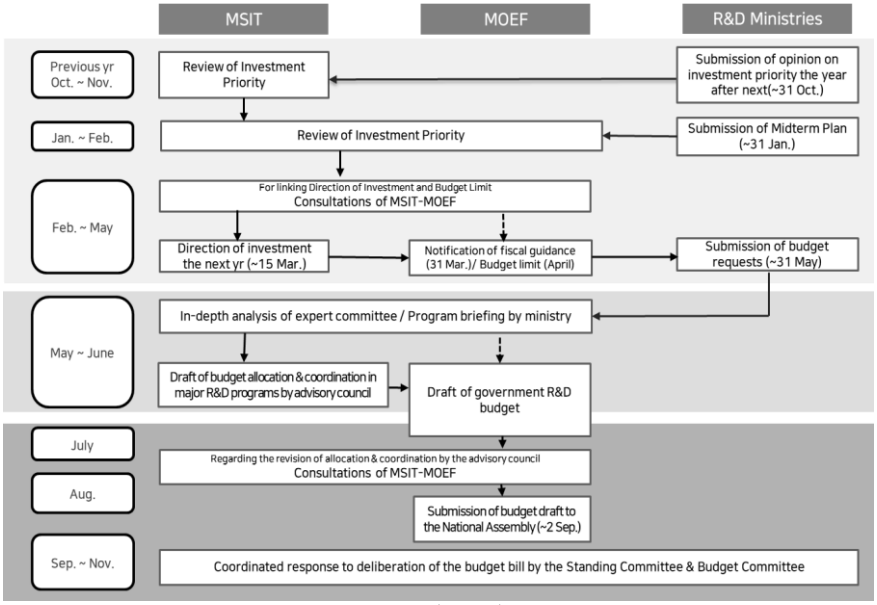
According to article 38 of the National Finance Act, the Minister of monetary authority shall conduct a preliminary feasibility survey on the *large-scale* program, the total project cost of which amounts to at least 50 billion won ($45 million), at least 30 billion won ($27 million) of which is to be subsidized by the State (MOEF, 2018). As with the large-scale infrastructure projects of construction and information, national R&D programs are also separately added

in the law as the total project cost increases rapidly due to the establishment of large-scale research facilities and equipment.

The Framework Act requires the responsible department of S&T to conduct technology evaluation of departmental R&D project before the Minister of monetary authority select projects subject to a preliminary feasibility study. The monetary authority is supposed to select projects subject to the preliminary feasibility study from among the projects with suitability after the evaluation (MSIT, 2018a). Last but not least, the Enforcement Decree of The Framework Act on Science and Technology regulates specific criteria for technological evaluation. There are four evaluation items: (a) Necessity and urgency for technology development; (b) Specificity of project plans; (c) Similarities to or redundancy with existing projects; (d) Suitability of support from the national treasury (MSIT, 2018b).

2. The Ex-ante Process at the Program-level

The ex-ante process of the national R&D programs begins with proposing a departmental 5-Year Midterm Plan to the monetary authority (Ministry of Economy and Finance, MOEF) and the responsible ministry of science and technology (Ministry of Science and ICT, MSIT). The ministry of S&T reviews an investment priority among departmental programs and discusses the setting of investment guidance and budget limit with the monetary authority. Once the departmental limit of the R&D budget is set by the monetary authority, the ministry of S&T establishes the next year's investment guidance (e.g., direction, criteria and etc.) and notify each ministry. The applicants work on budget requests reflecting the new programs by referring to that guidance and expenditure limit and submit it to the ministry of S&T.



Source: Ministry of Science and ICT, Korea (2020a)

Figure 7 Process of National R&D Budget Allocation & Coordination

The budget for departmental R&D programs is compiled through a process of feasibility evaluation. In particular, it is mandatory for large-scale programs with a total expenditure of over 50 billion won ($45 million) and a subsidy of over 30 billion won ($27 million) to conduct a preliminary feasibility test. Items for the test and other general considerations in the planning process will be addressed in more detail later. The draft budget of government R&D is established after the departmental allocation and coordination process. The monetary authority compiles a budget in practice based on the draft, followed by deliberation and confirmation of the budget bill by the National Assembly.

The 2001 Regulations on the Management, Etc. of National R&D Projects (Presidential Decree No. 17429) did not regulate any ex-ante evaluation at the *program* level, and subsequently, the detailed provisions regarding planning were added. Since the program is established by the government without a competitive process between various actors, it seems that the planning process is greatly emphasized, without separate ex-ante evaluations.

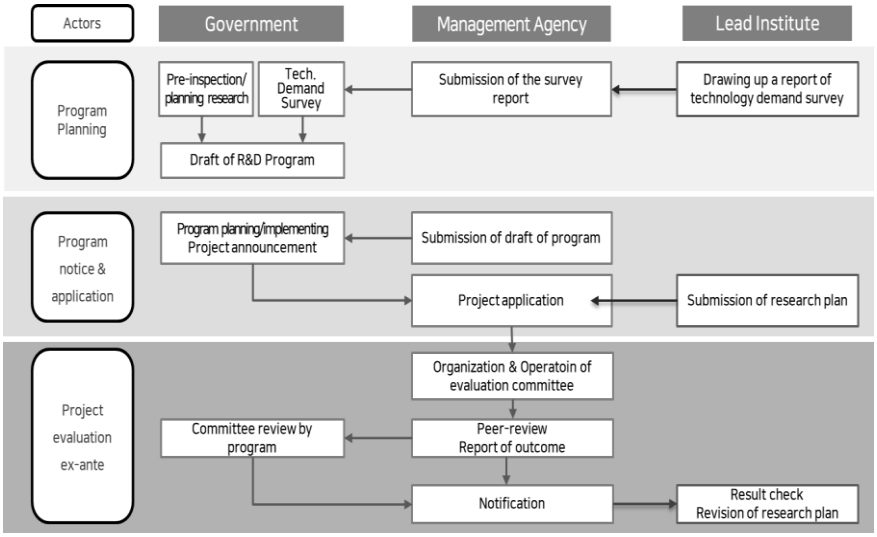
The Regulations on the Management, etc. of National R&D Projects stipulates the mandatory considerations for planning as below (MSIT, 2017):

(a) Objectives of the national research and development project, details of, and system for, the promotion thereof;
(b) Measures for adjusting matters related to affairs under the jurisdiction of

any other central administrative agency
(c) A plan for evaluation of the national research and development project;
(d) The scale of resources required and measures for securing human resources;
(e) Outcomes of feasibility study on Governmental support;
(f) A plan to utilize the outcomes of research and development and the expected effects thereof;
(g) Trends in patent, technology, standardization, and standard patent in or out of the Republic of Korea.

3. The Ex-ante Process at the Project-level

At the project-level, in general, the request for proposal (RFP) of each research project is established in the process of planning the higher program.[2] Research management agencies make project announcements using the RFP, and researchers from university-industry-government apply for them with their research proposal. The ex-ante evaluation proceeds with the received proposals, leading to the final result being confirmed and notified.



Source: Ministry of Science and ICT, Korea (2020a)

Figure 8 Process of Selecting National R&D Projects

2 In the case of project selection below, it should be noted in advance that it is described for the competitive entrusted projects, ruling out the institutional contribution based on non-competitive funding.

The selection process at the project level is very different from that of the program. While the selection of a project is generally organized from the perspective of excellency, the research program is mainly evaluated by its priority and feasibility among departmental programs under the budget limit. Even if it is recognized to be superior, it may be difficult to conduct the program due to the budgetary shortfall.

The Regulation of National R&D projects stipulates criteria of the ex-ante evaluation for a project as below (MSIT, 2017):

(a) Creativity and faithfulness of a research and development plan;
(a.1) Connectivity with the objectives of a national research and development project;
(b) Levels of research environments, such as human resources, facilities, and equipment for research;
(c) Overlapping with any research and development task which has been promoted or is being promoted as national research and development;
(d) Adequacy of the security levels;
(e) Adequacy of installation of research facilities and equipment;
(f) Possibility of linkage and cooperation in or out of the Republic of Korea in performing the research and development task;
(g) Effects resulting from the outcomes of research and development;
(h) The usefulness of the outcomes of research and development, such as technology transfer, commercialization, and follow-up research;
(i) Levels of research capacity and research ethics of a person in charge of research;
(j) Whether any publicly announced technology or intellectual property right exists.

Following these regulations, the ex-ante evaluation criteria for projects are, in practice, generally composed of the excellence and originality of the research plan, the capabilities of PI and researchers, and the expected impacts. There is a slight difference by programs. It can be seen that there is not much deviation from the regulations by the examples of Bio & Medical Technology Development Program and New & Renewable Energy Technology Program below (Table 1; Table 2).

Table 1 Evaluation Indicators for Projects of Bio & Medical Technology Development Program

Category	Indicators	Points
Research Plan (35)	Creativity and innovation based on the adequacy of social/industrial demand	20
	Feasibility of a research plan - Conformity with the announcement - Clarity of research goal - Adequacy of research details and implementation Structure	15
Research Competence (25)	Research experience and performance of PI and collaborator - Adequacy of PI regarding the research - Competence of PI to conduct a research	25
Performance Utilization (40)	Possibility of securing core technology and expected impacts - Specificity and validity of the core technology acquisition plan - Value of research performance, Impact on scientific community, people, and industry	20
	Adequacy of performance strategy - IPR strategy, Technology transfer, Roadmap for commercialization, etc.	20
Total		100

Source: Ministry of Science and ICT, Korea (2020b)

Table 2 Evaluation Indicators for Projects of New & Renewable Energy Technology Program

Type	Categories	Indicators
Core Technology	Excellency of Technology (60)	▪ Difficulty and creativity ▪ Creativity of method and strategy * Job creation plan
	Research Competence (30)	▪ Competence of organization including PI
	Commercialization and Profitability (10)	▪ Commercialization plan and volition ▪ Social and economic impact (value creation)
Innovative Products	Excellency of Technology (45)	▪ Difficulty and creativity ▪ Creativity of method and strategy

	Research Competence (30)	▪ Competence of organization including PI
	Utilization of Manpower (10)	▪ Utilization of manpower * Job creation plan
	Commercialization and Profitability (15)	▪ Commercialization plan and volition ▪ Social and economic impact (value creation)

Source: Ministry of Trade, Industry and Energy, Korea (2020)

V. Conclusion

The ex-ante evaluation of public R&D is largely conducted by the expert panels, and the evaluation criteria are constantly being improved for securing objectivity. This expert system is the modified version of the traditional peer-review (Rigby, 2002). However, it is reported that it is still rare to grant sole rights to expert panels or conduct R&D programs based on the complete mathematical/logical modeling. Since recent theoretical studies on the alternative approaches, such as random prioritization and another logic model, are underway, some novel works are expected to be followed in the field of the ex-ante evaluation system.

In this study, it is found that there are relatively few stakeholders get involved in the establishing process of R&D programs in Indonesia, and furthermore, there is a lack of alignment with the following projects. It is also difficult to confirm the well-structured planning process of program-level; this is, in part, attributed to the closed characteristic of the program planning process by inner-circle. However, from the perspective of the National Innovation System (NIS), the essential cause lies in the vulnerable industries, the absence of an organic collaboration network among industry-university-institute, and the lack of innovation support agencies.

As for the ex-ante evaluation system of Korean R&D, as a modified peer-review, it is highly structuralized by its detailed evaluation items, indicators, and points. In both general R&D projects and the large-scale programs of over 500 billion won ($45 million), the evaluation criteria are even stipulated by the Presidential Decree. As such, the minimum objectivity and legitimacy are secured by presenting evaluation criteria to the expert panels. In addition, this paper explicitly outlines the process of program planning and project evaluation in Korea.

The comparison of Korea and Indonesia has the following implications: (a) While, at the program level, neither side has an ‘elimination match,’ the Korean

R&D system regulates a planning process of programs in detail. This is because the programs are implemented by government departments, and it is reasonable for each ministry to emphasize the planning process of R&D programs for cost-benefit efficiency under its budget limits. In Korea, at both the program and project levels, the planning process and selection criteria are legally promulgated, and thus, have legal force. The institutional framework as such, if not fundamental innovation, can at least lay the foundation for incremental and exploitative innovation. (b) On the other hand, another critical difference is that there are scant competitions for project selection in Indonesia, compared to Korea, where the competitive entrusted projects account for a large portion of the total R&D budget by so-called the Project-based System (PBS). Most Indonesian PRIs, on contrary, plan a variety of projects autonomously with their own budget, and these non-competitive projects account for most of national R&D. Where the competition system develops, the selection criteria tend to be specified in order to secure objectivity. Despite the much controversy over the pros and cons of the PBS, it seems to have somewhat contributed to the development of the ex-ante evaluation system. Given the implication, it seems necessary to increase the proportion of entrusted projects in Indonesia's national R&D. The well-diversified national R&D portfolio is required to be established by rearranging the proportion of government-funded non-competitive projects (government contributions) and competitive entrusted projects.

The challenging issues that the Indonesian R&D system faces are as follows. Besides some concerns that have been mentioned above, other challenges also occur in the ex-ante evaluation process, such as (a) Monitoring and evaluation system of both research program and research project is not established yet. Therefore, no standard indicator to examine the success of research outputs. (b) MORT/BRIN does not have the authority to regulate research budget allocation, and thus, they do not have a strong position in managing research activities conducted by other ministerial/non-ministerial research institutions. Although Indonesia set and conduct R&D for the 47 national flagships/ products that correspond to the concept of strategic industries, the absence of the R&D control tower makes the ripple effect limited.

In essence, the question of whether the current R&D selection process can manage to unearth and fund ground-breaking research is not a unique issue just for Korea and Indonesia. This is a common concern even in countries with the most advanced research management systems. As the peer-review system tends to tilt to the side of traditional fields rather than the emerging ones, there are a variety of biases in the ex-ante evaluation process. This path-dependent bias, as a resistance to innovation, in specific areas for each scientific field, needs to be resolved. In the field of biomedical science, for example, there is a structural imbalance that the academic environment is more favorable to basic research than clinical discipline (Horrobin, 1996). However, what this study is trying to

convey is that a primary 'skeletal system' needs to be built to avoid the worst-case scenario, even if the best option is not available.

In principle, there are some aspects of South Korean experiences that can be used as a starting point to improve the Indonesian ex-ante evaluation system. However, there should also be a better understanding of the context within which the Indonesian R&D system has been nurtured and shaped, given the different political, economic, and socio-cultural settings between the two countries. As many have noted, the 1997-1998 Asian financial crisis has created a massive disturbance to the Indonesian political and economic landscapes, including the country's R&D foundation and trajectory (Sampurno-Kuffal, 2011; Thee, 2012). It was just about a decade ago that the country has been able to bring the R&D sector back on the national priority agenda. The current PRN framework is, therefore, a policy product that has not reached its maturity stage yet. PRN's initial concern is to improve the collaboration between different parties that were considered to be lacking in the ARN's policy (2006-2017) (Oey-Gardiner, 2011). Establishing a robust R&D (ex-ante and ex-post) evaluation system is thus considered as an area that needs further attention by the government. Not only the quality of R&D program and project will be potentially improved, the existence of such a system may also help to better integrate R&D development and economic development, thus potentially generating more economical and social impacts. Last but not least, the difficulty of quantification is another limitation of this study. The comparative study of the ex-ante evaluation for the R&D system between Korea and Indonesia does not cover quantitative analysis as there is a lack or absence of quantifiable data regarding evaluation indicators for National R&D Programs and Projects in Indonesia.

It is also necessary to reiterate that the Indonesian case is analyzed based on ex-ante evaluation of the R&D system under Indonesia's current mid-term R&D policy, PRN 2020-2024, not the previous policy, i.e., National Research Agenda (ARN), that was used as national R&D policy framework between 2006 and 2017. The ex-ante evaluation of R&D programs and projects under the ARN can be an additional research topic. As regulatory framework is a key element to institutionalize the whole-cycle of national R&D by ensuring its efficiency, a more in-depth analysis on the regulations is expected to be followed for the establishment of working R&D governance in Indonesia.

National R&D is not just a matter of science and technology. This is more fundamentally related to the industrial development model. If the development model is in the form of emulating or chasing the advanced countries (catch-up or fast-follower strategy), this group of countries will devote a large portion of their financial resources to the catch-up strategy. This policy direction leads to the following results. The application and/or development is emphasized, rather than basic research, which requires a long period of time, in the R&D stage, and

the incremental innovation strategy is adopted rather than a radical one from the perspective of innovation type. In this regard, the Indonesian government has not specified any clear development model as well as sector/industry priority that may complicate the country's R&D focus. As noted above, the long-term effect of the 1997-1998 Asian financial crisis has also forced the Indonesian economy to break from the previous path, mainly the one that had been gradually built under President Suharto's government (1967-1998).

The R&D system in Korea, historically, is optimized to achieve this incremental innovation. Although the question of whether the system is suitable for securing radical and disruptive innovation is in a different category, it is a subject that requires an elaborate study, at least to systemize the ex-ante evaluation. Indonesia is also expected to gain implications for the establishment of such a selection evaluation system from the case study of Korea. As for Indonesia, to put it briefly, it is important to set well-defined priority criteria for projects and to expand collaboration among industry-university-institute-government actors in R&D program planning and project selection process. This will be a cornerstone for co-evolution in the Indonesian system of national innovation.

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