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Letter from the Editor-in-Chief

The past several decades have seen a remarkable appreciation of worldwide national R&D investment. The importance of R&D policies has prevailed in the academic and political arenas due to their significance for national and industrial competitiveness. The R&D budget accounts for a significant portion of government expenditure. This trend is especially conspicuous among Asian countries with rapid economic growth. For instance, Korea has tenaciously focused on R&D investment to enhance its international competitiveness. Present government expenditure on R&D in Korea is four times more than that of a decade ago. Korea is now ranked 5th in the world in terms of R&D investment. Japan meanwhile boasts of its massive investment into R&D, which is ranked second. In terms of PPP (purchasing power parity), it is often argued that China has surpassed Japan in R&D investment.

The rapid increase of investment in R&D in both public and private sectors has made policy makers focus on its effectiveness. The causal relation between investment in R&D to the output of scientific knowledge as well as its application in state of the art technology has often been called into question. Sometimes R&D policy is highly influenced by political factors due to the complexity of the issue and its uncertain return on investment. In spite of abundant research on R&D policy related issues, a universal understanding of research policy issues still remains elusive. Furthermore, in spite of the rapid increase in R&D expenditure, understanding of the relationship between the social benefits and the costs of R&D investment is very limited. In particular, the literature of R&D management and policy has not drawn much attention to the uniqueness of Asian R&D and innovation activities.

Asian Research Policy (ARP) seeks to provide a dynamic forum to attract ideas and research findings from those interested in Asian R&D policies. It is available for wide-ranging debate and stimulating argument on research policy. Not only academic researchers but also policymakers in R&D can contribute their intellectual endeavors to the journal. Theory development, theory-based empirical research, comparative analysis, policy ideas and evaluation, and other data and information related to research policy will be covered within the journal. The main contents of the journal consist of contributed articles, articles developed from conference papers, book reviews, science and technology trends in Asia, and various comparative information and data-related to global research policies.

At its birth, the journal's editors gratefully acknowledge the leadership of Dr. June Seung Lee, President of KISTEP, who encouraged its inauguration and provided enormous moral, intellectual, and material support. Without the institutional and administrative assistance of KISTEP, the birth of this journal would have been almost impossible. Despite KISTEP's large contribution, however, ARP is not an official journal of KISTEP, but an independent academic journal for academic scholars and policy practitioners who are interested in Asian research policy.

I hope ARP can evolve as the major academic journal in Asian research policy. Readers, contributors, and editors should cooperate for this purpose. Although it seems imperfect at inception, ARP will take leadership of pioneering research and stimulating argument about R&D policy in Asia.

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A brief review of international experiences in technology foresight

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Abstract

This paper provides a brief overview of international experiences in national technology foresight. It begins with an account of the diffusion of foresight practice between countries and within them, demonstrating its still growing popularity. The paper then describes the different rationales that justify the use of foresight, highlighting their shift away from an original R&D priority-setting focus towards a more process-oriented focus that emphasises dialogue and networking between different actors in national systems of innovation. The methodological approaches used in different countries are then compared, suggesting a possible link between method preferences and political and institutional cultures. In a penultimate section, the paper offers several explanations for the lack of evaluation of foresight. A final section briefly speculates on the continuing need for foresight in future years. The paper draws heavily upon the recently published Handbook of Technology Foresight[1)], where the experiences of national technology foresight exercises conducted in many parts of the world are analysed in considerable detail.

1. Introduction

Basic research, which is considered to be the source of Over the last decade or so, foresight has become an increasingly well-established tool used by policy makers, strategists, and managers around the world. For instance, it has been widely applied at the national level by science ministries and research funding agencies for developing shared long-term visions, for setting research priorities, and for strengthening interactions within research and innovation systems. It is being increasingly utilised in regions to formulate regional science and innovation policies. It is also used in organisations – both public and private – for scanning future threats and opportunities, and for formulating and 'future-proofing' long-term strategies.

Our concern in this paper is restricted to national technology foresight activities. The paper begins by describing the diffusion of foresight practice and discusses the different configurations in which it may be embedded in policy making arenas. The diffusion and more extensive use of foresight have been accompanied by an expansion in the rationales of its use, so that much contemporary national foresight activity has a range of purposes, well beyond the early rationale of identifying national priorities. The paper explains these changes and highlights differences between world regions. The following section compares and contrasts methodological preferences between world regions, hypothesising that the choice

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1) See Georghiou et al (2008). For further information, see http://www.e-elgar-business.com/bookentry_main.lasso?id=3977

of some methods reflects political and institutional cultures. Similar hypotheses are put forward regarding the choice of time horizon in foresight exercises. A penultimate section discusses the lack of evaluation of technology foresight, while a final section asks the question, “whither foresight?”

2. The diffusion and ‘sites’ of technology foresight

A chronology of national technology foresight activities highlights its rapid uptake by governments in Western Europe and East Asia during the 1990s (Table 1). More recently, activities have spread to more countries, while most of the original players have instigated new

Table 1 Chronology of selected national foresight exercises

Year	Country	Exercise/Programme	Method(s)
Since 1971	Japan	1st to 4th STA surveys	Delphi
1991	Japan	5th STA survey	Delphi
	USA	Critical Technologies	Others
1992	New Zealand	Public Good Science Fund	Others
	Germany	BMFT, T 21	Others
1993	South Korea	Foresight Exercise	Others
	Germany	Delphi ’93	Delphi
1994	UK	1st TF Programme	Delphi + Others
	France	Technology Delphi	Delphi
1995	France	100 Key Technologies	Others
1996	Japan-Germany	Mini-Delphi	Delphi
	Austria	Delphi Austria	Delphi
	Japan	6th STA survey	Delphi
	Australia	Matching S&T to futures needs	Others
1997	Spain	ANEP	Delphi + Others
	Hungary	TF Programme (TEP)	Delphi + Others
	Netherlands	Technology Radar	Others
	Finland	SITRA Foresight	Others
1998	South Africa	Foresight Exercise	Delphi + Others
	Germany	Delphi ’98	Delphi
	Ireland	Technology Foresight Ireland	Others
	New Zealand	Foresight Exercise	Others
1999	UK	2nd UK Foresight Programme	Others
	Sweden	1st Swedish Foresight	Others
	Spain	OPTI Technology Foresight	Delphi
	South Korea	Korean Technology Delphi	Delphi
	Thailand	ICT Foresight	Delphi + Others
	China	TF of Priority Industries	Delphi + Others
2000	Japan	7th STA Survey	Delphi
	Brazil	Prospectar	Delphi
	Brazil	TFP Brazil	Delphi + Others
	France	2nd 100 Key Technologies	Others
	Portugal	ET2000	Others

Table 1 Chronology of selected national foresight exercises(cont'd)

Year	Country	Exercise/Programme	Method(s)
2001	Venezuela	TFP Venezuela 1st cycle	Delphi + Others
	Chile	TFP Chile	Delphi
	Germany	FUTUR	Others
	Czech Republic	TF Exercise	Others
2002	Turkey	Vision 2023	Delphi + Others
	Colombia	TFP Colombia 1st cycle	Delphi + Others
	UK	3rd UK Foresight Programme	Others
	Cyprus, Estonia, Malta	eForesee	Others
	Denmark	National TF Denmark	Others
	USA	NIH Roadmap USA	Others
2003	China	TF Towards 2020	Delphi + Others
	Greece	Technology Foresight Greece	Others
	Norway	Research Council 2020 studies	Others
	Sweden	2nd Swedish TF	Others
2004	Japan	8th Japanese Programme	Delphi + Others
	South Korea	Korea 2030	Delphi + Others
	Ukraine	Ukranian TF Programme	Delphi + Others
	France	FuturRIS	Others
	France	AGORA	Others
	Venezuela	TFP Venezuela 2ndt cycle	Others
	Russia	Key Technologies	Others
2005	Colombia	TFP Colombia 2nd cycle	Delphi + Others
	Brazil	Brazil 3 Moments	Delphi + Others
	Romania	Romanian S&T Foresight	Delphi + Others
	Finland	Finnsight	Others
	Luxembourg	FNR Foresight	Others
	USA	21st Century Challenges GAO	Others
2006	Finland	SITRA Foresight	Others
	Poland	Poland 2020 – TF Programme	Delphi + Others

Others include: scenarios, panels, roadmapping, critical technologies, etc.
Note: Dates given are point of significant activity rather than formal start or end
Source: Miles et al (2008a)

iterations of activity, though often departing from the formats they used initially. Various hypotheses can be attached to the reasons for this growth, including simple explanations such as diffusion through an 'epidemic' model or fashion, through to more complex analyses about the emergence of new challenges to the role of S&T in a networked economy for which foresight seems to offer some answers (Miles et al, 2008a).

Besides the international diffusion of technology foresight, foresight practices have also spread within countries. For example, in many Western European countries (particularly France, Germany, the UK, the Scandinavian countries, and the Netherlands), it is apparent that such activities are in fact carried out across a wide range of locations and at different levels, including various sites at the national level (e.g. in ministries, research councils, etc.), in sub-national regions, and in organisations (e.g. in national laboratories, large companies, etc.). At the national level, foresight has moved well beyond the boundaries of traditional S&T actors in many countries, and is now regularly carried out by a variety of ministries and agencies across several domains of government (ibid.).

The degree of connectedness between sites and levels of activity is minimal, however, with foresight landscapes typically ‘fragmented’ with little collaboration between different foresight exercises. This is hardly unexpected while foresight exercises remain largely ad hoc and one-off, as opposed to continuous activities (Saritas, 2006). Under these circumstances, cooperation is likely to be rare and opportunistic, with linkages mostly confined to some recycling of foresight products and to a few instances of methodological learning. By contrast, continuous activities would offer the time and stability for more profound cooperation to develop.

There is significant variety as to where in an organisation / innovation system / policy arena foresight is ‘located’, i.e. from where it is coordinated and managed, with little discernible pattern according to country/region or foresight rationales (see below). Many arrangements can be found, which tend to be variations of ‘in-house’, ‘semi-detached’, and ‘outsourced’ configurations. The pros and cons of these different arrangements can be framed in terms of an apparent trade-off between a foresight exercise’s autonomy and its connectivity to policy arenas. To elaborate, foresight is often viewed as providing a ‘space’ for the sorts of discourse, analysis and creative visioning that are normally absent in day-to-day policy operations, or even in more long-term strategic planning. This needs to be a ‘safe’ space, however, if foresight is to be open and adventurous, where the ‘unthinkable’ can be openly discussed and where discussions are not wholly dominated by current controversies. While this creates a natural need for some disconnection from the ‘rough and tumble’ of day-to-day policy and decision-making, the challenge has always lain in reconnecting foresight with contemporary policy arenas. This connection has often been achieved via the participation of major stakeholders in the foresight process itself, reflecting an increasingly common belief that foresight is more likely to impact on policy through the agenda-setting and mobilisation of actors – rather than through the dissemination of some new, enlightening codified facts at the end of the process (Miles et al, 2008b).

Another approach to ensuring connectivity to policy arenas has been to embed foresight in existing strategic processes, linking it ever closer to policy and decision-making, and making it (perhaps) more difficult to discern as a distinct and stand-alone activity. Some would argue that such foresight runs a greater risk of being compromised through its embeddedness. This is probably true, but it would be unrealistic to expect all foresight activities to conform to a specific organisational form (ibid.).

Experimentation will no doubt continue, and we are likely to see foresight being used in a wider variety of settings and in combinations with other decision-support tools and policy instruments. In fact, in some STI policy circles, foresight is increasingly viewed as one instrument in a distributed, strategic policy intelligence ‘toolbox’ that also includes evaluation, technology assessment and various other strategy-making tools. Conceptual work on how such tools might be combined in such a way as to provide policy makers with readily available ‘strategic intelligence’ has been funded by the European Commission (EC), e.g. the Advanced Science and Technology Policy Planning (ASTPP) network (see Kuhlmann et al., 1999) and the more recent RegStrat project (see Clar et al, 2008). This work suggests there is considerable untapped potential in embedding foresight into practices such as evaluation, although there remains little evidence of many multi-tool approaches being developed for use in policy-making at the current time (Miles et al, 2008b).

3. Rationales for foresight

With the wider adoption of foresight practices in different settings, an expanded and more sophisticated view of its uses has emerged. Accordingly, the rationales deployed by governments when offering justification for their foresight activities have also expanded well beyond the earlier, rather simplistic, rationales that were largely dominated by priority-setting concerns. The latter were driven by fiscal crises within states, as well as by the need to manage the ever-growing ‘scientific estate’. It quickly became apparent, however, that many of the issues around science and technology were connected to an ‘innovation deficit’ – particularly in Europe – and that firms needed to conduct more R&D or at least be better connected to centres of techno-science knowledge production to remain competitive in the longer-term. Foresight therefore assumed a more networking and community-building function, particularly by the mid-1990s, and sought to serve a variety of innovation system actors beyond a sole public R&D funding agency / S&T ministry.

By the late 1990s, a greater emphasis upon the relations of S&T with society also began to emerge, with many governments establishing or strengthening their policies and capabilities in this area. Again, in many places, technology foresight adapted to this new emphasis, particularly in Germany, the UK and Japan (the Nordic countries and the Netherlands already had a strong tradition in this area, which shaped their foresight activities somewhat earlier). To illustrate these changes, Table 2 summarises the shifting rationales of the UK national foresight programme from its inception in 1993 to the present day.

Since societal dialogue rarely substitutes priority-setting, for example, but is instead an additional rationale, much national technology foresight activity today has multiple 'layers' of rationales. A list of some of the common rationales associated with national technology foresight exercises is provided in Box 1. There is a danger, however, of overloading foresight with too many rationales. Well-known cases of this occurring can be found in Germany (see Cuhls, 2008) and the UK (see Keenan and Miles, 2008a), where previous rounds of national foresight activity have collapsed under the weight of multiple expectations.

It should be pointed out that the evolution of rationales described here is largely confined to those countries where foresight has been practiced for some time, particularly in Western Europe. But it would be presumptuous to assume that other parts of the world will follow the same (Western) Eurocentric trajectory, particularly given different political and institutional histories and traditions.

Table 2 Schematic picture of the evolution of UK Foresight

Parameter	Stylised particularities of each cycle		
	Cycle 1 (1993-1998)	Cycle 2 (1999-2001)	Cycle 3 (2002-present)
Main Rationales:	S&T priorities	Business and societal dialogue	Anticipating policy-relevant change and risk
Main Targets:	Initially, scientists and research funding agencies; latterly, also the business community	Wide variety of actors across government, business (including SMEs), the research world, and society	Predominantly government ministries
Coverage:	Mix of sectoral and technological areas spanning most of private sector and some public sector	Mix of sectoral and thematic areas – even wider coverage than the first cycle	Mostly small numbers of focused topic areas of interest to government ministries
Structure:	Standing sectoral panels	Standing sectoral and thematic panels with task forces	Rolling projects
Participants:	Essentially the same across all three cycles, although fewer industry actors are involved in the third cycle		
Methods:	Delphi and workshops used across the Programme, with bespoke methods used by the individual panels	Predominantly scenarios and consultation documents, website for dissemination and interaction	Wide variety of methods, including scenarios, workshops, simulations and gaming, Delphi, etc. used locally in different projects
Outputs:	Panel reports, priorities and recommendations, Delphi results, and a variety of other reports during the implementation phases	Panel and task force reports, many web publications (including scenarios and even videos at one point)	State of science reviews, scenarios, project reports, action plans, academic books, etc.
Reception:	Generally positive, though many argued that the Programme failed to realise its full potential, particularly with regards to reaching the business community	Generally negative, with some panel reports dismissed as dull and uninspiring and the Programme being deemed as unfocused	Very positive, with highly regarded outputs that have been taken up in policy formulation and adaptation

Source: Georghiou et al (2009)

Box 1 Common rationales for national technology foresight

Rationale 1: Directing or prioritising investment in STI
- Informing funding and investment priorities, including direct prioritisation exercises;
- Eliciting the research and innovation agenda within a previously defined field;
- Reorienting the science and innovation system to match national needs, particularly in the case of transition economies;
- Helping to benchmark the national science and innovation system in terms of areas of strength and weakness, and to identify competitive threats and collaborative opportunities;
- Raising the profile of science and innovation in government as means of attracting investment.

Rationale 2: Building new networks and linkages, often around a common vision
- Building networks and strengthening communities around shared problems (especially where work on these problems has been compartmentalised and is lacking a common language);
- Building trust between participants unused to working together;
- Aiding collaboration across administrative and epistemic boundaries;
- Highlighting interdisciplinary opportunities.

Rationale 3: Extending the breadth of knowledge and visions in relation to the future
- Increasing understanding and changing mindsets, especially about future opportunities and challenges;
- Providing anticipatory intelligence to system actors as to the main directions, agents, and rapidity of change;
- Building visions of the future that can help actors recognise more or less desirable paths of development and the choices that help determine these.

Rationale 4: Bringing new actors into the strategic debate
- Increasing the number and involvement of system actors in decision-making, both to access a wider pool of knowledge and to achieve more democratic legitimacy in the policy process;
- Extending the range of types of actor participating in decision-making relating to science, technology and innovation issues.

Rationale 5: Improving policy-making and strategy formation in areas where STI play a significant role
- Informing policy and public debates in these areas;
- Improving policy implementation by enabling informed "buy-in" to decision-making processes.

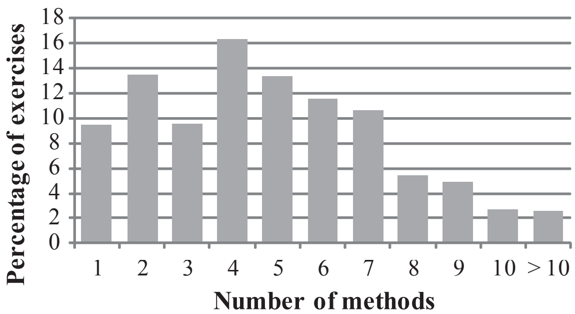
Source: Miles et al (2008a)

4. Methodological approaches

The choice of methods used in foresight is typically informed by a variety of influences, including available resources (particularly time and funding), desired outputs (and outcomes), sponsor preferences, the nature of the domain areas being covered (and existing knowledge of and approaches to understanding future trends and issues in those areas), and target groups (Keenan and Miles, 2008b; Popper, 2008). Coinciding with an expansion in the rationales for foresight is the emergence of more complex exercises in terms of scope and design. Recent mapping of two thousand foresight exercises by the EC-funded European Foresight Monitoring Network (EFMN) shows that, on average, exercises use 5-6 different methods (Figure 1).

As for preferences for individual methods, Table 1 shows there to be a clear family tree in terms of the use of large-scale Delphi surveys which also spills over into the hybrid exercises (those combining Delphi with other methods). Another explicitly-related family tree is that of critical technologies exercises. Among the activities which use other methods (e.g. scenarios, panels and roadmapping), the linkages are more complicated.

Analysis of EFMN foresight mapping data suggests that international learning is somewhat selective. Broadly speaking, the earlier exercises have been the most influential, partly because of their pioneering nature and partly because some of their key participants have become expert in the process of policy instrument transfer itself (Miles et al, 2008a).



Source: EFMN database

Figure 1 Common rationales for national technology foresight: Number of methods used in foresight exercises mapped by the EFMN (percentage; total number of mapped exercises analysed: 886)

It is perhaps for these reasons that large-scale Delphi surveys have been employed by many countries since the mid-1990s (following Japanese, German and UK experiences)[2], even though many other methods could have been used instead and perhaps more effectively.

Figure 2 shows the top ten foresight methods used in six world regions. It indicates that there are 16 different methods featured in the top ten across the six regions. Some methods are ubiquitous across the world, particularly the use of expert panels, scenarios, trend extrapolation, and literature review. Of more interest, however, are those methods that tell us more about differences in foresight 'style' between different parts of the world. The first of these methods is (futures) workshops, which figure prominently in Northwest Europe and North America but are much less prominent in Central and Eastern Europe and Asia (in fact, they are in tenth position in both regions) and are absent from the top ten in Southern Europe and South America. The second method of interest is Delphi, which, in terms of its regional distribution, has an almost opposite profile to that of futures workshops. Thus, Delphi is most commonly used in Southern Europe and South America, closely followed by Eastern Europe and Asia. It is absent from the top ten in Northwest Europe and North America.

To what extent can this apparent pattern of preferences be explained by political and socio-cultural factors specific to different parts of the world? Keenan and Popper (2008) offer a hypothesis, which would require further research to confirm or to refute. In the more established democracies of Northwest Europe and North America, actors more at ease with openly discussing contested futures confront one another in face-to-face forums offered by workshops. By contrast, in newer democracies, or in Japanese society, where there is less tradition of open confrontation, the more anonymous method of Delphi is preferred. Furthermore, Delphi generates a lot of codified output that is more amenable to analysis and assessment than workshop 'talk' and is therefore preferred by states with a 'strong' tradition of orchestrating socio-economic activity from the 'centre'[3].

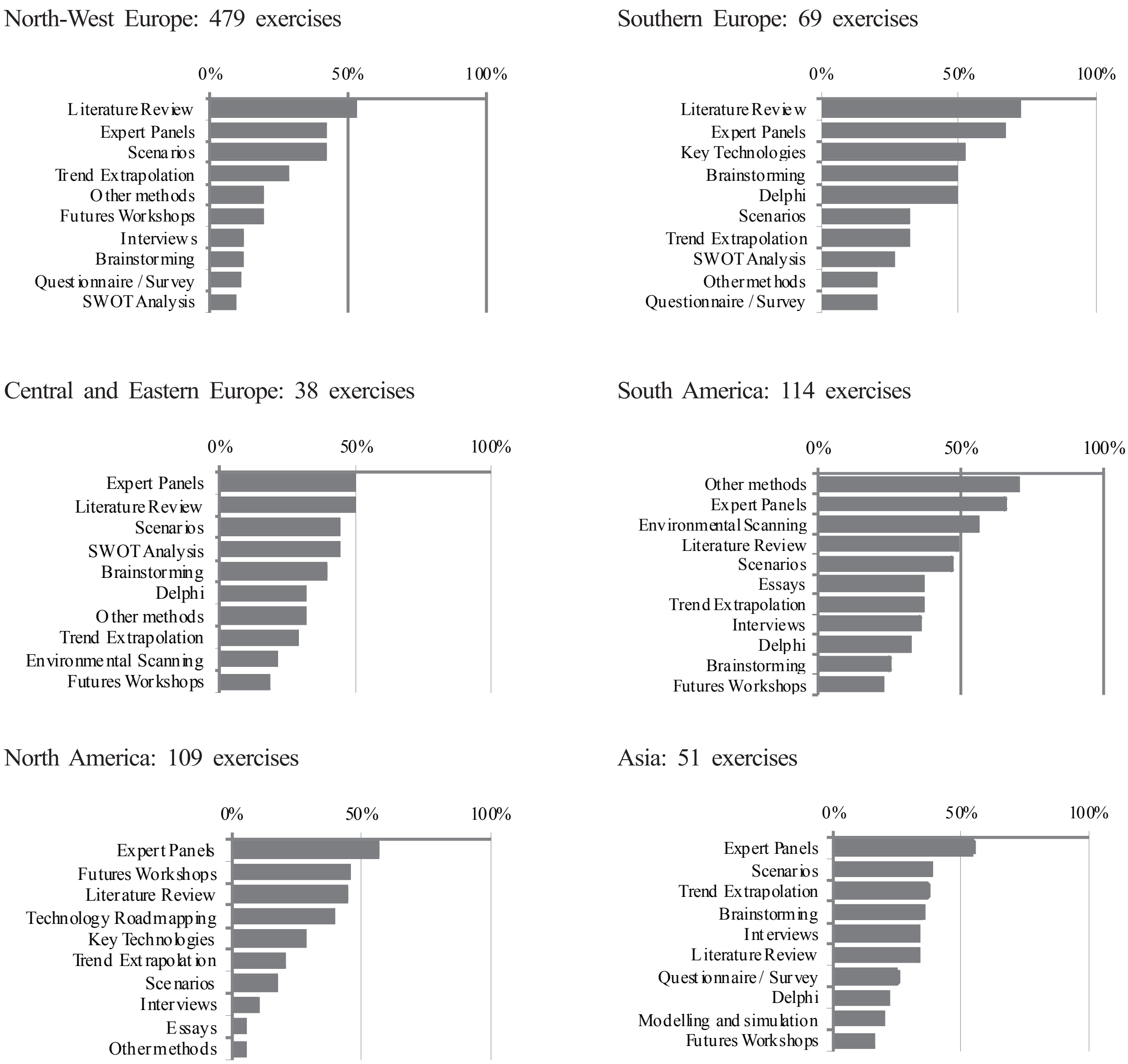
5. Preferred time horizons

Another aspect of foresight with notable variety between different world regions concerns the time horizons that are used. These tend to be heavily dependent upon the domain area being addressed and the information needs of target groups. For example, a foresight exercise focused upon the energy sector might have a time horizon of more than 50 years whereas an exercise focused upon information technologies might look out no further than 10 years.

As Figure 3 shows, the most common time horizon among those exercises mapped by the EFMN lies between 2010 and 2020. As virtually all of the exercises mapped by the EFMN were carried out between 2001 and 2006, it can be assumed that most exercises are looking 10-20 years ahead. The only exceptional region in this regard is Central and Eastern Europe, where shorter 5-10 year time horizons are by far the most common. Around one-

2) The German and UK experiences were in fact earlier imitations of the Japanese experience, with, for example, the first German exercise an almost direct translation of the most recent Japanese survey (see Cuhls, 2008; and Keenan and Miles, 2008a).

3) There are other possible explanations for these patterns of course: for example, the early adopters of foresight, i.e. Northwest Europe and North America, also made more extensive use of methods like Delphi in previous times but have since moved to other approaches. So the regional patterns observed may reflect, at least in part, different points on an adoption curve. Another possible explanation relates to 'measurement bias' in the EFMN database, where a lot of foresight activity mapped for Northwest Europe is relatively small-scale and therefore more likely to favour 'light' methods (e.g. workshops) over 'heavy' methods (e.g. Delphi).

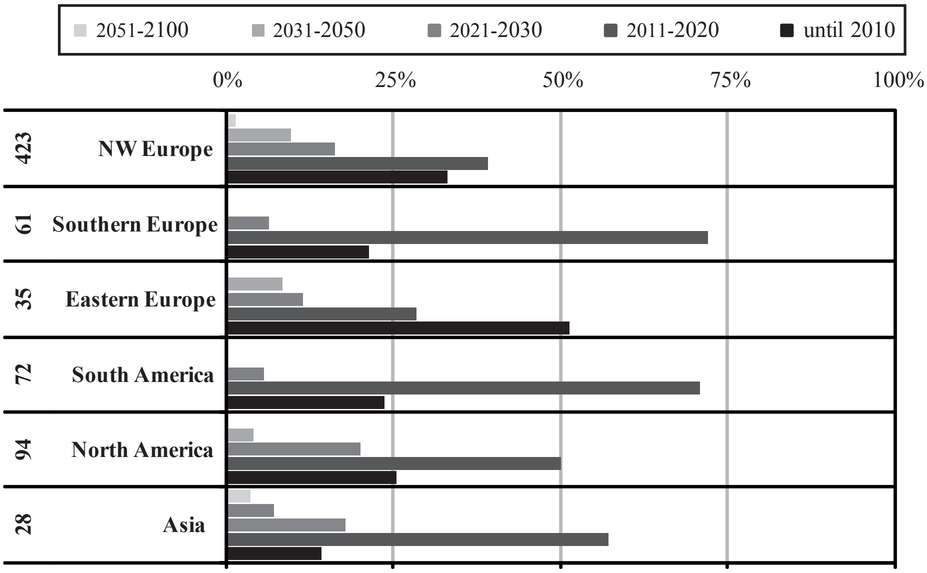


Source: Keenan and Popper (2008)

Figure 2 Top ten methods used in foresight exercises, by world region

third of exercises mapped in North-West Europe, Asia, and North America have time horizons longer than 15 years, whereas less than 10% of exercises in Southern Europe and South America fall into this category. Central and Eastern Europe lies somewhere in between.

How to explain this regional variety? Again, Keenan and Popper (2008) offer a hypothesis: that time horizons are more likely to be shorter in fast-changing societies marked by rapid socio-economic transition than in those where there is more stability and greater certainty around short-term prospects[4]. Of course, alternative hypotheses are possible: for example, it might be that those regions with technological leadership positions will need to adopt longer time horizons given their relevance for advanced S&T development efforts.



Source: Keenan and Popper (2008)

Figure 3 Time horizon of foresight exercises, by world region

6. Assessing the benefits of foresight

An expansion in expectations around technology foresight has outpaced a better understanding of the dynamics of foresight. This conceptualisation 'gap' needs to be bridged to allow systematic evidence to be collected around the impacts of foresight exercises. However, attempts to address this gap, and by extension, to evaluate the impacts of foresight exercises, have been frustrated by several factors (Barré and Keenan, 2008):

- The objectives set for foresight are often wide-ranging and vague, making them problematic starting points for evaluation
- The intangible benefits that are said to accrue from foresight are difficult to assess in themselves
- The complexity of cause–effect relationships, which cannot be handled by the often overly simplistic models used when trying to understand and give meaning to foresight activities and their effects, make evaluation difficult
- The systemic and distributed nature of foresight means that benefits are likely to be dispersed across a landscape of actors and systems making attempts to account for effects resource-intensive
- Many expected impacts of foresight take several years to materialise, and when they do, they are often dependent upon other factors, leading to attribution problems
- There are so many different methodologies and settings for foresight that it is difficult to arrive at standardised evaluation approaches
- The costs associated with a full evaluation of foresight activities tend to be well above the recommended 2-5% of total exercise budgets

Nevertheless, attempts have been made to assess foresight's impacts, particularly at the national level. As Table 3 shows, a variety of approaches have been used, ranging from student studies to full-fledged evaluations (e.g. PREST, 2005). This partly reflects the quite different rationales and approaches associated with foresight exercises, but also the different types of issues that might be covered by an evaluation. For example, foresight can be evaluated at different levels of aggregation: as a policy, a programme or as practice. Each of these levels raises different sets of issues that demand a different evaluation approach.

4) Of course, Asia is perhaps undergoing the most profound and rapid transition of all world regions today, but as the EFMN's Asian sample is dominated by Japanese foresight exercises, this transition is not reflected in the Asian data for time horizon

Table 3 Evaluation of national foresight activities

Country	Evaluation Effort
Austria	Internal assessment of impacts by Science Ministry
Colombia	Panel evaluation 2007/8 addressing process and impact with national & international Validation / Evaluation Committees.
Germany	Delphi 98 evaluation questionnaire; FUTUR evaluated during 2002 and again in 2004
Hungary	Panel evaluation 2003/4 addressing process and impact
Japan	Assessment of realisation of results some 15-20 years after identification in STA forecasts. Also foresight evaluated as a part of broader evaluations of its host institute NISTEP.
Malta, Cyprus and Estonia	"Light" expert evaluation of the eForesee project, examining the achievements of an EU-funded project that linked the foresight activities of these 3 small countries
Netherlands(OCV)	Self-evaluation, PhD study, evaluation by Advisory Council for Science & Technology (AWT)
Sweden	Process (and not the impacts) evaluated continuously by an Evaluation Committee. New evaluation in 2005
United Kingdom	For the first cycle, sub-critical ad hoc studies; some limited external (and independent) scrutiny, e.g. by Parliament, a PhD study, etc. OSI conducted a self-evaluation of the second cycle. External evaluation conducted of the third cycle (PREST, 2005).

Source: Georghiou and Keenan (2008)

In a policy evaluation, issues of rationale for public action are dominant and the interaction of foresight with other policies becomes a topic of focus. In programme evaluation, the objectives of the foresight exercise become a primary focus, mostly in terms of the achievement of objectives but also in terms of their appropriateness, which constitutes a link to policy evaluation. Foresight as practice focuses on the methods and structures used. These may be evaluated both in their own terms and in terms of whether they were fit for purpose. In a full-fledged evaluation, combinations of these levels, albeit with different emphases, are likely to be in evidence (Georghiou and Keenan, 2008).

7. Whither foresight?

The need for foresight, as well as its likely range of applications, is expected to continue to grow. In the field of techno-science alone, there are many newly-emergent frontiers opening up that will require an active shaping if future problems are to be managed. These include issues around environmental degradation, energy supply, various forms of human-enhancement, and the convergence of nanoscience, biotechnology, information technology and cognitive science (NBIC), to name but a few. How foresight will be used to address these, and other 'grand challenges', remains to be seen. But they will need to be addressed and foresight practitioners will need to rise to the challenge (Miles et al, 2008b).

8. References

1. Barré R and Keenan M (2008) "Revisiting the Rationales for Future-Oriented Technology Analysis", in Cagnin C, Keenan M, Johnston R, Scapolo F and Barré R (eds.) Future-oriented Technology Analysis: Strategic Intelligence for an Innovative Economy, Heidelberg: Springer
2. Clar G, Acheson H, Hafner-Zimmermann S, Sautter B, Buczek M, and Allan J (2008) Strategic policy intelligence tools. Enabling better RTDI policy-making in Europe's regions, Stuttgart: Steinbeis-Edition
3. Cuhls K (2008) "Foresight in Germany", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
4. Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) (2008) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
5. Georghiou L and Keenan M (2008) "Evaluation and Impact of Foresight", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
6. Georghiou L, Keenan M and Miles I (2010) "Assessing the Impact of the UK's Evolving National Foresight Programme", International Journal of Foresight and Innovation Policy, forthcoming

7. Keenan M and Miles I (2008a) "Foresight in the UK", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
8. Keenan M and Miles I (2008b) "Scoping and Planning Foresight", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
9. Keenan M and Popper R (2008) "Comparing Foresight 'Style' in Six World Regions", Foresight, vol. 10, No. 6
10. Kuhlmann S et al (1999) Distributed Intelligence in Complex Innovation Systems, final report of the Advanced Science and Technology Policy Planning Network (ASTPP), Karlsruhe: FhG-ISI
11. Miles I, Cassingena Harper J, Georghiou L, Keenan M and Popper R (2008a) "The Many Faces of Foresight", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
12. Miles I, Cassingena Harper J, Georghiou L, Keenan M and Popper R (2008b) "New Frontiers: Emerging Foresight", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
13. Popper R (2008) "Foresight Methodology", in Georghiou L, Cassingena Harper J, Keenan M, Miles I and Popper R (eds.) The Handbook of Technology Foresight, Cheltenham: Edward Elgar
14. PREST (2005), Evaluation of the United Kingdom Foresight Programme, London: Office of Science and Technology
15. Saritas O (2006) Systems Thinking for Foresight, PhD thesis submitted to the University of Manchester

National R&D Planning Strategy and Budgeting System in Korea

Pyengmu Bark[1]

Abstract

Proposed increases to the Korean government's R&D budget should be discussed based on the merits of meeting efficiency and effectiveness criteria. The evaluation of the national R&D budget and related programs are performed in two areas: a system of R&D budget coordination and allocation, and a system of R&D program performance. This paper mainly focuses on the operational areas of the R&D budget evaluation system with a focus on their impact on efficiency and effectiveness. The core view point for a R&D budget evaluation system involves two directions: Firstly, to detail the relationships between the activities in the latter stage (ex. post) such as program surveys, analyses, and program performance evaluations, with the budget evaluation. Secondly, to oversee all R&D coordination and procedures a different perspective. Budgeting is generally known as a serial process of policy making, planning and executing. It is highly desirable for the budget to be allocated to, and spent by, specific programs as planned, and that each plan is aligned with a specific policy. As such, a strong relevance between the program structure and budget code system is integral to successful execution. It should be performed using a decision-making system that closely examines the link between policy and budget. It is also recommended that systematic relationships be maintained among budget coordination and allocation, performance evaluations of policy and program levels, and the program survey and analysis system, and that furthermore, their operational schedule should be reviewed comprehensively as one integrated system. The National Science and Technology Council is expected to play a major and practical role as the center of policy planning and should be supported by an objective and unbiased system which covers the overall process from policy making to program evaluation. Finally, increased utilization of contents, timely program survey and analysis, accurate scheduling of budget coordination and allocation, as well as diligent program performance evaluation, all contribute towards a more efficient and effective overall evaluation system.

1. Introduction

Strategic R&D planning and coordination and a budget allocation system in accordance with such a plan is the fundamental requirement for the enhancement of R&D effectiveness and efficiency. As taxpayer's money takes up a substantial portion of the national budget, strategic planning and coordination and budget allocation is important. In the case of Korea, the R&D strategic planning and coordination, allocation and deliberation, and drawing up of the budget, as well as inquiries about, analysis of and evaluation of the programs has been carried out regularly since 1999, and has been continuously improved. Due to this ongoing evolution process there have been difficulties in the maintenance of consistency of operation due to several modifications of the relevant government organizations. Considering R&D as a series of continuous temporal steps, adherence to consistency at the national level is

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becoming increasingly important[1]. Effective and efficient deliberation, drawing up, and execution of budget are possible only when the association between policies and the budget is reinforced.

This thesis discusses the operation of the budget system with respect to the coordination, allocation and execution of the R&D budget. The subjects of the discussion are the R&D budget and programs. Jeong, Geun Ha and others (2005) generally define the inquiry, analysis and evaluation of national R&D programs, and the coordination, allocation and deliberation of the program budget as a comprehensive coordination. This thesis focuses on the coordination, allocation and deliberation of the budget, which is the first stage of comprehensive coordination (Yang, Hee Seung, 2004; Bark, Pyengmu, 2007). There are two new perspectives that need to be established. The first is to more closely link the viewpoints on inquiries, analysis and evaluation of R&D programs that are carried out in the second stage of comprehensive coordination to the preceding stage, and the second is to shed new light on the system of overall comprehensive coordination of this process.

In order to reinforce the linkage between policies and the budget, there is a need to view the approach to comprehensive coordination from different perspective, and, therefore, there is a need to partially supplement or improve the system's operation. For this purpose, in Section 2 we will examine the characteristics of the R&D budget system of Korea and the core changes it had undergone. In Section 3, inquiries into and analysis of R&D programs and program evaluation systems relating to, and focusing on, the coordination, allocation and deliberation of budgets will be examined in detail. Problems related to this will be pointed out and means of resolving such problems will be proposed. Lastly, the conclusion will summarize suggested areas of improvement, the proposals to achieve them, and then discuss the limitations and implications of the research

2. R&D Strategic Planning and Budget System

Figure 1 introduces the overall process of R&D strategic planning and coordination and budget allocation in Korea. The process of coordination and budget allocation commences with the preliminary coordination process and deliberation upon the submission of a request (proposal) for a budget by each ministry to the Ministry of Strategy and Finance (MOSF). The drawing up of a budget by MOSF reflects the opinion of deliberation related to the direction of investment and coordination and allocation as well as the results of inquiries, analyses and evaluations carried out annually. The MOSF draws up the final government budget proposal that includes the R&D budget (Figure 2).

In the case of Korea, 'Total amount of allocation in self-regulated drawing up(top-down)' system, in which the ceiling on the budget request proposal for each ministry is set in advance and then each ministry autonomously draws up their own budget on that basis commenced in 2004. The government's budget proposal including the R&D budget is then finally confirmed as the total budget for the following year through deliberation at the National Assembly, after having been confirmed as the government's proposal through the cabinet meeting and government-ruling party consultation[2].

Social issues related to the R&D budget are deciding the appropriate size of the investment and the fulfilling of social demands of investment performance (Lee, Jang Jae, 2004). Accountability in terms of the transparency and accuracy of the performance evaluation is a key issue. The government's budget has a close relationship with the national priorities, viewed from the perspective of the taxpayers. Since the government has the responsibility and authority for the planning and execution of the budget, there is a risk of the principal-agency problem and moral hazard.

1) Office of Science and Technology Innovation was dissolved due to the reorganization of government structure in 2008 with a portion of its relevant functions transferred to the Ministry of Education, Science and Technology (MEST) and other portions to the Ministry of Strategy and Finance(MOSF). Recent disputes on the inadequacies of the top management system related to science and technology policy making could impose greater difficulties in the maintenance of consistency.

2) Refer to Seong, Ji Eun (2006), p.12 and Bark, Pyengmu (2007), pp.61-69

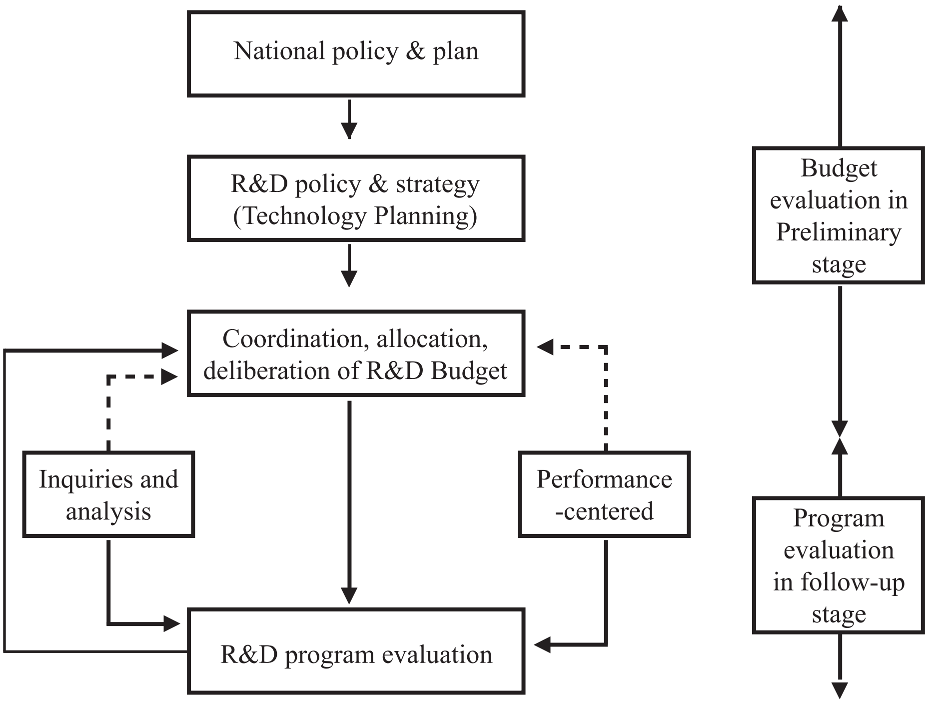

Figure 1 Preceding and Follow-up Stages of Comprehensive Coordination

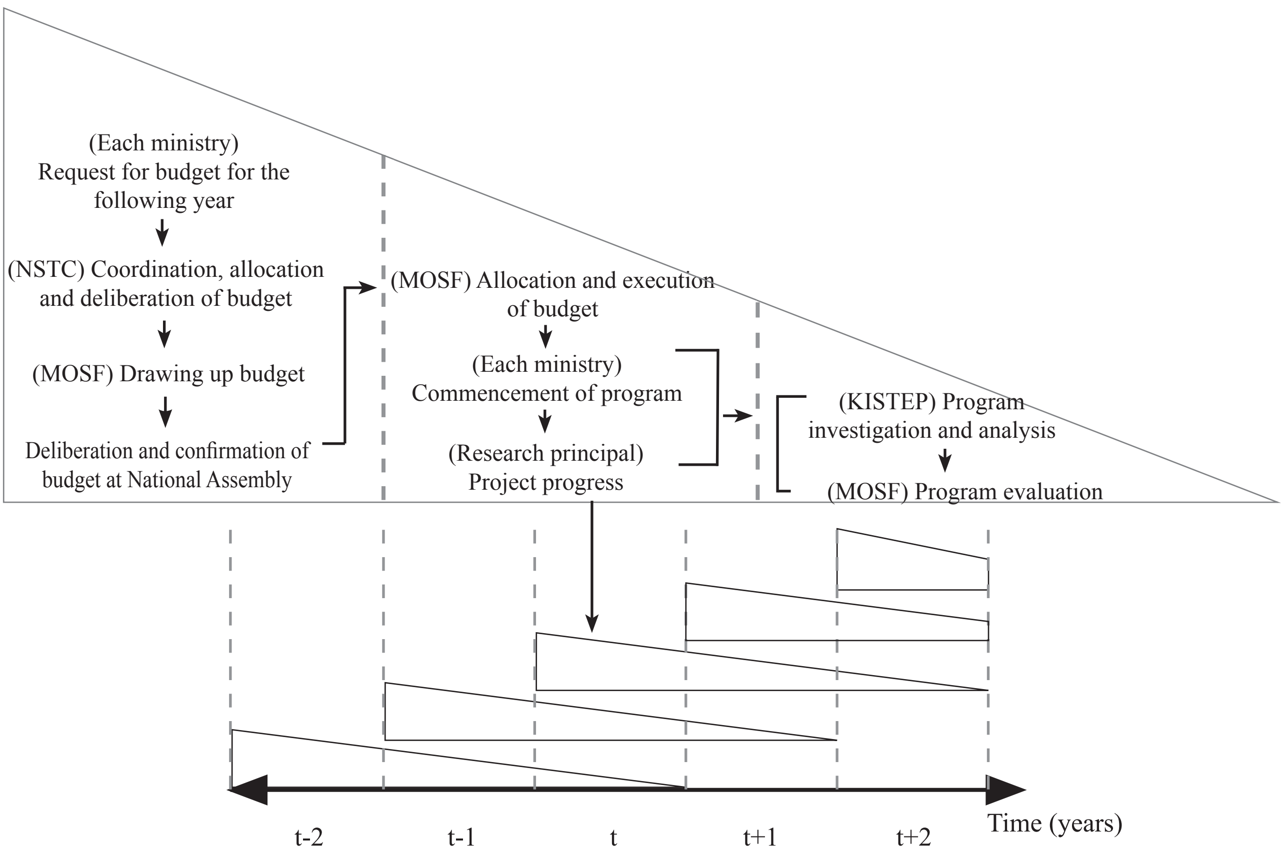

Figure 2 Comparing between cross-section and three year flow of R&D budget and program performance

Opportunity cost may arise from selection process, and therefore, the establishment of priority rather than the first-best choice could ultimately induce primary inefficiency. In the case of government investment, the crowding-out effect may affect the private sector investment.

In the case of R&D, although the principal in the planning and execution of the budget on the surface is the government, it is frequently the case that the principal in the actual utilization of the budget is the researcher or research organization. They also participate in R&D planning at a national level on the basis of their expertise. Therefore, it is inevitable that disputes over whether the execution of the budget is in essence for benefit of the country or the research principals arise endlessly. In particular, it is quite possible that such disputes could develop into a social dispute if the goal of the government and research principal differ. Moreover, if R&D activities arising from the budget are focused on public interest and basic core technologies, the analysis or verification of economic and social benefits may become complicated by the economic conception period, high risk and a high level of competition[3]. Therefore, the evaluation of the linkage between policy and performance generation is essential.

Reviews on plans to link performance with budget in order for full-scale introduction of performance-centered budget system began in 2003 (Seong, Ji Eun, 2006). In 2004, total amount of allocation self-regulated drawing up (top-down) system was introduced. In the case of R&D budget, efforts are being put in order to enhance the efficiency of coordination and allocation system through performance evaluation based on strategy, expertise and fairness (Park, Jeong Woo et al, 2004). In order to reinforce this strategy for the accomplishment of national R&D vision and goals, R&D budget coordination and allocation is being pursued on the basis of national plans with medium to long-term strategic planning. Such plans include the Basic Plan for Science & Technology, the National Innovation System (NIS) and the National Technology Road-Mapping (NTRM), and an investment portfolio that considers the division of roles and linkage relationships with the private sector. An in-depth and permanent review system by the professional committee for each technology area is being reinforced through an expansion of the participation of diverse specialists from the private sector. Also the activation of the program evaluation and review and linkage system of budget was sought after through the increased exchange of members between professional committees for program evaluation and budget coordination. Emphasis is also placed on reinforcement of fairness and transparency for rationalization of coordination and allocation on the basis of substantiated performance evaluation by setting the objective standards aimed at closely linking the results of performance evaluation with the budget. and goals, R&D budget coordination and allocation is being pursued on the basis of national plans with medium to long-term strategic planning. Such plans include the Basic Plan for Science & Technology, the National Innovation System (NIS) and the National Technology Road-Mapping (NTRM), and an investment portfolio that considers the division of roles and linkage relationships with the private sector. An in-depth and permanent review system by the professional committee for each technology area is being reinforced through an expansion of the participation of diverse specialists from the private sector. Also the activation of the program evaluation and review and linkage system of budget was sought after through the increased exchange of members between professional committees for program evaluation and budget coordination. Emphasis is also placed on reinforcement of fairness and transparency for rationalization of coordination and allocation on the basis of substantiated performance evaluation by setting the objective standards aimed at closely linking the results of performance evaluation with the budget.

The national R&D program evaluation is carried out every year by applying the performance evaluation method in accordance with Article 12 of the Basic Law on Science and Technology, and Article 20 of the Implementation Ordinance of the same Law. Although

3) Refer to Bark, Pyengmu; Heo, Hyeon Hwoi (2008), pp.555-559

the unit of evaluation is already the detailed items in the R&D budget, if the corresponding R&D programs are in turn composed of a diverse range of subordinate projects, the individual subordinate projects themselves should become the units of evaluation[4).

Evaluation is carried out by categorizing into subject of specific in-depth evaluation and subject of in-house evaluation by the ministry. The MOSF carries out regularly scheduled in-depth evaluations and superordinate evaluations on long-term and large programs, redundantly coordinated and linked programs, and the joint programs of several ministries. Each ministry carries out in-house evaluation of performances in accordance with the characteristics of the program that are not the subject of specific evaluation for the corresponding year. As a form of superordinate evaluation, MOSF examines the appropriateness of in-house evaluation by providing standardized performance indices which can be used for in-house evaluation. For the issues that require coordination and consolidation in accordance with the evaluation results, specific options for the improvement of the details of the program are proposed to the comprehensive recommendation[5)].

Performance-centered management is a concept that is applied to all performance evaluations as well as budget evaluations. Also important is the management or evaluation of R&D strategic planning, coordination and budget allocation, and overall performances obtained as the result of planning and execution of ensuing programs. Depending on the situation, although there is no problem with the execution of the program, problems may exist in the preceding stage such as the planning of policy and program or the coordination and allocation of the relevant budget. Currently, performance evaluation of the planning, coordination and execution of the budget is quite insignificant in Korea, and focus is being placed mainly on the performance evaluation of program units. Even in the case of an in-depth, in-house, superordinate, and institutional evaluations in accordance with the recently improved system, it is difficult to find details of policy evaluation with concepts that have ultimately been mutually linked macroscopically and microscopically.

Table 1 is a representative case that implies such phenomenon, and summarizes the core key contents of coordination and allocation of the relevant budget the inquiries about and analysis of programs, and results of program evaluations with cases of programs pursued through the execution of the 2008 budget . The budgeting process was carried out in 2007 while the process of inquiries and analysis as well as program evaluation were carried out in 2009. Figure 2 implies that a single packaged process that includes the budget process and program evaluation process is carried out at the interval of every 3 years. Firstly, it should be noted that in Table 1 although the capacity of the subjects of coordination and budget allocation, and inquiries on and analysis of programs on the basis of the total budget is slightly less than 11 trillion Korean Won with 442 programs for budget and 486 programs for inquiries and analysis, only the programs with a total budget size of approximately 3 trillion Korean Won (80 programs), which is less than 1/3 of the total budget, are subjects of the elaborately segmented program evaluation[6)].

Another discovery is that the contents of inquiries and analysis of executed programs (2009) have some differences in key features and directions of allocation of financial resources decided in the budget. The contents of decision-making in 2007 can be reviewed only in some cases. For example, the goals in terms of R&D investment size for the regional areas set in 2007 not only failed to be accomplished but, further regressed. However, such details are not being mentioned in any of the evaluation reports. In addition,

4) The recent detailed item unit has been revised into a program, a detailed program and a highly detailed program. However, the subject unit in operation can be changed by receiving the opinions of the corresponding ministry.

5) Refer to Bark, Pyengmu (2006), pp.71-75; Lee, Jeong Won; Lee, Gi Jong (2008), pp.603-608.

6) The size of subject of evaluation decreased because, in the case of the in-house and supraordinate evaluation, it was reduced to 1/3 through departmental consultation, and, in the case of the specific evaluation, it was changed from a check-list format to an in-depth format. Improvement of the program evaluation through reduction-oriented types of change in the subject of evaluation is interpreted as efforts to change the evaluation format concept from a vertical approach to a horizontal approach. Attention should paid to how to pursue the programs excluded from the corresponding year of evaluation, and, how to link the issues of performance of budget evaluation.

Table 1 Comparison of contents of coordination and allocation, inquiries, analysis and performance evaluation related to national R&D programs pursued in 2008

Budget Evaluation (coordination, allocation and deliberation)	
Subject	10.8 Trillion Korean Won (442 programs)
Key features	• Strategically support national policy programs and public welfare areas: Aerospace development, Cope with climate change, Oriental medicine • Expansion of support for the area of new growth engine: Generation of future employment opportunities, Next-generation growth engine projects, Expansion of investment into core foundation technology in component materials • Assertive excavation and support for FTA related R&D requirements: Development of new drugs, Cultivation of high quality agricultural species, Environment-friendly cultivation technology • Coordination of redundant and excessive investment: University research center, Costly equipment, Nano-infrastructure, LMO area, Areas related to yellow-dust (Asian dust) • Settlement of system of deliberation of budget allocation among performances: Reinforcement of linkage between evaluation and budget, Reduction of product with similarity redundancy and inadequate execution performances, Analysis of technology, economy and policy validity of large capacity programs
Direction for allocation of financial resources	• Expansion of investment into basic research: 26.4% • Expansion of investment into regional R&D: 40.3% • Human resources development related programs: 9.9% • Total Roadmap technology area: Environment (4.7%), Basic science (4.4%), Universe, environment, astrology and maritime affairs (10.5%), Nano-materials (4.6%), Mechanical process (15.2%), Information and electronics (22.1%) • Establishment of stabilized research environment and reinforcement of specialization of government supported research institutes
Direction of future pursuit	• Preliminary feasibility study on new large capacity programs (more than 50 billion Korean Won) • Settlement of coordination and budget allocation on the basis of the weight of medium to long-term investment into technological areas of Total Roadmap • Enhancement of weight of results of performance evaluation to be reflected onto the budget
Time of decision-making	August 27, 2007 National Science & Technology Council → plans to pursue programs in 2008

Inquiries on and Analysis of the Project	
Subjects	11 Trillion Korean Won (486 projects)
Key results	• Socio-economic purpose: (implications) need for expansion of investment into aspects that are directly linked with global issues such as quality of life including environmental pollution, depletion of energy and health, and global warming • Principal of research execution: (implications) Need to increase mutually supplementary research productivity through reinforcement of fundamental and foundation research activities of universities and government subsidized research institutes, and reinforcement of cooperation amongst industry, academia and research institutes. • R&D stage: proportion of fundamental research at 25.6% (implications) Expansion of the base for fundamental research by expanding support for fundamental foundation research of universities and government subsidized research institutes, and for creative individual research • Region: (implications) Need to pursue customized R&D that is appropriate for regional features and continuous expansion of investment by reducing the proportion of regional investment (34.2%→31.1%) • Technology area: (implications) Need to occupy vantage point in core technology through expansion of investment into the area of low-carbon and green growth technology, and need to expand proportion of investment into areas including bioscience, energy and resources, which have substantial effect on creation of new industry.
Plans for future pursuit	• Enhancement of level of utilization of results of inquiries and analysis: Linkage service for the results of the previous years with other information within the NTIS after having reported the results at the National Science & Technology Council • Improvement of inquisition and analysis system: Improvement of system of inquisition and analysis items in accordance with reorganization of 2-dimensional categorization system, and provision of practical data for policy planning through in-depth analysis for each issue.
Time of decision-making	July 28, 2009 National Science & Technology Council→ Subject of programs that were pursued in 2008

Table 1 Comparison of contents of coordination and allocation, inquiries, analysis and performance evaluation related to national R&D programs pursued in 2008 (cont'd)

	Program Evaluation
Subjects	3 Trillion Korean won (80 projects): • In-house/supraordinate evaluation: 2.1743 trillion KW (70 projects) • Specific evaluation: 820.4 billion KW (10 projects) • Government subsidized institutions: 35 government subsidized research institution (in-house evaluation), 4 government subsidized institutions (supraordinate evaluation)
Key results of evaluation	• (Specific evaluation) Public disclosure of details of qualitative evaluation as a program unit (4 short-term projects): Reports on 6 long-term programs are planned to be made at the National Science & Technology Council in December • (In-house/supraordinate evaluation) 21.4% of the 70 projects were found to be insufficient • (Evaluation of government subsidized institutions) 7 institutions among the 35 institutions that carried out in-house evaluation were found to be insufficient, all of 4 institutions that carried out supraordinate evaluation received judgment of being appropriate (minimum of 72.5 points and maximum of 90.6 points)
Utilization plan	• In-house/supraordinate evaluation: Reflect at the time of drawing up of R&D budget for 2010 • Specific evaluation: Check execution of measures for improvement of system → Reflect onto the guidelines for drawing up of budget proposal for 2010 in order for the projects that have not been executed to be abolished or its budget allocation reduced. • Evaluation of government subsidized institution: Reflect at the time of coordination of the annual salary of the head of the institution, and at the time of drawing up of budget for investment into institutions in 2010
Time of decision-making	September 17, 2009 National Science & Technology Council→ Subject of programs pursued in 2008

Note: Refer to Figure 1 and Figure 2. Summary and comparison of National Science & Technology Council (2007, 2009 a and b).

details of the area of Total Roadmap technology, were emphasized in 2007 but not included in the inquiries and analyses of 2009. Instead, details on the area of low-carbon and green-growth technology, a new policy, are covered and expansion of investment into these areas is emphasized. Therefore, not even the fundamental evaluations of the performance of budget execution for technological areas, deemed key in 2007, were carried out. Accordingly, it is not a system that can be macroscopically linked with the results of budget execution.

3. Budget Coordination and Allocation Related Problems and Improvement Plans

Two core problems will be discussed, namely the system and proposed improvement plans. There is a focus on the characteristics of the currently implemented budget coordination and allocation and relevant inquiries and analysis, as well as the program evaluation system of Korea, and details of operation and results of the system. The First consideration is linkage between strategic planning and the budget. The approaches to the process of budgeting and aspects of the structural system of programs in Korea are discussed. Then the connection between budget, and inquiries and analyses at the level of the budget system's operation is discussed.

3.1 Linking of Strategic Planning with Budget

Important issue is the linking of policy with the budget (Lynch, 1979). The drawing up of the budget is the final stage of planning that makes the plane concrete, and the optimal policy alternative is confirmed through the drawing up of the budget (Wildavsky, 1974). Since planning is the process of selecting the optimal alternative to accomplish the goal of organization, reflecting of goals by? the budget signifies the linkage between the planning and budget. Planning and budget are inseparably related and, because planning cannot be segregated from policy, budget and policy are connected with planning as the medium. Ultimately, linkage between planning and budget signifies the linkage between policy and budget[7].

Firstly, in order for efficient linkage between policy and budget to be possible, an in-depth review of the current government organizational system is necessary. The core function of the NSTC should be seen as a science and technology related policy and R&D strategy relation functions viewed from the perspective of taking overall responsibility for the country's microeconomics[8]. If so, policy-related functions must have the foremost priority, and functions such as coordination, allocation, evaluation and management, which are at the level of executive methods, should be subordinate functions. However, it is difficult to view the current organizational system for science & technology related decision-making to be a system that sufficiently reflects this. Given the characteristics of organizations, it is unavoidable that there are limitations in organic cooperation between organizations. Therefore, in order to overcome such limitations, a review of the organizational system and research for a way to reinforce the organic cooperative system between organizations is exigent. The linkage between essential policies and budget can be further reinforced only through such measures. Furthermore linkage between the planning and execution of budget, planning and pursuit of programs, and reflection of results of evaluation onto the budget in the future should be reinforced. To this end, means of establishing an organizational and administrative system of the government that can assure the mutually and disjunctively independent functions of MEST, NSTC, and MOSF should be additionally discussed in depth[9].

Passive participation of the relevant ministries at the time of establishing the Basic Plan for Science and Technology represents a specific problem at the stage of establishment and analysis of program plans in the budget process (Lee, Jang Jae, 2004). This is because the adaptation of the relevant ministries, in reality, relies on the NSTC for the establishment of the direction of and plans for future science and technology. This is insufficient. Due to this, there is lack of consistency between the establishment of the Basic Plan at the level of foremost national priority, and planning and execution of program at the level of individual ministry. Setting of the priority, coordination and allocation signifies that it undergoes review and deliberation in accordance with prescribed criteria in order to accomplish consistency between the fitness of the budget and policy determination. Execution of rational and efficient resource allocation and coordination functions for each program is strived for in this way. Setting a comprehensive priority of programs, reduction in budget inefficiency through the coordination, and pursuit of appropriate allocation and utilization must be possible in order to achieve the improvement and efficiency of the budget system[10]. Enhancement of the practical operations of comprehensive coordination functions of the NSTC, and effectiveness of functions of the MOSF in the coordination and drawing up of the R&D budget are necessary (Table 2).

What needs to be considered in the stages of formation and execution of policy is that the ultimate role of the national R&D program in principle is to supplement the R&D activities of the private sectors

7) Refer to Yoon, Seong Shik (2003), p. 183

8) The role of NSTC is to coordinate the planning of key policies and R&D of science and technology, and program and science & technology innovation related industry policies, human resources policies and regional technology innovation policies, and to deliberate and confirm issues on setting of direction and coordination of budget allocation and efficient operation of R&D programs being pursued by each ministry. However, it is determined that it would be difficult to be in charge of realistic microscopic economic policy or management. Moreover, as the policy coordination and planning officer of MEST (formally the Ministry of Science and Technology) is in charge of the administrative function of the management committee, and the Presidential advisor for Education, Science and Culture is in charge of the administrative functions of NSTC, there could be problems in consistency, fairness and appropriateness of actual works.

9) The Office of the Cabinet is in charge of the Comprehensive Science & Technology Council of Japan. System of permanent secretariat is composed of total of approximately 100 staffs by broadly appointing personnel from within and outside of administrative organization such as the industry, academia and government including officer in charge of policy and deliberation from the Office of the Cabinet. Officer in charge of policy who belongs to the Office of the Cabinet without inter-departmental interests will be appointed as the personnel in charge of the secretariat (official website of Comprehensive Science and Technology Council of Japan).

10) Refer to Yang, Hee Seung (2004) and Jeong, Geun Ha et al (2005), p.202-203.

Table 2 Process and Problems in Budget

Budget Process	Problems	Solutions
Establishment and analysis of the Basic Plan	• Passive participation of relevant ministries • Inadequate mutual linkage between the Plan for each key part and total amount plan	• Reinforcement of coordination functions of NSTC • Neutralization and specialization of the status of the Secretariat
Establishment and execution of policy	• Dualization of principal of establishment and principal of execution of policy • Inadequacy in presentation for specific linkage of budget • Issues of redundancy and possibility of insufficient performance • Difficulties in strategic utilization of limited resources	• Categorization of systematic policy functions and goals • Establishment of linkable budget items for each detailed program
Examination and evaluation	• Inadequacy and inaccuracy in the performance information data • Lack of understanding on and application of performances • Inadequate linkage between details of examination and analysis with budget system • Difference in the subject of and perspectives in evaluation	• Permanence of examination and analysis function for R&D • Emphasize policy (ministrial) evaluation • Reinforcement of research and analysis of the project level productivity • Coordination of expansion of budget schedule

through efficient allocation of R&D resources, and to strategically induce the progress of science and technology at the national level. However, because each ministry is pursuing the programs that they directly needs, problems of redundancy in the areas of execution and insufficiency of performance, as well as issues over the strategic utilization of limited resources have been raised continuously[11]. The future direction of programs currently concentrated in the area of advanced technologies,are problematic due to gray areas surrounding allocation of resources to areas that are weak nationally, those that prepare for the future and??? those where the private sector are reluctant to participate. Therefore, the fact that the budget system must be seen from the macroscopic perspective of a national system must not be overlooked. Rather than having interest only on designing policies and budgets that aim to accomplish the specific goal and purposes of ministries, a balanced coordination and allocation must be accomplished from a wider perspective in order let the innovative system evolve effectively.

The problem confronted at the stages of evaluation is that although the processes of program evaluation and budget are being executed through the participation of specialists , analysis and evaluation of performance is not easy because there is no sufficient performance information[12]. As the determination of efficiency of R&D centered-around performance often differs according to the subject of analysis, there is a need to approach the issue by firstly conceptually segregating it in spite of the mutual connectivity.

The efficiency issues of government R&D performance have been approached from the perspective of programs viewed mainly at the meso-level thus far. However there has been a lack of interest in, discussions on, and effort to connectedly analyze and evaluate both the macroscopic level, specifically the effectiveness of government policy, and the microscopic level, specifically the enhancement of the productivity of projects considering characteristics of the areas and each of the stages (basic, application and development) of research. This arises from the fact that although tasks to be pursued in accordance with policies and planning are presented in advance through systematic planning stages and processes, there are limitations on the enhancement of the actual effectiveness of those policies closely linked to performance because there is no presentation of a specific and definitive budget connection of them afterwards (Lee, Gi Jong, 2002). In addition, the definition of highly diversified and different performances and the settlement of a proper understanding of their performance reconciled with both the dimensions of the evaluation and the characteristics of subject itself

11) Refer to Kim, Jae Young et al (2002), pp.114-117.
12) Refer to Byeon, Soon Cheon et al (2006), p.98; Korea Institute of S&T Evaluation and Planning (2008), pp.17-19

are still needed.

3.2 Structural System of Programs

Problems occur primarily at the linkage between policy and budget because the strategic allocation of finance is not being realized due to an insufficiency of segmentation and systematization of policy tasks reflected in the budget structure, leading to an insufficiency of analysis and evaluation. In order to improve this, policy functions and goals must be categorized systematically, by budget code (items) for each detailed program endowed, and problems of inequality of budget size for each program resolved[13]. Furthermore, the connection between the plans for each key area and to the overarching plan must be reinforced. Efforts to secure the system through linkage between the policy goals and program are accomplished by systematically by linking the basic science and technology plan and total budget necessary (Total Science & Technology Conference, 2008). For this purpose, there is a need to pursue a program of systematizing the policy goal of the Basic Plan and connecting it to the relevant programs in detail. A series of such efforts by themselves will enable the reinforcement of the R&D execution strategy and coordination, and• budget allocation.

Evaluation of R&D budget is actually carried out by the Specialization Committee and Budget Deliberation Meeting for each technological area of the NSTC. Therefore, whether there is concordance between the categorization of committee on technological areas, structure and system of program, and structure of budget items (code) is an important issue. However, it is impossible to clearly and definitively categorize each of individual programs from the perspective of their specific technological areas practically since the currently implemented individual programs are highly interweaved in terms of technological areas, R&D stages, and type of research institution.. As a result, there is a fundamental problem of the effectiveness and viability of coordination and allocation of a deliberate budget among the program units This is because the structure of the budget items do not realistically coincide with the categorization system bodies, such as committees or the categorization system for program evaluation and coordination and budget allocation that the NSTC is dealing with at the moment. In order to supplement this, the composition of specialists in the specialization committee for each technological area must be broadened, alleviating leaning towards specific areas without special reason by maintaining macroscopic and balanced viewpoints[14]. If, in reality, it is difficult for the technological specialists and non-technological specialists to work within the same committee, then it would be possible to consider composing and operating more detailed committees for each function where the viewpoints or functions are independently different from each other even though the subject area is the same[15]. In addition, the structural system reorganization of the program that has been attempted experimentally at the level of some of the ministries must be made to maximally coincide with policy and budget, and the system of planning and execution of budget at the level of all the ministries16). Such efforts need assertive changes in the awareness of NSTC and MOSF, and the specialized functions and knowledge of Korea Institute of Science and Technology Evaluation and Planning (KISTEP) on inquisition and analysis of research and development programs must be utilized fully (Hyeon, Jae Ho 2006).

3.3 Budget and Program Evaluation, and Inquisition and Analysis Schedule

In order for relevant ministries and principal institutions of R&D to assertively accommodate the

13) Ministry of Knowledge Economy (formally the Ministry of Industry and Resources), Ministry of Information and Communication, and Ministry of Education, Science and Technology (formally the Ministry of Science and Technology) have attempted the partial reorganization of the existing program structure (Ministry of Knowledge Economy (formally the Ministry of Industry and Resources)), (2005). However, the series of such works is not at the level for which the endowment of a systematic budget code could be expected due to the limitation that these are done from the perspectives of each individual corresponding ministry rather than being founded on the direction of policies or strategies at a national level (Hyeon, Jae Ho, 2006).

14) Refer to PREST (2000); Lee, Jeong Won; Lee, Gi Jong (2008), p.595.

process of coordination,, deliberation, and drawing up of the budget, it is important to apply the same criteria from the guidelines for the initial drawing up of budget until the evaluation stage following project execution. In drawing up the budget for the following term, it is also important to establish a realizable system for drawing up the budget by considering future-oriented goals while at the same time applying the same criteria to each ministry and program. For this purpose, schedules and systems that can verify whether policy instructed as a guideline at the beginning of the term has been reflected in each program must be established. A comprehensive, strategic and detailed review and analysis of the results (performances) of coordination, allocation and execution of budget in compliance with the basic direction of investment set out two years previously (t-2 years) must also be executed.

From the perspective of single-year accounting, schedule for the relevant activities fall in the period from January to December of every year. In addition, since deliberation and confirmation of budget for the following year is made by the end of December at the National Assembly, relevant preliminary works in general needs to be completed in the first half, and from the positions of MOSF, all budget related preliminary works must be completed before September at the latest. Two-stage works including delivery of guideline for advanced total amount of allocation and review and deliberation on follow-up self-regulated drawing up in accordance with the execution of the total amount of allocation self-regulated drawing up system must be completed by the end of August at the latest. During the same period, inquiries, analysis and evaluation on programs for each ministry will be carried out. NSTC, MOSF, MEST and KISTEP, and more than 20 relevant central ministries and institutions participate in this program.

The current schedule of deciding the size of the total amount to be allocated by the end of February of the corresponding year, and making an in-depth deliberation decision on the detailed request and plan for budget by the end of August needs to be slightly adjusted or supplemented. In order to confirm the size of the total amount to be allocated as soon as the new year starts, there is realistically only January available, which leads to a concern over whether effective details can be deduced. Therefore, details of works related to the latter half of the previous year (mostly after September) and details of works during the period from March to June of the following year must be supplemented and improved. It is recommended to pursue the following: 1) carry out reviews and analysis of the extent of linkage between the policy and budget; 2) carry out in-depth analysis on the extent of concordance between budget deliberation guidelines and outcomes of deliberation(t-2 year), and the extent of concordance between the results of deliberation confirmed in the t-2 year and results of budget executed in the t-1 year (including program performances); and 3) review and analyze the extent of reflection and concordance of the results of execution in the t-1 year on the budget deliberation guidelines for the t-2 year in the latter half of the previous year, and between March and June of the corresponding year (Figure 2). Execution of these three tasks are necessary because there must be policy and budget related review and analysis for the performance-centered evaluation and management of policy and budget in advance, and because a rational and effective budget system can only be established and settled when the policy direction and details of deliberation guidelines for the future are confirmed based on feedback provided by the system's previous outcomes.

In order for the extent of linkage between and the concordance of policy and budget, analysis of the effective execution and performance of the budget, and the preliminary and ex post facto significance of that performance analysis and evaluation in accordance with program execution and tasks should be accomplished broadly and accurately. Execution and utilization

15) The term "non-technological specialist" refers to people who are experts in national R&D program or budget -elated areas from perspectives other than specific technological area. For example, middle or higher level decision makers in industries, experts in areas of policy, finance and accounting, economics and management with abundant experience in national R&D related planning, strategy and evaluation are deemed to be non-technological specialists.

of more advanced inquisition and analysis is more important than other issues. Therefore, the currently implemented inquisition and analysis needs the supplementation of two aspects. The first is to enable utilization of inquiries and analysis to be available at all times. As in the case of Council for Science & Technology Policy (CSTP) of Japan, regularization and embodiment of the NSTC in monthly units and the introduction of a system that completes inquiries and analysis for the coordination, allocation and deliberation of the budget in the first half of the fiscal year should be considered. Secondly, contents directly associated with the budget process must be added. There is a need to seek a means of including the inquisition and analysis of contents that can allow a review in detail of the policies and strategies at the national supraordinate level, and the basic directions that the budget itself is pursuing. Contents of analysis that compare and assess the extent of concordance with directions of policy and budget deliberation guidelines, and macroscopic contents specifically and in phases must be provided. For this purpose, improvement of contents to be contained in and an execution schedule for the inquiries and analysis is necessary. Although there is a realistic difficulty of temporal disparity, it appears to be recommendable to expand and convert the currently implemented inquisition and analysis system into a dualized system for program evaluation and budget. Establishment of an analysis system and provision of contents that realistically supports the budget process must be accomplished, and may be achieved by the following. Firstly, an in-depth analysis of the deliberation among the technological area and ministry, and research principal should be carried out. Secondly, a policy and strategy should be established, and an analysis of whether there has been a substantial accomplishment of its contents such as preliminary planning works should be undertaken. Thirdly, a microscopic and macroscopic comprehensive analysis centered-around the national R&D system by the expansion and deepening of the scope and contents of the analysis to the core of the individual program and project should occur

4. Conclusion and Policy Proposal

The system in Korea related to national R&D budget and programs has undergone a succession of changes and evolution. Segregation of coordination, allocation and deliberation of function (NSTC) and drawing up of function (MOSF) has been established for budget-related decision-making processes, and the relevant support system (KISTEP) has undergone a repetition of unified progress. In addition, the program evaluation system has established a system for in-house and supraordinate evaluation, specific evaluation and evaluation for government subsidized research institutions by introducing the concept of performance evaluation.

Comprehensive coordination thus far has the tendency to concentrate on overall activities centered on the annual unit. This is on the premises that policy and budget are effectively linked through the reinforcement of planning and budget. However, evaluation of coordination, allocation and drawing up of the budget, and the outcome of programs, and the results of a comparative review of the inquiries and analyses of programs pursued in 2008 imply that the contents and directions intended by policy and budget can substantially differ from those of the results of overall programs. There is a need to accept the implication that emphasis should be placed on a comprehensive coordination taking place as a series of processes over an period of three years, rather than just on an annual basis, as illustrated in Figure 2. It can also be seen as pointing out the need to improve and supplement the inquiries and analysis, as well as the program evaluation system.

Improvement of the budget system should firstly be approached from the viewpoint of linkage between policy and budget, and, in addition, there is a need to approach from the perspective of connectivity between budget schedule, schedule and contents of inquisition and analysis. Drawing up of the budget is the final stage of planning, and the optimal policy alternative is confirmed in the drawing up of the budget. For effective linkage of policy and budget, it is a prerequisite to establish an organizational and administrative system of government that can guarantee a mutually disjunctive independence function of the department in charge of operation of MEST and NSTC, and the establishment of an organically cooperative system with MOSF that is in charge of drawing up the budget. There is a need for improvement to the system of establishment and analysis of program planning, formation and execution of policy, and the examination and evaluation stage. For this purpose, budget items must be established to enable a systematic policy function, categorization of goals and the linkage of each detailed program. In addition, there is a need for the permanent establishment of an inquisition and analysis function for research and development.

It is important to apply the same criteria from the guidelines for initial drawing up of budget to the stage of evaluation following the execution of the program. There must be a sufficient schedule and system that examines whether the guidelines for the drawing up of budgets and the direction of coordination and allocation has been reflected in the case of each program. Additional supplementation of contents that are directly helpful in the budget process by enabling full time utilization of inquiries and analysis is required. For this purpose, it is recommendable to develop the currently implemented inquisition and analysis system into a dual system for program evaluation and budget process. Establishment of an analysis system and the provision of contents that practically support the budget process by enabling a macroscopic and microscopic comprehensive analysis centered-around the R&D system must be accomplished.

The limitation of this research is that it is relying on the comparative analysis of a single case package with a focus on programs in 2008 rather than a diversified and broad empirical study, which is a preliminary work for the establishment of an elaborate system for the enhancement of efficiency of the budget system. In addition, there is also the risk that the fact that the year 2008 was the boundary point for changes in the Korean government system may make it difficult to generalize the implications of the case study. Obviously, it is possible to paradoxically present the assertion that the maintenance of consistency at such a time could be more important. In addition, there could be inaccuracies and biases in the conclusion or pointing out of problems due to other reasons. Inadequacies in the specific contents of the proposed improvements and a lack of verification of the true possibilities could also be seen as a major limitation. These are the aspects for which supplementation is necessary in future research.

5. Reference

1. National Science & Technology Council (2007), “Coordination and allocation (proposal) of budget fund for National R&D Program for 2008,” Deliberation item, Bill No. 2.
2. National Science & Technology Council (2009a), “Results (proposal) of inquiries and analysis of National R&D Programs in 2009,” Deliberation item, Bill No. 7.
3. National Science & Technology Council (2009b), “Results of performance evaluation of National R&D Programs in 2009,” Report item, Bill No. 3.
4. Kim, Jae Young; Lee, Gi Jong; Son, Byeong Ho; Oh, Se Hong; Choi, Cheol Shin (2002), 「Analysis of National R&D Development Program for each key issue(Comprehensive Issue)」, Research Report 2002-10, Korea Institute of S&T Evaluation and Planning(KISTEP)
5. Bark, Pyengmu(2006), 「Study on improvement of performance management system for efficiency in National R&D Programt」, Consigned Report 06-26, Korea Institute of S&T Evaluation and Planning, Management Research Center of Pukyong National University.
6. Bark, Pyengmu(2007), 「Plans for efficient enhancement of advanced coordination system for National R&D Program」, Korea Institute of S&T Evaluation and Planning, Consigned Research Report, Management Research Center of Pukyong National University.
7. Bark, Pyengmu·Huh, Hyeon Hwoi (2008), “Effective support plans for private sector R&D,” 「National finance management plan for 2008~2012: Comprehensive Report for the area of industrial finance」, R&D Area Chapter 2, pp. 554-591, Work group for each area.
8. Park, Jeong Woo; Park, Gi Young; Han, Ju Yeon (2004), 「Case study on comprehensive coordination related system in advanced country」, Research Report 2004-06, Korea Institute of S&T Evaluation and Planning.
9. Byeon, Soon Cheon; Jeong, Bo Seop; Kim, Mi Jeong (2006), 「Study on plans for reorganization of the inquisition and

analysis system for enhancement of level of utilization of inquiries and analysis of National R&D Program」, Research Report 2006-14, Korea Institute of S&T Evaluation and Planning.

10. Ministry of Industry and Resource (2005), "Study on plans for reorganization of industrial technology R&D," Internal material.
11. Seong, Ji Eun (2006), "Budget determination and allocation system of National R&D Program," 「Science & Technology Policy」, 16(5), pp. 2-19.
12. Yang, Hee Seung (2004), "Comprehensive coordination of National R&D Program – evaluation and coordination of budget," paper presented at the Winter Academic Conference of the Korean Association for Policy Evaluation and Analysis
13. Yoon, Seong Shik (2003), 「Theory of Budget」, Nanam Publication.
14. Lee, Gi Jong (2002), "Effective linkage between basic Science and Technology Plan and budget", paper presented at the Summer Academic Conference of the Korean Association for Public Administration.
15. Lee, Jang Jae (2004), 「Study on plans for efficiency in government's investment into R&D」, Science & Technology Advisory Council.
16. Lee, Jeong Won; Lee, Gi Jong (2008), "Direction of improvement for National R&D Program evaluation system," 「National finance management plan for 2008~2012: Comprehensive Report for the area of industrial finance」, R&D Area Chapter 3, pp. 593-632, Work group for each area.
17. Jeong, Geun Ha; Moon, Jin Gyeong; Park, Moon Soo; Bark, Pyeong Mu(2005), "Study on plans for improvement of comprehensive coordination system of National R&D Program," 「Journal of Korea Technology Innovation Society」, Vol. 8, No. 1; pp.183-208.
18. Korea Institute of S&T Evaluation and Planning (2008), 「Report on performance analysis of National R&D Program in 2008」.
19. Hyeon, Jae Ho (2006), "Trend of structural reorganization and direction of future pursuit of government's R&D programs," 「Science & Technology Policy」, 16(5); pp. 20-31.
20. 總合科學技術會議(2008), "平成21年度科學技術關係豫算への源配分方針の適用についての具體的進め方", 「*科學技術政策* (Science and Technology Policy)」, 平成20年7月10日(PDF), 日本, from http://www8.cao.go.jp/cstp/index.html.
21. Lynch, Thomas D. (1979), Public Budgeting in America, Englewood Cliffs, New Jersey: Prentice-Hall.
22. PREST (2000), Changes in the Research Landscape and the Impacts of Research Assessment Exercise, from http://www.hefce.ac.uk.
23. Wildavsky, Aaron (1974), The Politics of the Budgetary Process, 2nd Ed., Boston: Little Brown.

Measuring the Quality of Research Performance by Relative Rank-normalized Impact Factor (R^2nIF)

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Abstract

Due to the recent rapid increase in the size of investment into R&D in Korea, the performance evaluation of government R&D programs has become an important issue in the evaluation and establishment of policies on R&D. Although the results of R&D are produced in a wide range of forms in accordance with the purpose of the R&D, in most cases, these results are primarily in the form of research papers or patents. Accordingly, the analysis of papers and patents is the most fundamental means of evaluating the research performance.

This article attempted to analyze the qualitative status of government R&D programs in Korea and the world through an evidence-based approach with the SCI papers. A new qualitative measurement indicator for the SCI papers, namely the Relative Rank-normalized Impact Factor (R^2nIF), which enables comparison between each field of research, between each country and to global standards, was developed by compensating the limitations of the qualitative indicators that various research groups have been using.

The results in the R^2nIF analysis of government R&D programs showed that although the government R&D programs of Korea have been making contributions towards the enhancement of the qualitative level of SCI papers to a certain extent, the qualitative separation from the global standard still remains substantial, and is particularly large in the fields of Bio-science and Computer science.

It is anticipated that the R^2nIF developed in this paper can be appropriately applied to the majority of performance analysis and evaluation for which the collection of citation information is impossible.

1. Introduction

In common with the rest of the world, Korean Investment into science and technology is increasing in order to enhance national competitiveness. The total government R&D budget of Korea in 2008 was 34.4981 trillion Korean Won (₩), which is a 10.2% increase from the previous year, and the proportion of the R&D budget in comparison to the GDP at 3.37% was ranked 4th in the world. The R&D budget of the government increased drastically from ₩3.7 trillion in 1999 to ₩12.3 trillion in 2009, and is planned to be expanded continuously at an annual average of 10.7% until 2012. With such an increase in the size of investment into R&D in Korea, interest in research performance is rising. Accordingly, the

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government has established the legal foundation for the efficient management of government R&D programs' performance by enacting the "Law on performance evaluation and performance management of government R&D programs".

Performance evaluations of government R&D programs have become one of the most important topics in the evaluation and establishment of policies on R&D. In most cases, research papers and patents are the most fundamental means of measuring research performance since the results of research are manifested in the forms of papers or patents. Accordingly, the number of SCI papers published, the number of patent applications and registrations, the citations and the SCI Impact Factor (IF) of journal are often used in R&D program evaluation. However, these performance indicators of SCI papers and patents used in most evaluations of R&D programs are only tools to measure the quantitative performance rather than the quality of research, and have limitations in properly reflecting the intrinsic characteristics of each of the research fields. Numerous researchers are developing qualitative measurement indicators in order to overcome such limitations, and the National Research Foundation (NRF) of Korea has analyzed the qualitative characteristics of SCI papers by using a qualitative measurement indicator referred to as the modified rank-normalized Impact Factor (*mrnIF*)[1]. However, these qualitative measurement indicators continue to have the limitation that comparative analysis between country and with global standards is impossible.

Accordingly, this paper will propose a new qualitative measurement indicator (Relative Ranking-normalized Impact Factor, R^2nIF) that can overcome the limitations of the existing qualitative indicators. In addition, we examined the qualitative status of government R&D programs in overall research performance within Korea and the world by applying this indicator to the performance analysis of Korean government R&D programs.

2. Relevant Researches

R&D program evaluation can be divided largely into peer review that represents a qualitative evaluation and quantitative indicator evaluation. Of these, although the peer review does not produce an objective quantification, it is considered to be the most effective method of evaluating R&D programs, pointed particularly qualitative research performance. However, numerous researchers have pointed out the following problems of this method.

Kim, I. M. (2002) pointed out as a problem of peer review the loss of some universal and valid objectivity and fairness when using the subjective judgments of human beings which are influenced by surrounding circumstances. Kostoff (1995) presented the following 6 problems of peer review. Firstly, if the major field of study of the evaluator does not precisely coincide with the corresponding field, then, evaluation results can become distorted. Secondly, the rate at which scientists and engineers receive research grants is much higher in traditional research fields than newly emerging ones. Thirdly, there is a higher probability of receiving a research grant regardless of the qualitative level of the contents of research as there may be halo effect on well-known researchers and research institutions. Fourthly, each evaluator's judgment is subjective, and can be subject to different interpretations and standards of evaluation. Fifthly, substantial consent and consistency between evaluators on the premises used in peer review are required. Sixthly, the cost and time required for peer review is quite substantial.

In order to overcome the aforementioned disadvantages of peer review, many researchers have put much effort into developing quantitative analytic methods. Prichard (1969) developed a new concept referred to as the "bibliometric", and this has become the origin of measurement indicator evaluation and analysis. Measurement indicators for the qualitative analysis of SCI papers using bibliometric include the citation frequency and SCI Impact Factor (IF). Firstly, qualitative analysis using the number of citations began

1) Pudovkin. A. I. (2004); Heo, J. E. (2008)

from the belief that quality of a paper is manifested through its citation by peer scientists (Garfield, 2001). Because most papers cannot be cited by other papers immediately after publication in journals, the average number of citations in a 5-year cycle is frequently used in citation frequency analysis. The comparative indicator for qualitative level of the Center for Science & Technology Studies (CWTS) of Lieden University in Netherlands is one of the cases in which the number of citations in 5-year cycle is used. CWTS carried out analysis of the qualitative level by categorizing the number of citations in 5-year cycle of a particular group as outstanding if it is greater than other groups by 1.2 fold, average if it falls in the range of 0.8~1.2 fold, and inadequate if it is less than 0.8 fold. However, there is a serious limitation in using the extent of citation in a 5-year cycle in analysis or evaluation of performance in that there are difficulties in collecting the information on the number of citations since the majority of papers subjected to analysis and evaluation of performance have been published more recently than 5 years. Accordingly, most of the reports on the analysis and evaluation of performance is employing indirect analysis methods by using the SCI IF rather than direct analysis by using the number of citations.

While the number of citations indicates the impact of individual papers, the SCI IF mainly indicates the influence of the journal itself. The SCI IF of an academic journal is computed by dividing the number of citations in the standard year of all papers published in the corresponding journals during the most recent 2 years, with the exception of the standard year, by the number of papers. However, many researchers have been presenting problems with the SCI IF for the qualitative analysis of papers for a comparative analysis between research fields, made impossible because of the deviation in SCI IF between the research fields which has not been accounted for (Sen, 1992; Marshakova-Shaikevich, 1996; and Seglen, 1997, etc). For example, a direct comparison of SCI IF between ‘Mathematics’ for which there are a smaller number of academic journals and low overall SCI IF and ‘Bio-science’ for which the number of academic journals and SCI IF are higher, may lead to unfair analysis as it does not consider differences between the research fields at all.

In order to overcome the aforementioned limitations of SCI IF analysis, many researchers have proposed a diverse range of qualitative measurement indicators. In particular, Pudovkin (2004) proposed an indicator referred to as the rank-normalized Impact Factor (*rnIF*) that only utilizes the ranking of SCI IF within a field rather than using the SCI IF. The method proposed by Pudovkin can simply and effectively compensate for the limitations of the SCI IF by means of the following equation (Equation 1).

$$rnIF_j = \frac{(N - R_j + 1)}{N} \qquad \text{(Equation 1)}$$

Here, $rnIF_j$ is the rank-normalized Impact Factor of an academic journal (*j*), *N* is total number of journals for the JCR category to which a journal (*j*) is assigned, while R_j is the SCI IF ranking of a particular journal (*j*) within the JCR category. In order to compute *rnIF*, information outside that provided by the Journal Citation Reports (JCR) is not needed. *rnIF* presumes that academic journals in different fields but with a similar status within their respective fields have the same qualitative level. If *rnIF* has value of x, then it signifies that an academic journal with (1-x) × 100% has superior SCI IF than the academic journal with a value of x.

In addition, Sen (1992) suggested the following normalization procedure: $SnIF_j = \frac{IF_j}{maxIF} \times 10$, where IF_j is the SCI IF for journal (*j*), *maxIF* is the maximal SCI IF for the JCR category to which journal (*j*) is assigned. Marshakova-Shaikevich (1996) also suggested a similar normalization: $MnIF_j = \frac{IF_j}{av5maxIF} \times 100$, where *av5maxIF* is the weighted average of the top five SCI IF values in the JCR category, to which the journal (*j*) pertains. The National Research Foundation (NRF) developed a modified rank-normalized Impact Factor (*mrnIF*) to overcome the limitation that the *rnIF* value of the lowest ranking journal for each field relies on number of journals within a field, and allocated integer values in the range of 1~5 on the basis of *mrnIF* (Heo, Jeong Eun et al, 2008).

However, the aforementioned measurement indicators (*rnIF*, *mrnIF*, etc) based on the SCI IF ranking within a field continue to have the limitation that comparative analysis for each country and with the global standard is impossible. Accordingly, in this article, a new qualitative measurement indicator (R^2nIF) that can overcome the limitations of the existing rank-normalized Impact Factor will be proposed. Furthermore, the current status on the scientific and technological ripple effects of government R&D programs will be accurately diagnosed by utilizing this indicator for the performance analysis of government R&D programs.

3. Analytic Method

3.1 Analytic Model

This article aims to analyze the quality of SCI papers generated from the Korean government's R&D programs. Therefore, the most accurate method would be to investigate and analyze the number of citations of individual papers. However, since this study is on papers published between 2006~2008, analysis of the qualitative level of papers through a citation survey of individual papers is not possible, and it is deemed that numerous performance analyses or performance evaluations would also be subjected to the same limitations. Accordingly, in this study, the method of indirectly analyzing the qualitative level of papers by using the SCI Impact Factor (IF) of journals in which the papers are published has been employed.

As mentioned above, the problem is that there is room for controversy over the fairness of comparing the SCI IF between other research fields since the SCI IF of journals displays substantial differences between each research field. In order to solve these problems, we have developed new qualitative measurement indicator that enables the comparative analysis between other research fields and countries based on the method of compensating the limitations of the SCI IF proposed by Pudovkin *et al.*.

In this article, SCI papers published in the academic journals listed in the JCR database that provides information on SCI IF were chosen up as subjects. The rank-normalized Impact Factor (*rnIF*) was introduced to compensate for the deviation in the SCI IF between research fields. In order to allocate the SCI IF ranking for each field, it was necessary to categorize the academic journals in each field. The model proposed by Pudovkin et al. and the model utilized by NRF (National Research Foundation) categorized the research fields by using the JCR categories (categorization of 175 JCR by Thompson). However, when such a categorization method is employed, there are several fields with less than 20 academic journals within a field, thereby presenting problems in computation of the ranking of journals. Accordingly, in this article, analysis was carried out by employing the method of categorizing journals with National Science Indicators (NSI) standard fields. The NSI standard fields are given in Table 1 below.

After having categorized journals with NSI standard fields, the rank-normalized Impact Factor (*rnIF*) of each journal was allocated in accordance with Equation 2 on the basis of the SCI IF information using the 2007 JCR version and the method proposed

Table 1 NSI standard fields

Main Categories	Standard Field
Engineering and Computer	Computer Science
	Engineering
	Materials Science
Physics, Chemistry and Earth Science	Chemistry
	Geosciences
	Mathematics
	Physics
	Space Science
Bio-science	Biology & Biochemistry
	Immunology
	Microbiology
	Molecular Biology & Genetics
	Neuroscience & Behavior
	Pharmacology & Toxicology
Medical Science	Clinical Medicine
Agriculture, Biology, Environmental Science	Agricultural Science
	Environment/Ecology
	Plant & Animal Science
Multidisciplinary	Multidisciplinary
Social Science	Economics & Business
	Social Science, general
	Psychiatry/Psychology

by Pudovkin.

$$rnIF_j = \frac{(N - R_j + 1)}{N} \qquad \text{(Equation 2)}$$

N : Total number of journals in the corresponding field

R_j : SCI IF ranking of journal (j) within the corresponding field

Then, the modified rank-normalized Impact Factor (*mrnIF*) was computed in order to overcome the char-acteristic of *rnIF* that it relies on the number of journals within a field. Since the lowest value of *rnIF* for each field relies on the number of journals within a field, values of *rnIF* were standardized with a minimum value of 0 and a maximum value of 100 through the following Equation 3.

$$mrnIF_j = 100 \times \frac{(N \times rnIF_j + 1)}{(N-1)} \qquad \text{(Equation 3)}$$

N : Total number of journals in the corresponding field

$rnIF_j$: *rnIF* of journal (j) in which paper is published

However, as mentioned above, the *mrnIF* also continues to have the limitation that it does not allow comparative analysis between countries or at the global level. Therefore, in this article, the Relative Rank-normalized Impact Factor (R^2nIF), with additional factors to the *mrnIF* which enable international comparison, is developed and used in analysis. R^2nIF is an indicator that compares the *mrnIF* of a paper to be analyzed with the $mrnIF_{Global\ average}$ of the same research field as shown in Equation 4. For example, R^2nIF of a paper published in the '*Physics Review Letters*' in 2008, which is a journal under the category of 'Physics', can be computed by dividing the $mrnIF_j$ of '*Physics Review Letters*' (=97.035) by $mrnIF_{Global\ average}$ of the field of 'Physics' (=68.715) in 2008.

$$R^2nIF_j = \frac{mrnIF_j}{mrnIF_{\text{Global average of the same research field)}}} \qquad \text{(Equation 4)}$$

To compute the R^2nIF, the $mrnIF_{\text{Global average}}$ of each of the 22 NSI standard fields must be computed for all the papers in the world. Information on the number of papers in each journal is necessary to compute the $mrnIF_{\text{Global average}}$ for each NSI Standard Field. This data was extracted from the Science Citation Index Expanded (SCIE) Database held by KAIST. The $mrnIF_{\text{Global average}}$ for the field of 'Physics' in 2008 can be easily computed by applying Equation 5. The $mrnIF_{\text{Global average}}$ computed using the number of papers (N_i) and the $mrnIF_i$ information for each journal is shown in Table 2.

$$mrnIF_{Global\ average(2008)\ of\ the\ physics} = \frac{\sum_{i=1}^{n} (mrnIF_i \times N_i)}{\sum_{i=1}^{n} N_i}$$

(Equation 5)

N_i : No. of papers in the i[th] journal in 2008 under the category of 'Physics' in 2008

$mrnIF_i$: *mrnIF* of the i[th] journal under the category of 'Physics'

Then, the R^2nIF_j of each paper is calculated by dividing the $mrnIF_j$ of the publishing journal by the $mrnIF_{\text{Global average}}$ of the same research field, and is shown in Table 3. Allocating R^2nIF_js to each paper in this way, the quality of SCI papers generated with government R&D support was analyzed in comparison to global standards.

3.2 Limitations of Analysis

We would like to mention the limitations of performance analysis using R^2nIF_j as employed in this article. Firstly, in order to analyze the qualitative characteristics of SCI papers generated from government R&D programs, it would be most accurate to calculate the $rnIF_j$ for each journal after classifying all journals into the 'Science and Technology Standard Category' set by the 'National Science & Technology Council'. However, this is impossible in reality due to the enormous amount of work it would involve. Accordingly, the NSI standard field was used in this analysis. In addition, if a journal is repeated in more than one NSI standard field, then, the average $rnIF_j$ was used.

Table 2 Global average of *mrnIF* for each NSI standard field (2006-2008)

NSI Standard Fields	$mrnIF_{Global\ average}$		
	2006	2007	2008
Agricultural Sciences	71.727	71.381	72.261
Biology & Biochemistry	65.200	65.046	64.644
Chemistry	68.122	68.180	68.182
Clinical Medicine	65.802	65.861	65.509
Computer Science	67.987	69.022	68.622
Economics & Business	67.749	67.866	73.543
Engineering	73.044	73.807	73.544
Environment/Ecology	66.233	68.167	67.454
Geosciences	69.138	67.947	70.168
Immunology	60.468	61.956	61.663
Materials Science	75.359	76.497	76.994
Mathematics	67.858	67.045	66.059
Microbiology	63.240	63.116	63.016
Molecular Biology & Genetics	62.330	62.247	62.164
Multidisciplinary	74.368	75.250	74.934
Neuroscience & Behavior	65.608	65.971	65.975
Pharmacology & Toxicology	61.114	61.152	60.642
Physics	67.482	68.482	68.715
Plant & Animal Science	68.200	68.494	69.083
Psychiatry/Psychology	65.593	65.979	65.459
Social Sciences, general	68.992	69.847	68.413
Space Science	74.347	77.368	72.938

Table 3 Example of computation of R^2nIF of SCI paper (2008)

Paper	Journal	NSI Standard Field	SCI IF	*mrnIF* (A)	$mrnIF_{Global\ average('08)}$ (B)	R^2nIF (A/B)
Chemical tools for functional studies of ...	Chemical Society Reviews	Chemistry	13.082	99.424	68.182	1.458
Assay of diazinon pesticides in cucumber ...	Microchimica Acta		1.959	68.300		1.002
Effects of anonaine on dopamine biosynthesis ...	Molecules		0.940	39.193		0.575
Current status of ENSO prediction skill in ...	Climate Dynamics	Geosciences	3.961	98.118	70.168	1.398
Does the restoration of an inner-city stream in Seoul ...	Theoretical and Applied Climatology		1.674	70.353		1.003
Two-dimensional waveform inversion of multi-component ...	Geophysical Prospecting		0.731	31.529		0.449
Choice of neighbor order in nearest-neighbor ...	Annals of Statistics	Mathematics	1.944	94.316	66.059	1.428
Weighted Poincare inequality and heat kernel estimates ...	Mathematische Annalen		0.877	67.789		1.026
List-coloring the square of a subcubic graph	Journal of Graph Theory		0.503	33.263		0.504

Table 3 Example of computation of R^2nIF of SCI paper (2008) (cont'd)

Paper	Journal	NSI Standard Field	SCI IF	$mrnIF$ (A)	$mrnIF_{Global\ average('08)}$ (B)	R^2nIF (A/B)
Combinatorial patterns of histone acetylations ...	Nature Genetics		25.556	99.170		1.595
Basal c-Jun N-terminal kinases promote mitotic progression ...	Cell Cycle	Molecular Biology & Genetics	3.314	60.996	62.164	0.981
Adaptive response to GSH depletion and resistance to ...	Molecular and Cellular Biochemistry		1.707	26.556		0.427
Anisotropic behaviours of massless Dirac ...	Nature Physics		14.677	99.191		1.444
Miniaturization of a Fresnel spectrometer	Journal of Optics A-Pure and Applied Optics	Physics	1.752	68.733	68.715	1.000
Time-dependent Wigner distribution function ...	Physica Scripta		0.946	40.431		0.588
A subhalo-galaxy correspondence model of galaxy biasing	Astrophysical Journal		6.405	93.333		1.280
The high activity of 3C 454.3 in autumn 2007 ...	Astronomy & Astrophysics	Space Science	4.259	80.000	72.938	1.097
Enhanced luminosity of young stellar objects in cometary globules	Astrophysics and Space Science		0.834	31.111		0.427

4. Analysis of Qualitative Characteristics by Using the Relative Rank-normalized Impact Factor (R^2nIF)

4.1. Comparison of Each Country by R^2nIF

Among the key countries, the Relative Rank-normalized Impact Factor (R^2nIF) of the SCI papers of the USA was the highest in 2008 at 1.066, with the U.K and Germany also illustrating high values of 1.044 and 1.015, respectively. In comparison, the R^2nIF of SCI papers of Korea in 2008 was 0.924, which is below the global average of 1.0, as were Japan and Taiwan with a figure of 0.947 and 0.966 respectively. The qualitative level of SCI papers in Korea is, however, slightly higher than newly industrialized countries such as China and India.

When the qualitative level SCI papers in Korea is calculated limiting the scope to those with government R&D support, the R^2nIF of SCI papers published in 2008 is 0.934, which is still below the global average, but slightly higher than that of all Korean papers at 0.924. This indicates that government R&D programs are making a contribution towards the improvement of paper quality. However, the annual average R^2nIF of SCI papers with government R&D support decrease from a peak of 0.942 in 2006, and exhibit a growing gap with average global quality levels. Therefore, further study is needed to establish the cause of failure to improve the quality of SCI papers in spite of the efforts the government has made to increase it. R^2nIF of SCI papers of key countries during 2006~2008 are shown in Table 4.

The results of R^2nIF analysis for each of the NSI standard fields illustrated that Korea has strength in the fields of space science, earth science, material science, and plant & animal science (Table 5). The R^2nIF for SCI papers in these fields in 2008 were 1.107,

Table 4 Average R^2nIF of SCI papers of key countries

Key Countries		2006	2007	2008
Korea		0.862	0.915	0.924
	Government R&D	0.942	0.940	0.934
USA		1.071	1.076	1.066
U.K.		1.034	1.046	1.044
China		0.901	0.914	0.896
Germany		0.991	1.014	1.015
Japan		0.914	0.938	0.947
Taiwan		0.926	0.955	0.966
India		0.862	0.874	0.866

1.055, 1.020 and 1.011, respectively, and were higher than the global average at 1.0. In addition, although not many papers were published in the field, papers in the field of ‘multidisciplinary’ had an R^2nIF of 1.080, which is also higher than the global average. In comparison, the R^2nIF for the BT-related NSI standard fields including biology & biochemistry, clinical medical science, immunology, microbiology, molecular biology & genetics, and pharmacology were in the range of 0.8~0.9, thereby displaying a substantial gap with global standards.

Figure 1 shows the results of a comparison of the R^2nIF for each NSI standard field in 2008 with the USA, the UK, Germany, Japan, Taiwan, China and India. In comparison to the USA, the UK and Germany, Korea substantially lags behind in a majority of fields with the exception of a few fields such as space science, material science, earth science and agriculture. In particular, the gap in computer science and BT-related fields (microbiology, molecular biology & genetics, and immunology) is quite substantial. Korea displays R^2nIF characteristics that are similar to Japan and Taiwan for each field, and when compared to China and India, Korea displays qualitative paper characteristics which are equivalent or superior in most fields, the one exception being computer science where Korea lags behind.

Table 5 R^2nIF of SCI papers of Korea for each NSI standard field

NSI Standard Field	R^2nIF		
	2006	2007	2008
Agricultural Sciences	1.014	1.021	0.996
Biology & Biochemistry	0.902	0.896	0.905
Chemistry	0.994	0.981	0.995
Clinical Medicine	0.900	0.902	0.899
Computer Science	0.737	0.784	0.733
Engineering	0.981	1.002	0.996
Environment/Ecology	0.894	0.910	0.977
Geosciences	1.049	1.061	1.055
Immunology	0.820	0.892	0.804
Materials Science	1.022	0.996	1.020
Mathematics	0.914	0.969	0.887
Microbiology	0.888	0.886	0.902
Molecular Biology & Genetics	0.880	0.872	0.857
Multidisciplinary	1.149	1.071	1.080
Neuroscience & Behavior	0.897	0.910	0.904
Pharmacology & Toxicology	0.901	0.914	0.890
Physics	0.952	0.981	0.958
Plant & Animal Science	1.000	1.008	1.011
Psychiatry/Psychology	1.062	1.002	0.967
Social Sciences, general	0.977	1.064	0.965
Space Science	1.099	1.085	1.107

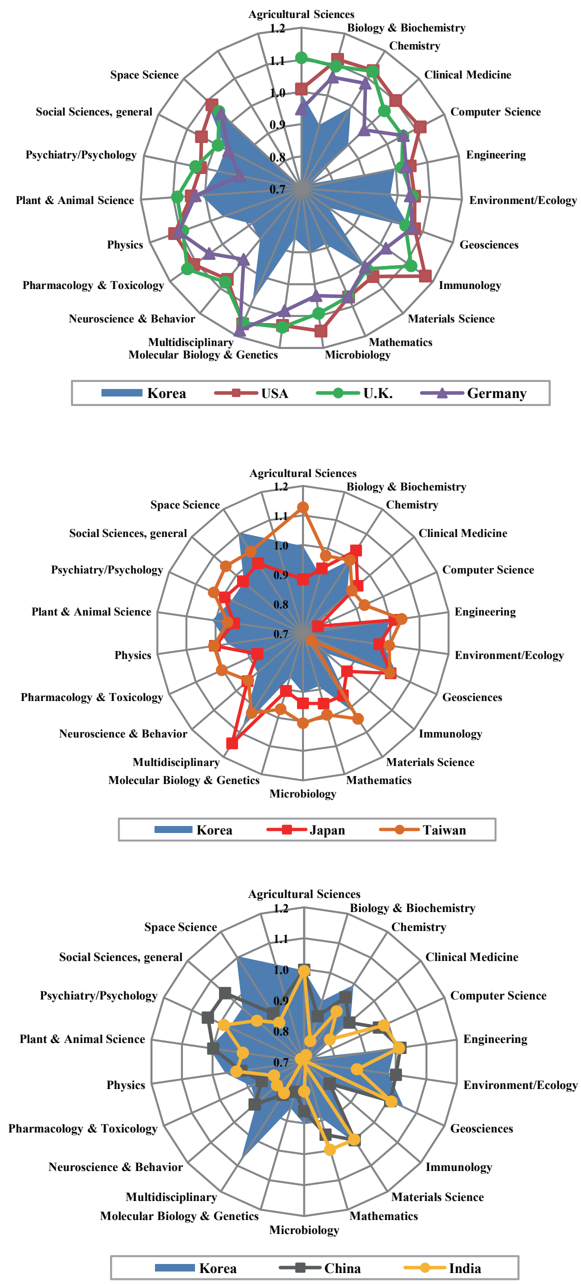

Figure 1 Comparison of R^2nIF for each NSI standard field of key countries (2008)

Table 6 Comparison of qualitative measurement indicators of SCI paper for each category of research institution

Category of research institution	No. of SCI papers			SCI IF			*mmIF*			R^2nIF		
	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
National and Public Research Institutes	295	409	560	2.12	2.03	2.39	56.5	55.9	57.5	0.850	0.838	0.863
Government Subsidized Research Institutes	2,738	2,941	3,181	2.03	2.25	2.25	61.2	65.0	63.3	0.883	0.932	0.909
Universities	6,793	9,557	11,450	2.70	2.58	2.56	66.0	65.3	65.2	0.969	0.949	0.948
Large Enterprises	177	300	363	2.83	2.27	2.25	70.9	67.2	62.8	1.034	0.966	0.907
Small & Medium Enterprises	175	265	269	2.39	2.23	2.04	61.5	63.2	61.6	0.902	0.912	0.888
Others	150	215	205	2.01	2.15	2.05	61.3	58.3	62.0	0.883	0.838	0.887
Total	10,328	13,687	16,028	2.49	2.47	2.47	64.4	64.8	64.4	0.942	0.940	0.934

4.2. Comparison of R^2nIF for Each Detailed Standard

4.2.1 Comparison of R^2nIF across categories of research institution

The results of the R^2nIF analysis broken down by categories of research institution (Figure 2) illustrated that universities have the highest R^2nIF, and that the qualitative level of all categories of research institution were lower than the global average. Among the categories of research institution, the R^2nIF of SCI papers published by universities in 2008 was the highest at 0.948, followed by government subsidized research institutes (0.909), large enterprises (0.907), small & medium enterprises (0.888) and national & public research institutes (0.863). Although the number of SCI papers published by all categories of research institution increased substantially in comparison to the previous year, the R^2nIF, which is a qualitative indicator, decreased, thereby indicating an urgent need to improve the qualitative aspects. In particular, in the case of universities, although the number of published papers increased enormously (6,793 → 11,450), the R^2nIF on the contrary decreased from 0.969 in 2006 to 0.948 in 2008 as shown in Table 6.

Figure 3 and Table 7 show the results of breaking

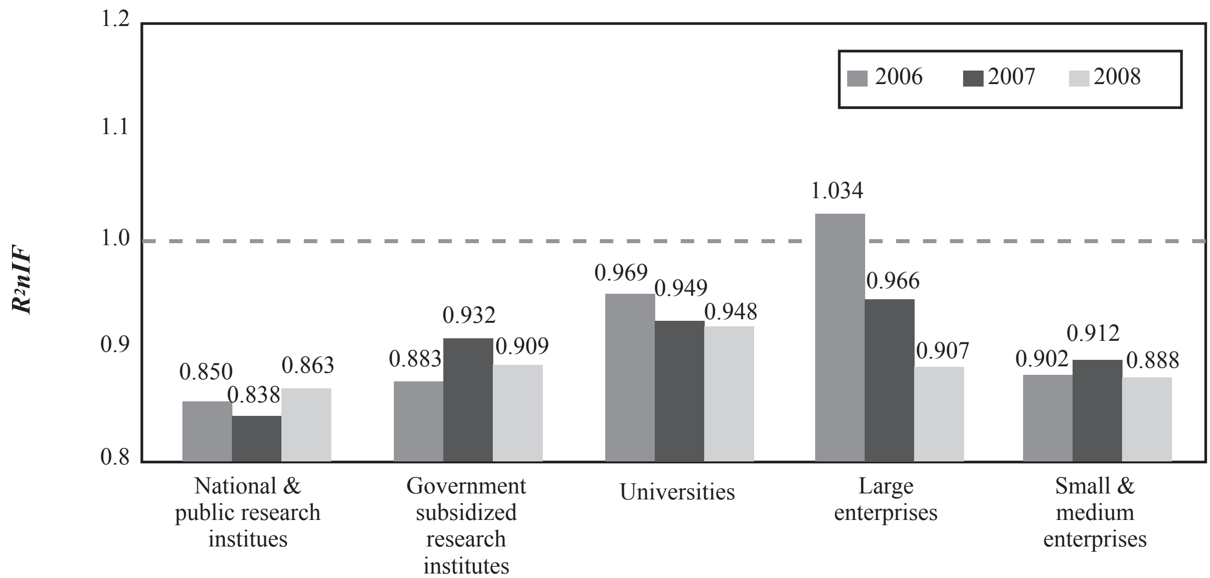

Figure 2 Comparison of R^2nIF for each category of research institution

Table 7 Comparison of qualitative measurement indicators of SCI paper for each R&D stage of categories of research institution

Categories		No. of SCI papers			SCI IF			*mmIF*			R^2nIF		
		2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
National and Public Research Institutes	Basic Research	98	167	252	2.22	2.19	2.15	56.6	57.2	56.0	0.861	0.864	0.840
	Applied Research	71	149	225	1.49	1.75	2.82	51.5	55.1	60.9	0.766	0.816	0.914
	Development Research	125	93	73	2.40	2.22	1.93	59.4	54.8	53.6	0.891	0.827	0.803
	Others	1	0	10	0.86	-	2.07	44.9	-	48.3	0.658	-	0.726
	Subtotal	295	409	560	2.12	2.03	2.39	55.6	55.9	57.5	0.850	0.838	0.863
Government Subsidized Research Institutes	Basic Research	826	1,184	1.310	2.63	2.62	2.57	67.2	67.5	65.6	0.980	0.975	0.950
	Applied Research	1,222	1,053	1,076	1.84	2.21	2.13	59.7	64.8	62.2	0.860	0.930	0.894
	Development Research	614	660	703	1.67	1.61	1.88	57.8	60.6	61.2	0.826	0.855	0.866
	Others	77	43	93	1.40	2.88	1.84	47.9	68.2	59.9	0.682	0.978	0.846
	Subtotal	2,738	2,941	3,181	2.03	2.25	2.25	61.2	65.0	63.3	0.883	0.932	0.909
Universities	Basic Research	4,174	5,975	6,999	2.95	2.82	2.86	67.7	67.5	68.1	0.998	0.985	0.995
	Applied Research	1,850	2,551	3,247	2.38	2.35	2.20	63.7	62.7	61.4	0.932	0.908	0.889
	Development Research	728	911	1,101	2.15	1.81	1.78	62.6	60.3	58.6	0.909	0.862	0.837
	Others	41	120	104	1.35	1.18	1.25	57.3	51.1	54.3	0.812	0.713	0.762
	Subtotal	6,793	9,557	11,450	2.70	2.58	2.56	66.0	65.3	65.2	0.969	0.949	0.948
Large Enterprises	Basic Research	15	32	16	2.78	2.60	2.71	65.9	71.2	67.4	0.995	1.040	1.001
	Applied Research	46	83	102	3.44	3.09	3.08	69.1	71.3	63.5	1.033	1.046	0.944
	Development Research	117	185	246	2.59	1.85	1.88	72.3	64.7	62.3	1.040	0.918	0.886
	Others	0	0	0	-	-	-	-	-	-	-	-	-
	Subtotal	177	300	363	2.83	2.27	2.25	70.9	67.2	62.8	1.034	0.966	0.907
Small & Medium Enterprises	Basic Research	10	12	19	3.05	2.38	2.30	56.5	52.0	64.1	0.863	0.789	0.931
	Applied Research	20	37	60	2.21	2.71	2.00	59.3	69.4	58.6	0.872	0.998	0.847
	Development Research	145	216	185	2.37	2.14	2.04	62.1	62.8	62.4	0.908	0.904	0.898
	Others	0	0	3	-	-	1.22	-	-	56.5	-	-	0.789
	Subtotal	175	265	269	2.39	2.23	2.04	61.5	63.2	61.6	0.902	0.912	0.888
Others		150	215	205	2.01	2.15	2.05	61.3	58.3	62.0	0.883	0.838	0.887
Total		10,328	13,687	16,028	2.49	2.47	2.47	64.4	64.8	64.4	0.942	0.940	0.934

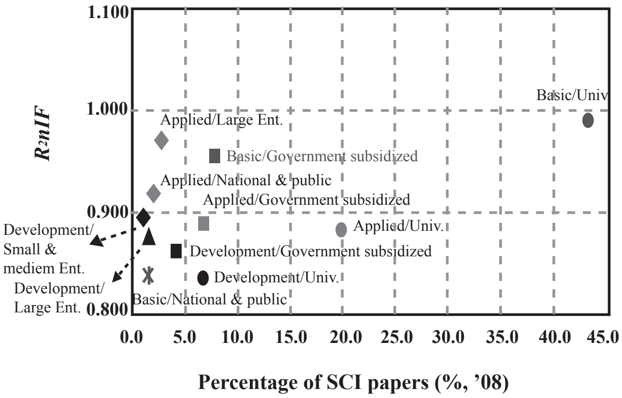

Figure 3 R^2nIF for each R&D stage/ category of research institution (2008)

down the R^2nIF for each category of research institution by each stage of R&D. SCI papers with a high R^2nIF were generated from basic research carried out by universities. Although the R^2nIF of papers published for basic research projects by universities was 0.995 in 2008, close to the global level, the quality of papers of applied research and development research carried out by universities were substantially lower than the global level. In addition, although the R^2nIF for applied research carried out by large enterprises in 2008 was the highest among the categories of research institution at 0.944, this value is still substantially lower than the global level.down

Table 8 Universities with high ranking R^2nIF

2006				2007				2008			
Institutions	No. of papers	SCI IF	R^2nIF	Institutions	No. of papers	SCI IF	R^2nIF	Institutions	No. of papers	SCI IF	R^2nIF
POSTEH	404	3.30	1.092	POSTEH	630	2.96	1.055	KAIST	591	3.18	1.062
Ewha Womans Uni.	151	3.72	1.079	Ewha Womans Uni.	190	3.27	1.037	POSTEH	775	3.07	1.054
KAIST	453	2.89	1.057	Yonsei Uni.	645	3.16	1.033	Ewha Womans Uni.	247	3.50	1.048
Seoul Nat. Uni.	1,027	3.21	1.030	KAIST	542	2.88	1.011	GIST	210	2.63	1.029
Yonsei Uni.	452	3.09	1.027	Seoul Nat. Uni.	1,404	2.91	1.002	Yonsei Uni.	822	3.16	1.014
Kyungpook Nat. Uni.	222	3.20	1.011	Hanyang Uni.	418	2.51	0.988	Seoul Nat. Uni.	1,562	3.03	1.011
Korea Uni.	415	2.65	0.984	Sungkyunkwan Uni.	441	2.69	0.984	Sungkyunkwan Uni.	536	2.73	1.004
Sungkyunkwan Uni.	291	2.76	0.984	GIST	191	2.65	0.980	Kyungpook Nat. Uni.	344	2.76	0.963
Chungbuk Nat. Uni.	107	2.54	0.945	Korea Uni.	539	2.46	0.956	Gyeongsang Nat. Uni.	197	2.54	0.957
Chungnam Nat. Uni.	124	2.42	0.941	Chungnam Nat. Uni.	152	2.39	0.938	Seoul Nat. Uni. Hospital	175	3.54	0.933
Ajou Uni.	99	2.82	0.937	Kyungpook Nat. Uni.	248	2.59	0.930	Korea Uni.	576	2.40	0.931
Catholic Uni. of Korea	112	3.20	0.932	Ajou Uni.	127	2.46	0.930	Chonbuk Nat. Uni.	322	2.19	0.929
Hanyang Uni.	305	1.96	0.921	Chonnam Nat. Uni.	187	2.74	0.920	Chonnam Nat. Uni.	270	2.32	0.907
Inha Uni.	215	2.27	0.916	Pusan Nat. Uni.	410	2.35	0.917	Pusan Nat. Uni.	455	2.17	0.905
Chonbuk Nat. Uni.	155	2.22	0.911	Chonbuk Nat. Uni.	225	2.03	0.904	Hanyang Uni.	611	2.03	0.903
Gyeongsang Nat. Uni.	118	2.38	0.909	Konkuk Uni.	146	2.37	0.872	Konkuk Uni.	204	2.37	0.883
Pusan Nat. Uni.	227	2.25	0.904	Gyeongsang Nat. Uni.	194	2.24	0.861	Ajou Uni.	169	2.24	0.880
Chonnam Nat. Uni.	152	2.79	0.899	Chungbuk Nat. Uni.	187	2.02	0.853	Chungnam Nat. Uni.	169	2.16	0.856
Konkuk Uni.	104	2.42	0.898	Kyung Hee Uni.	214	2.22	0.851	Kyung Hee Uni.	259	2.08	0.847
Kyung Hee Uni.	131	2.21	0.850	Inha Uni.	258	1.80	0.831	Inha Uni.	331	1.81	0.833

Note) These are results of analysis that excluded the BK21 performances. For KAIST and GIST, analysis was carried out by excluding the performances generated from institutional subsidies the R^2nIF for each category of research institution by each stage of R&D. SCI papers with a high R^2nIF were generated from basic research carried out by universities. Although the R^2nIF of papers published for basic research projects by universities was 0.995 in 2008, close to the global level, the quality of papers of applied research and development research carried out by universities were substantially lower than the global level. In addition, although the R^2nIF for applied research carried out by large enterprises in 2008 was the highest among the categories of research institution at 0.944, this value is still substantially lower than the global level.

4.2.2 Comparison of R^2nIF for each institution conducting research

The results of the R^2nIF analysis of SCI papers for each university revealed that Pohang University of Science & Technology (POSTECH), Korea Advanced Institute of Science & Technology (KAIST), Ewha Womans University, Yonsei University, and Seoul National University published papers in renowned academic journals (Table 8). In 2008, the universities with an average R^2nIF of more than 1.0 included KAIST (1.062), POSTECH (1.054), Ewha Womans University (1.048), Gwangju Institute of Science & Technology (GIST) (1.029), Yonsei University (1.014) and Seoul National University (1.011). In particular, 5 universities including POSTECH, Ewha Womans University, KAIST, Seoul National University and Yonsei University have displayed R^2nIFs that are higher than the global average of 1.0 for 3 years in succession since 2006.

The examination of qualitative characteristics of SCI papers produced by 26 government-subsidized research institutions (under the jurisdiction of the Korea Research Council of Fundamental S&T and the Korea Research Council for Industrial S&T) revealed that the Korea Astronomy and Space Science Institute (KASI) and the Korea Basic Science Institute (KBSI) published papers in well-known academic journals (Table 9). The R^2nIF for KASI and KBSI in 2008 were 1.098 and 1.035, respectively, indicating publishing in journals above the global average, while the R^2nIF for KIST, KRIBB and KRICT in 2008 were 0.982, 0.966 and 0.960, respectively, and lagged behind the global average slightly. In comparison, the R^2nIF for KAERI

Table 9 subsidized research institute with high ranking R^2nIF

2006				2007				2008			
Institutions	No. of papers	SCI IF	R^2nIF	Institutions	No. of papers	SCI IF	R^2nIF	Institutions	No. of papers	SCI IF	R^2nIF
KRISS	96	2.17	1.019	KASI	68	4.32	1.071	KASI	79	4.54	1.098
KASI	74	4.00	1.013	KIST	382	2.45	1.014	KBSI	105	3.09	1.035
KBSI	66	2.58	1.003	KRISS	163	2.06	1.013	KIST	480	2.52	0.982
KIST	334	2.19	0.975	KRICT	132	2.59	1.000	KRIBB	222	3.05	0.966
KRICT	103	2.31	0.973	KBSI	102	2.68	0.993	KRICT	170	2.50	0.960
KIMM	83	1.83	0.962	KIMM	122	1.96	0.954	KIER	92	2.05	0.960
KRIBB	219	3.01	0.937	KRIBB	258	2.72	0.929	KIMS	83	1.79	0.948
NFRI	59	1.46	0.875	KERI	108	1.59	0.919	KRISS	172	2.30	0.938
ETRI	132	1.25	0.801	KIER	70	1.70	0.886	KORDI	91	2.24	0.916
KIGAM	71	1.66	0.746	KFRI	61	1.82	0.861	KIMM	73	1.79	0.912
KAERI	257	1.28	0.735	KORDI	95	1.98	0.842	NFRI	53	1.32	0.904
				KIGAM	93	1.42	0.825	KIGAM	98	1.59	0.855
				ETRI	210	1.41	0.818	ETRI	205	1.63	0.851
				KAERI	315	1.33	0.763	KFRI	58	1.85	0.846
								KERI	88	1.47	0.792
								KAERI	418	1.18	0.705

Note) Arranged in the order of R^2nIF with research institutions that produced more than 50 research papers as subjects

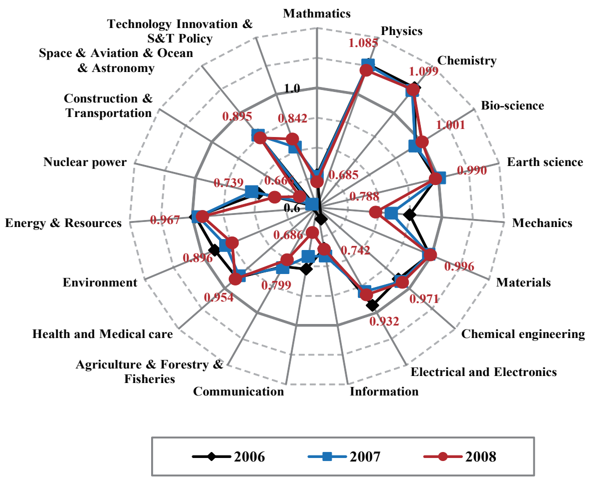

Figure 4 Comparison of R^2nIF for each technological field

and ETRI in 2008 were 0.705 and 0.851, respectively, illustrating a substantial gap with the global standard, thereby requiring qualitative improvements.

4.2.3 Comparison of R^2nIF for each technology field

The examination of the R^2nIF for each S&T standard category illustrated that the qualitative level of SCI papers generated in the fields of physics and chemistry were higher than the global average as shown in Figure 4. The R^2nIF for physics and chemistry in 2008 were 1.085 and 1.099, respectively, showing that the SCI papers were on the average published in journals with a level of citation higher than the global average. In comparison, the R^2nIF of papers generated from fields including information, communication, agriculture & forestry & fisheries, environment and nuclear power were less than 0.9, thereby continuing to exhibit a substantial deficiency when compared to global standards.

4.2.4 Comparison of R^2nIF for each key R&D program

Table 10 shows the R^2nIF of the top 10 R&D programs in terms of numbers of SCI papers published in 2008. Among the key R&D programs, the R^2nIF of the 'Creative Research Program' was 1.131, which is higher than the global average, so it is publishing a large number of SCI papers in qualitatively outstanding journals. In addition, the R^2nIF of SCI papers generated from the '21C Frontier R&D Program' was 1.011, illustrating that its quality of papers is close to the global level. In contrast, R^2nIF of 'Particular Basic Research Support Program' that generated the largest number of SCI papers was 0.949, thus failing to achieve the global average. The R^2nIF for the 'University IT Research Center Cultivation Support Program' and the 'Nuclear Power Technology Development Program' were below 0.7, thereby illustrating an enormous difference when compared with the global standard.

4.2.5 Comparison of R^2nIF for each type of cooperative R&D by universities

Table 10 Comparison of the qualitative measurement indicators of SCI papers for the top 10 programs in terms of number of papers published (2008)

Program Name	No. of papers	SCI IF	R^2nIF
Creative Research	466	4.11	1.131
21C Frontier R&D	971	2.82	1.011
Cultivation of outstanding research center	900	2.79	0.992
Cultivation of outstanding research center <SRC,ERC,MRC,NCRC>	814	2.70	0.988
Development of Foundation Technology (Nano, Bio)	377	3.05	0.986
National Research Laboratory	886	2.56	0.986
Particular Basic Research Support	1,630	2.44	0.949
Public Health and Medical Technology R&D	352	2.92	0.924
Support for Cultivation of University IT Research Center	483	1.18	0.697
Development of Nuclear Power Technology	325	1.18	0.687

Table 11 Comparison of qualitative measurement indicator for SCI papers for each type of cooperative R&D by university (2008)

Category of research institution	Types of cooperative R&D		No. of papers	SCI IF	R^2nIF
University	Non-execution of international cooperative R&D	Enterprise·University	885	1.92	0.839
		Enterprise·University·Research institute	376	2.52	0.943
		University·Others	53	2.60	0.927
		University·Research institute	175	2.40	0.863
		University· University	2,658	2.27	0.899
		No Cooperation	5,245	2.76	0.980
		Subtotal	9,392	2.53	0.940
	Execution of international cooperative R&D	University·Overseas Institute	1,700	2.80	1.005

The R^2nIF of SCI papers generated from the projects in which universities participated as the category of research institution were examined for each type of cooperative R&D. As shown in Table 11, the R^2nIF of SCI papers generated from the projects in which universities pursued research jointly with overseas research institutions was 1.005, or in other words these papers were published in academic journals with level of citation that is above the global average. This value is higher than the papers generated from the projects in which universities did not carry out international cooperative R&D (0.940), thereby illustrating that the execution of cooperative R&D by universities in the field of basic science in collaboration with overseas research institutions enhances papers quality. However, further study is needed to be certain how much of the paper quality difference is actually due to the international collaboration since groups able to set up international collaboration may already have an above average research quality.

5. Conclusion

This article attempted to analyze the qualitative status of Korean government R&D programs in comparison to the global standard by proposing and utilizing a new measurement indicator to analyze the qualitative level of papers based on the SCI Impact Factor (IF). A wide range of qualitative measurement indicators that can analyze SCI papers have been developed by numerous researchers. Among these, the SCI IF is the most commonly used in performance analysis and evaluation. However, the SCI IF has the problem that comparative analysis between technology fields is impossible since it displays substantial differences between each field. Qualitative measurement indicators such as the rank-normalized Impact Factor (*rnIF*) that try to overcome these problems also have the limitation that international comparisons such as between countries and or to a global standard are not possible. Accordingly, in this article, a new qualitative measurement indicator (Relative Rank-normalized Impact Factor, R^2nIF) that enables a comparison with global standards was developed by advancing the supplemented SCI IF indicator (*rnIF*) a step further. R^2nIF is an indicator ($R^2nIF_j = mrnIF_j / mrnIF_{\text{Global average in the same field}}$) computed by dividing the modified rank-normalized Impact Factor (*mrnIF*) of a paper by the global average of the *mrnIF* in the same research field, and is an enhanced indicator that enables analysis in qualitative comparison with the global level.

The results of the analysis of the qualitative level of government R&D programs by utilizing R^2nIF, which was newly developed in this study, can be summarized as follows. Firstly, although it was revealed that the government R&D programs are making some contributions towards theenhancement of the qualitative level of the SCI papers of Korea, the qualitative level has stagnated. Although the R^2nIF average for all the SCI papers generated from government R&D programs was 0.934 in 2008, thereby falling behind the global average of 1.0, it is slightly higher than the average R^2nIF of all papers generated in Korea, 0.924.

However, it was revealed that the R^2nIF for each year has gradually decreased from the peak of 0.942 in 2006, showing the need for additional detailed analysis and discussions in the future of the reasons for the failure to improve the qualitative level in spite of the recent efforts of the government to enhance the qualitative level of SCI papers. Secondly, the result of a comparison of the qualitative level of papers with those of advanced countries such as the USA, the UK and Germany revealed that the levels are substantially lower in most fields, with a particularly large gap in BT-related fields (such as biology & biochemistry, clinical medical science, immunology, microbiology and molecular biology) and in the computer science field. Thirdly, among categories of research institution, the quality of papers by universities that carry out basic research was found to be comparatively superior. In technology fields, the quality of papers in basic science fields such as physics and chemistry were found to be comparatively superior. Lastly, it was found that the quality of papers generated from international cooperative research was comparatively superior.

As explained above, the new qualitative indicator (R^2nIF) proposed in this article enables the comparison between countries, technology fields and categories of research institution, and it is anticipated that this indicator can be utilized for the identification of areas of strength and weakness of institutions carrying out research including universities and government subsidized research institutes, and in the evaluation of individual papers from R&D programs.

This article has proposed a new measurement indicator that can analyze the qualitative level of an SCI paper. As research performances can manifest themselves diversely according to the nature of the R&D program, there is a need to pursue follow up studies on the qualitative measurement indicator for various types of research performances other than research papers. In particular, patents are an important indicator that can be used to assess technology innovation by country, region, technology and the category of research institution. Therefore, discussion of a qualitative measurement indicator that can internationally compare the technological and economical values of patents is necessary. For example, supplementing the citation frequency for each patent, the number of patent claims and the patent family size indicator, which are frequently used in qualitative analysis of patents, would enable international comparison. A comparison with the global average for the technological field can be considered. In addition, there is a need to pursue follow-up studies on the development of a customized performance indicator that is appropriate not only for comparison between technological fields but also between each R&D program. For this purpose, a follow-up study to quantify the quality level of research performance which is appropriate for R&D programs, other than by papers and patent, such as by technology transfer, commercialization and cultivation of manpower, is required.

6. Reference

1. Kim, I. M. (2002). Examination and study on policy for defining and establishment of evaluation strategy for each basic science research support program. Daejeon: National Research Foundation.
2. Korea Institute of Science & Technology Evaluation and Planning (2009). Report on the survey of research and development. Seoul: Ministry of Education, Science and Technology.
3. Lee, H. J., Yeo, W. D., & Lee, S. P. (2006). Evaluation model for scientific research performance based on journal articles. Journal of Korea Technology Innovation Society, 9(3), 538-557.
4. Yeon, G. N., Lee, S. J., Lee, J. H., & Song, C. H. (2005). A study on the use of quantitative indicators for the research proposal assessment. Journal of Korea Technology Innovation Society, 8(1), 261-276.
5. Kang, D. S., & Moon, S. B. (2009). A study on informetric analysis for measuring the qualitative research performance. Korea Society for Information Management, 26(3), 377-394.
6. Heo, J. E., Kim, H. D., Cho, Y. D., Cho, S. M., & Cho, S. R. (2008). Developing bibliometric indicators for analysis & evaluation of national R&D programs. Journal of Korea Technology Innovation Society, 22-41.
7. National Research Foundation (2008). Report on performance analysis of R&D program by Ministry Education, Science

& Technology. Seoul: Ministry Education, Science and Technology.

8. Korea Institute of Science & Technology Evaluation and Planning (2009). SCI analysis research. Seoul: Ministry Education, Science and Technology.
9. Korea Institute of Science & Technology Evaluation and Planning (2008). Report on performance analysis of Government R&D Program in 2008. Seoul: Ministry Education, Science and Technology.
10. Kostoff, R. N. (1995). Federal research impact assessment: axioms, approaches, applications. Scientometric, 34, 163-206.
11. Oh. D. H. (2008). The role of expert review in the evaluation of science and technology: issues and suggestions for advanced practices. OECD.
12. Prichard, A. (1969). Statistical bibliography or bibliometrics. Journal of Documentation, 358-359.
13. Garfield, E. (2001). Interview with Eugene Garfield, chairman emeritus of the Institute for Scientific Information (ISI). Cortex, 37(4), 575-577.
14. CWTS(Center for Science & Technology Studies) (2000). Bibliometric profiles of academic electrical and electronic engineering research in Netherlands(1989-1998).
15. Sen, B. K. (1992). Normalized impact factor. Journal of Documentation, 48, 318-329.
16. Marshakova-Shaikevich, I. (1996). The standard impact factor as an evaluation tool of science and scientific journals. Scientometric, 25, 283-290.
17. Seglen, P. O. (1997). Why the impact of journals should not be used for evaluating research. British Medical Journal, 314(7079), 498-502.
18. Pudovkin, A. I., & Garfield, E. (2004). Rank-normalized impact factor: a way to compare journal performance across subject categories. Proceedings of the 67th ASIS&T Annual Meeting, 41, 507-515.
19. Warner, J. (2003). Citation analysis and research assessment in the United Kingdom. Bulletin of the American Society for Information Science and Technology, 30, 26-27.
20. Leeuwen, T. N., Van, L. J. Van der Wurff, & A. F. J. Van Raan (2001). The use of combined bibliometric methods in research funding policy. Research Evaluation, 10(3), 195-201.
21. Oppenheim, C. (1997). The correlation between citation counts and the 1992 research assessment exercise ratings for British research in genetics, anatomy and archaeology. Journal of Documentation, 53, 477-487.
22. Norris, M., & Oppenheim, C. (2003). Citation counts and the research assessment exercise V - Archeology and the 2001 RAE. Journal of Documentation, 59, 709-739.

Intrinsic Characteristics of Basic Research: With Focus on Horizontal Knowledge Transfer

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Abstract
The paper studies the intrinsic characteristics of basic research. Its main purpose is to prevent a negative side effect, which is the possible distortion of the characteristics and the role of basic research, when both the reinforcement of innovation system efficiency and the promotion of basic research are pursued simultaneously. Furthermore, the study clarifies the role of basic research. Methodologically, we conduct a questionnaire survey and a paper citation network analysis. It turns out that the intrinsic characteristics of basic research can be explained by the uncertainty of reaching basic research results and the horizontal knowledge transfer. Our study also suggests that it is desirable to set the role of basic research, as the expansion of knowledge stock through both horizontal and vertical knowledge transfer, differently from that of applied research in the innovation systems.

1. Introduction

Basic research, which is considered the source of knowledge creation, has been studied by various experts, including Pavitt (1990) and Salter and Martin (2000), since its importance was first mentioned by Bush (1945). Bush emphasized the importance of basic research by explaining that basic research creates general knowledge such as laws of natural phenomenon, knowledge of which provides methodology for further problem solving. He asserted that finding the precise answer to a specific problem is the function of applied research. Therefore, he mentioned that the roles of basic research and applied research are different. Since main function of basic research is to create general knowledge, it may become distanced from technology, in contrast to applied research. By mentioning that basic research plays the leading role in technological advancement, Bush once again emphasized its importance. In discussions about the economic contribution of basic research Pavitt(1990) asserted that although basic research may exert the influence on technology through the direct transfer of knowledge, it more commonly acts as an input factor for other processes or plays the role of the starting point of innovation. He did this by quoting from David et al (1988) that, "the outputs of basic research rarely possess intrinsic

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economic value. However, they are critically important inputs to other investment processes that yield further research findings, and sometimes yield innovations". In addition, he explained that the linkage between basic research and technology is, at least, accomplished in a complex 4-dimensional structure, and that the effect, which basic research has on technology, is due to the combination of extensive knowledge and is highly diversified, ranging from gradual progress to groundbreaking technology that opens a new era. In addition, the effect of basic research on technology is accomplished not only through the direct transfer of knowledge, but also through methodology and devices. Lastly, the transfer of knowledge is accomplished mainly by people participating in activities such as meetings and thereby transferring knowledge. Therefore, Pavitt asserted that policy supporting the "selectivity and concentration" of basic research, results from a misunderstanding of the nature of basic research. Salter and Martin (2000) emphasized the following 6 aspects of the social contribution of basic research, including long-term economic effects: increasing the stock of useful knowledge, training skilled graduates, creating new scientific instruments and methodologies, forming networks and stimulating social interaction among experts, increasing the capacity for scientific and technological problem-solving, and creating new firms.

Due to a recognition of the aforementioned social contributions of basic research, the advanced countries, such as the USA, Japan, or OECD members as a whole, are reinforcing their investment in basic research as their economies enter into a knowledge-based structure. OECD (2001) proposed to policy makers that a higher priority must be placed on basic research in order to further promote innovation and to expand the knowledge stock. The USA (2005, 2008), well aware of the need to expand investment into basic research to reinforce national competitiveness, has been significantly expanding and will further expand their support of up-and-coming researchers and high-risk high-return basic research over the next 10 years. Similarly Japan put a high emphasis on basic research in its 3rd Basic Plan for Science and Technology 2006-2010, and is assertively pursuing support for basic research in order to create an extensive diversity of knowledge and to become a source of radical innovation. Likewise the EU established the European Research Council in order to enhance the creativity of European basic research in 2005.

Furthermore, in addition to the expansion of public research support for basic research, efforts have also been taken to improve the efficiency and effectiveness of R&D activities. This is because the expansion of support for public R&D does not automatically ensure performance and there is also a need to reinforce responsibility in public spending. Therefore advanced countries are implementing performance evaluation systems for R&D programs. For example the USA is implementing the Government Performance and Results Act with the goal of improving the efficiency and effectiveness of all government programs, including R&D. Also the UK is implementing the Public Service Agreements in order to clarify and properly evaluate the details of each task, performance targets and the responsibilities of all government departments. Likewise, Korea is also doing its best to improve the efficiency, effectiveness and responsibility of its public institutions by introducing the Basic Act on Evaluation of Government Tasks. These, or similar, performance management systems are also applied to R&D programs, and basic research is not an exception. Under the current conditions, in which international technological competition is getting more severe and technological lifecycles are becoming shorter, basic research is playing more the role of a compositional element within the innovation system rather than having an autonomous existence. Therefore, continuing efforts to enhance its efficiency and effectiveness may cause problems.

The globally accepted definition of basic research is "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view", as stated in the OECD Frascati manual (2002). In other words, only the research undertaken for the purpose of the "acquisition of knowledge" of various phenomena and observable facts rather than for the purposes of a "specific application" is understood as basic research.

As stated above, the performance management systems aim to enable innovation systems to operate efficiently by increasing the productivity of R&D. The application of these management systems may however be problematic in the case of basic research. For example, because the result of basic research is the "acquisition of knowledge" the method of measuring productivity consistently is unclear. In addition, even though basic research has quite different characteristics to applied research, basic research is generally grouped into R&D along with applied research and development. As a result, a distortion of the role of basic research may occur when the role of R&D within the innovation system is described without correctly understanding the characteristics of basic research.

This study aims to present the role of basic research within the innovation system by understanding its intrinsic characteristics. Firstly, the study identifies the role of R&D in the innovation system, as described by the linear, chain-linked open innovation models, and examines how a performance management system aimed at the enhancement of efficiency can distort the role and characteristics of basic research. Secondly, a questionnaire survey of researchers and network analysis, into the intrinsic characteristics of basic research, was carried out and the results presented. The questionnaire survey examined the areas, timing and methods of utilization of the results of basic research. The network analysis was conducted into the relations network of paper citations using the Science Citation Index Expanded Paper DB of Thomson. As a research paper may be considered as the primary result of basic research and the citation of a paper as knowledge transfer, the relations network of a paper's citations can be considered as its knowledge transfer network, the result of the basic research. In this way, it is possible to understand the intrinsic characteristics of basic research through an analysis of the mechanisms of its utilization and the transfer of its results. Based on this understanding, the study further aims to present the role performed by basic research which is undertaken for the purpose of the "acquisition of knowledge" within the innovation system, unlike applied research or developments that are carried out for the purpose of a "particular usage".

2. Models of the innovation system and roles of basic research

The characteristics of the representative models of the innovation system, including the linear model, the chain-linked model and the open innovation model, are examined in this chapter. Furthermore, the role of R&D, and in particular the role of basic research, in each of the innovation system models is discussed. Moreover, the possibility of the distortion of the role of basic research, particularly from side effects of efforts to improve of the efficiency of innovation, is discussed.

2.1 Linear model

The Linear model asserts that research, development, production and marketing are carried out sequentially and vertically as follows: once knowledge stock is accumulated through scientific research, development occurs by applying this scientific knowledge, and then the developed results are commercialized and eventually sold through marketing activities. Research within the linear model is further distinguished into basic research and applied research. Basic research is undertaken for the purpose of acquisition of knowledge rather than for a particular usage, and applied research for the purpose of a particular usage or for the discovery of solutions to particular problems by utilizing the scientific knowledge produced. Therefore, the relationship between basic research and applied research is stipulated as a relationship that progresses sequentially. The linear model is an innovation system model that has been accepted widely since the Second World War (Kline and Rosenberg, 1986), and presented in accordance with the viewpoint that "science leads to technology and technology satisfies market needs" (Gibbons et al., 1994). The linear model is conceptually very simple and easily explains the justification for public support in case of market failures. In addition, the linear model explains the situation quite well from a macroscopic perspective. Therefore, even though it was introduced quite some time ago, it has established itself as a fundamental concept of numerous other innovation models that were proposed since its introduction. Each stage of the linear model is a preparatory stage for the immediately following stage. Therefore, research must take the role of knowledge production for development, and must eventually bring economic effects through product manufacture and marketing. Considering that in this model basic research is undertaken for the purpose of the “production of knowledge”, this knowledge produced by basic research only becomes meaningful if it is applied and further developed by being transferred directly to the next stage. In this study, the process of knowledge transfer to the next stage is referred to as the sequential or vertical knowledge transfer method. Assuming that R&D is related to technology, technology to industry and industry to economy, the vertical knowledge transfer method of the linear model, as the fundamental framework that forms the basis for the innovation model, is in fact very important. Knowledge can achieve an economic ripple effect only if it is transferred to the next stage.

However, the one-sided vertical knowledge transfer method has limitations when used alone to explain the innovation model. If the knowledge generated in basic research is not utilized, because of a failure to feed into the next stage, then this knowledge is considered useless, as the innovation process of the linear model stops at that stage. If one were to improve the efficiency of innovation as described by the linear model, the sequential and vertical system of transfer from research to marketing would be linked even more strongly. Moreover, this would lead to the efforts to narrow the vertical distance between all stages. Knowledge not transferred to the next stage, acts as an obstructing factor that causes further vertical distance between research and development. Thus, the efficiency of innovation increases, when “knowledge carried over to the next stage” also increases. And that is the shortcoming of the linear model. The linear model differs from the reality of innovation because it is too simple. The weaknesses of the linear model were highlighted by Kline and Rosenberg (1976) in detail. They pointed out that the existence of defectiveness and failure in the process of learning which creates innovation, proves that feedback and re-attempt are essential in an innovation system. In other words, a model, such as the linear model, in which knowledge transfer occurs only in one direction which excludes feedback and re-attempt, cannot fully explain the innovation system. Therefore, Kline and Rosenberg proposed the chain-linked model as an alternative to the linear model.

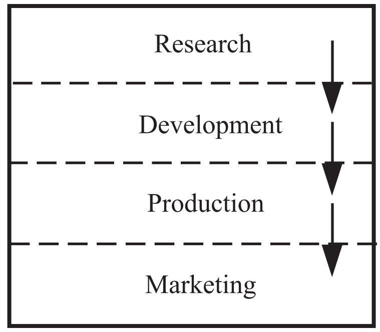

Figure 1 Linear model (Kline and Rosenberg, 1986)

2.2 Chain-linked model

The chain-linked model more realistically advances the linear model in which 4 stages, namely, research, development, manufacturing and marketing, are carried out in sequential and vertical manner. According to the chain-linked model, a foundation of knowledge through research must be accumulated first. Then, the market-sided five elements, including the potential market, invention and/or production of analytic design, detailed design and test, redesign and production, distribution and market, interact like a chain on this knowledge foundation.

The simple method of sequential and vertical knowledge transfer in the linear model is advanced in the chain-linked model. This model explains that knowledge and information interact somewhat freely between the elements of innovation. Feedback is given at each of the stages, which represent the five elements of sequential innovation. For example, in case of a problem in the last stage related to product launch in the market, information about this problem is fed back to each previous stage. Thus a large proportion of the knowledge transfer process included in the chain-linked model in this way cannot be explained by the linear model. Further, research and knowledge directly interact at each stage of innovation.

For example, commercial research is carried out to solve problems occurring at any stage. Unlike the linear model, in which "knowledge" gained as results of basic research, is applied and developed through direct transferred to the next stage, the chain-linked model explains that knowledge accumulated through scientific research turns into the foundation of innovation, and represents the concept of the "accumulated knowledge of science".

In the chain-linked model, the roles of basic research and applied research are not distinguished in detail. However, the role of basic research, which aims to "acquire knowledge", can be interpreted as expanding the "accumulated knowledge of science", while applied research, aimed at a "particular utilization", is focused on commercial research to solve problems that occur at any of the market-sided innovation stages. If one wishes to improve the efficiency of innovation in the chain-linked model, one must stimulate interaction between each of the elements. The feedback delivery between the five market-sided elements is a significant effort. However, where roles of basic research and applied research are not strictly distinguished, efforts to improve efficiency manifest as efforts to strengthen the vertical linkage between the research stage and five market-sided elements, that is to narrow the vertical distance between them. This ultimately has the potential side effect of putting more value on the activation of applied research undertaken with the aim of a "particular utilization" rather than on the further expansion of the "foundation of accumulated knowledge of science".

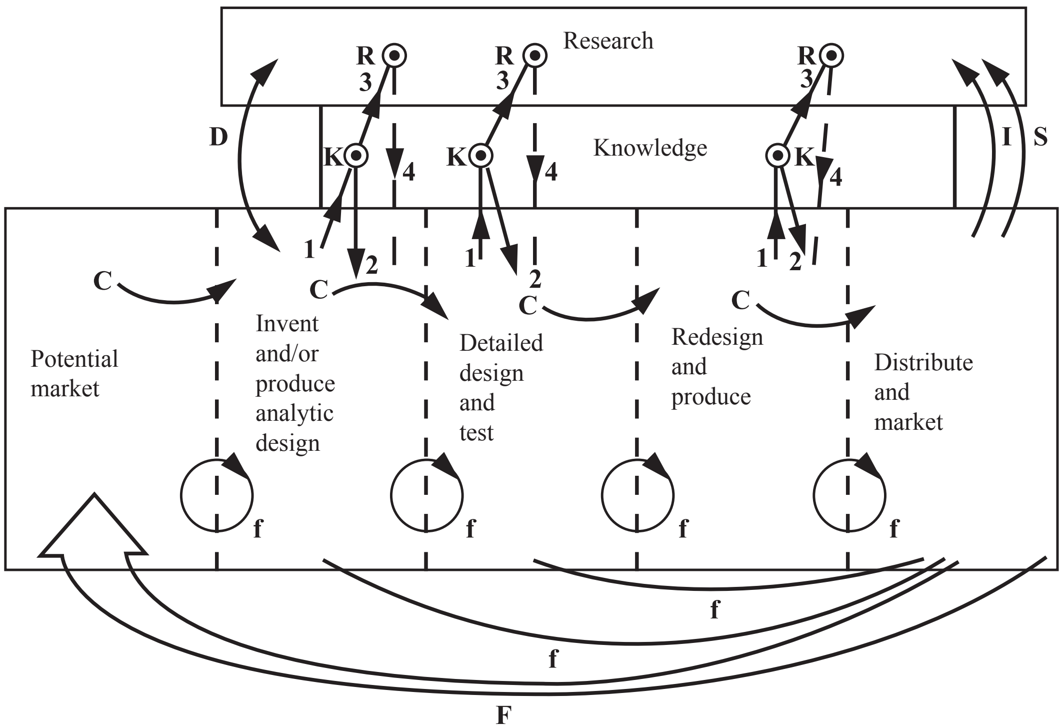

Figure 2 Chain-linked model showing flow paths of information and cooperation (Kline and Rosenberg, 1986)

Symbols on arrows:
C = Central chain of innovation
f = Feedback loops
F = Particularly important feedback
K-R = Links through knowledge to research and back. If a problem is solved at node K, link 3 to R is not activated. The return link from research (link 4) is problematic, therefore represented by a dashed line
D = Direct link to and from research in case of problems in invention and design
I = Support of scientific research by instruments, machines, tools, and procedures of technology
S = Support of scientific research by gaining information directly and by monitoring outside work. The information obtained may apply anywhere along the chain

In other words, in spite of the fact that the chain-linked model is more advanced and expanded than the linear model, there are aspects of basic research which remain unexplained by vertical knowledge transfer alone.

2.3 Open innovation

Thirdly, the open innovation model (Chesbrough, 2003), which has been receiving the spotlight recently, is analyzed. The main feature of the open innovation model is to create new markets by expanding the interactions between the research projects, enabled by breaking down the boundary between internal and external domains of R&D activities. This is expected to maximize the efficiency of R&D. In this model, the activities in all forms including joint research, technology transfer and outsourcing are possible thanks to the interactions between research projects. In addition, interactions between research projects are principally possible regardless of the project's type, whether basic research, applied research, development, manufacturing or marketing. Therefore the knowledge transfer path of the chain-linked model has been further expanded, allowing an increased possibility of knowledge transfer as well as an equivalent increase in innovation opportunities.

However, when the overall aspects of the open innovation model are examined, highly definitive directionality is manifested, which pursues the aggressive maximization of efficiency including the creation of new markets. This is the advancement from research to the market through development. In other words, the basic framework of the open innovation model is the same as that of linear model. The difference is that the open innovation model encourages interactions between research projects. However, even these interactions, when viewed from a general perspective, lead to enormous sequential and vertical flow towards the market. Although Figure 3 and Figure 4 appear to express itself horizontally, it is basically only a 90° rotation of the Figure 1. The expression "vertical" is appropriate from a stepwise perspective). The improvement of innovation efficiency in the open innovation model is manifested as efforts to shorten the overall length of the sequential and vertical flow that undergoes the process of research, development and (new) marketing. Ultimately, the research stages of open innovation are similar to those of the linear model but with the difference that it is composed of detailed stages rather than the sequential two stages of basic and applied research. Thus, in the open innovation model efforts to increase efficiency and quantity of "knowledge carried over to the next stage" could have the side effect of reducing basic research aiming to "accumulate knowledge".

3. Intrinsic Characteristics of Basic Research

In the previous chapter, we discussed the role of basic research and the possibility of side effects arising from the distortion of its role caused by efforts towards the "reinforcement of efficiency of innovation" in the linear, chain-linked and open innovation models. Under circumstances, in which the expansion of investment into basic research and efforts for the improvement

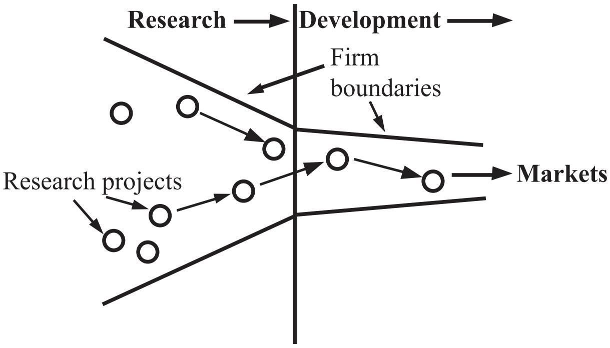

Figure 3 Closed innovation model (Chesbrough, 2003)

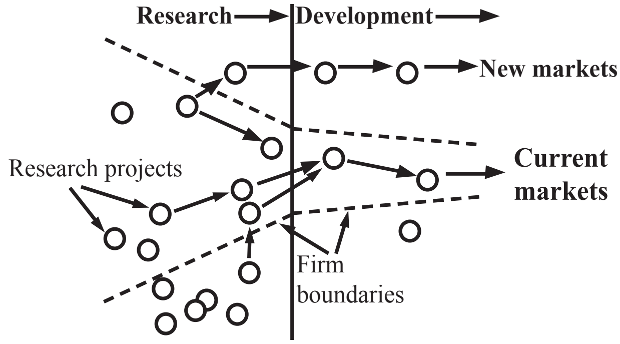

Figure 4 Open innovation model (Chesbrough, 2003)

of the efficiency of the innovation system are being simultaneously pursued, side effects that distort the role of basic research could occur. This distortion could not only hinder expansion of knowledge stock, but also impart influence on overall aspects of the innovation system. Therefore, in order for both the expansion of investment into basic research and efforts to improve the efficiency of innovation system to coexist, it is necessary to distinguish and clearly present the role of research, which is currently both too simple and too comprehensive. The difference between basic research aimed at the "acquisition of knowledge" and applied research aimed at "particular utilization" must be properly clarified. For this purpose, this chapter includes a description of the characteristics of basic research.

Firstly, we carried out an experts-oriented questionnaire survey on when, how and in which area the results of basic research were utilized. The questionnaire survey on the experiences of researchers provided clues as to the mechanism of knowledge transfer generated from basic research. The survey results were used to analyze the utilization of basic research results and particularly the uncertainties surrounding their application. Secondly, we carried out a bibliographic analysis of publications in order to more objectively and statistically study the mechanisms of knowledge transfer and further develop insights derived from the previous step. We studied the mechanism of knowledge transfer using the citation relationships between the fields of papers that can be considered as direct products of basic research. Citation relations are analyzed by applying the network analysis method. The uncertainty of basic research results and the outcome of the network analysis on paper citation relationships verified through the results of questionnaire survey signify that the expansion mechanism for knowledge stock by basic research cannot be properly explained by the simple vertical knowledge transfer method. In other words, the analysis implies that not only the vertical knowledge transfer but also the horizontal knowledge transfer method is highly significant. Such a discovery reveals that the current tendency of expressing the fundamental framework of innovation only through the vertical knowledge transfer method must be modified. In this chapter, the results of the questionnaire survey and network analysis of paper citation relationships are closely examined, and the significance of both the vertical and the horizontal knowledge transfers in the innovation system are discussed in order to understand the intrinsic characteristics of basic research.

3.1 Questionnaire survey results: Uncertainty in the process of utilization of results of basic research

A questionnaire survey was carried out with researchers as subjects in order to study the characteristics of basic research. Questionnaires were distributed electronically to 2,350 researchers currently involved in national R&D projects, out of which 161 subjects responded. The questionnaire was designed to analyze basic research, particularly its success or failure at its conclusion, the areas of utilization of its results, the ways its results were utilized and the time taken for its results to be utilized. 32% of respondents answered that they usually perform basic research, 41% applied research, and 26% development. 1% of respondents performed basic research and applied research together. 91% of respondents stated that they have utilized the results of their own basic research and 94% the results of basic research undertaken by other researchers. In this part, subjects were instructed to consider not only the originally anticipated results but also all the other incidental results of the basic research. We requested the subjects to include incidences of utilization in R&D in totally different areas (thus not limiting them to following the simple framework of the linear model that stipulates progress from basic research and applied research to development).

3.1.1 Evaluation of success or failure of basic research at the end of research

Subjects were asked about the evaluation of their basic research at the end of the research. 81% claimed the research as successful in Figure 5. However, 15% replied that they obtained unexpected incidental results rather than the results intended originally. Approximately 4% evaluated the research as failure.

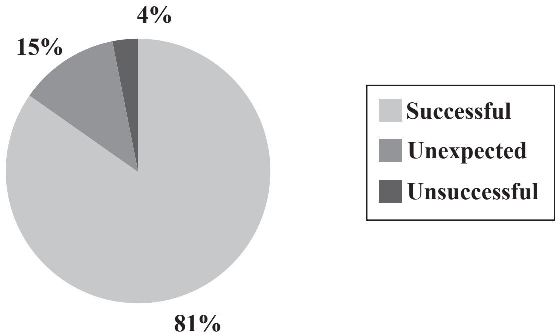

Figure 5 Evaluation of the results at the end of research (survey results)

The respondents further replied that, in spite of the fact that approximately 19% of the results were either incidental or even considered as a failure, they are being further utilized in various fields. This may be the first evidence that the method of vertical knowledge transfer alone is insufficient to explain of the benefits of basic research.

3.1.2 Areas of utilization of results of basic research (path of knowledge transfer)

Subjects were asked about the area in which the results of their basic research were utilized. In Figure 6, 71% of them replied that the results were used in the same academic discipline. 14% stated that they were utilized by being transferred between intermediary academic categories, while 8% responded that they were utilized by being transferred between main academic categories. Thus in approximately 22% of cases, the knowledge generated from basic research has been utilized by being transferred to a proximal academic discipline or to other academic domains. This result signifies that the probability of knowledge generated from basic research encountering the knowledge of other domains is approximately 22%. Knowledge transfer to other domains is the starting point of interdisciplinary research. Thus it was proved that the series of processes including knowledge transfer to a diverse range of domains, the expansion of knowledge stock and the creation of interdisciplinary research, can be regarded as benefits of basic research.

This is the second piece of evidence that application of the method of vertical knowledge transfer only is insufficient when trying to explain the benefits of basic research. However, since this percentage is based only on the questionnaire survey, more accurate and objective analytical data are needed to determine a more precise ratio of knowledge transfer between areas. Therefore, the paper citation network analysis between different fields of science and technology was carried out and is explained in the following chapter.

3.1.3 Utilization ways of basic research results

Lastly, subjects were asked about the ways of utilization of basic research results. The largest proportion of the respondents in Figure 7, 45%, pursued already-planned applied research or development research on the basis of the results. However, quite a high proportion of the subjects, 31%, also carried out new applied research or development research in directions suggested by the results. Furthermore, 22% of the respondents carried

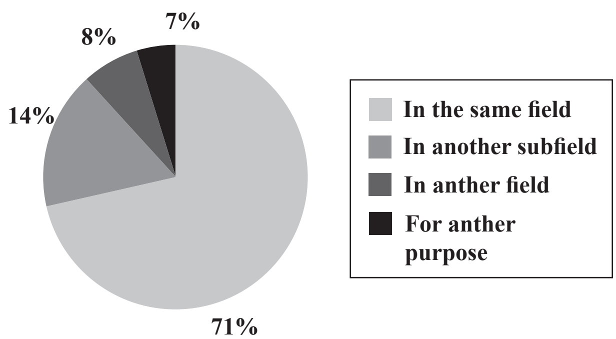

Figure 6 Fields of application for basic research results (survey results)

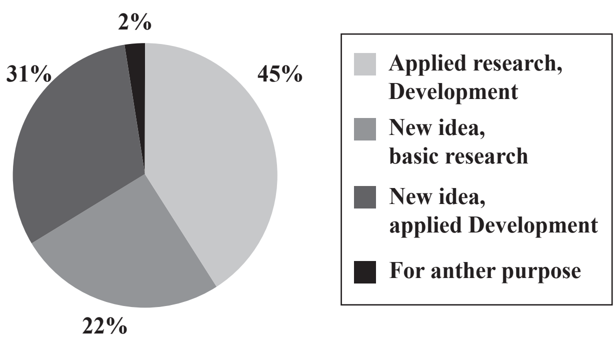

Figure 7 Utilization ways of basic research results (survey results)

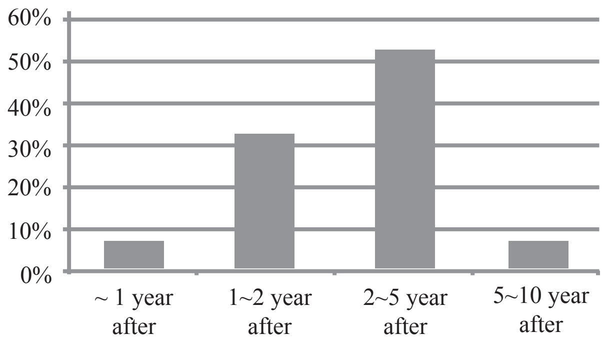

Figure 8 Time required for the results of basic research to be utilized (survey results)

out new basic research by obtaining ideas from the results. That means that although the results of the basic research are often utilized in succeeding research that was already planned, they also provide opportunities for new, originally unplanned research activities. This confirms that basic research plays very important role in the expansion of knowledge stock. Although basic research may not be vertically linked with applied research or the development stage immediately upon its completion, it elevates the level of potential economic and social contribution by expanding knowledge stock through the generation of new knowledge. This implies that the process of knowledge transfer is not simple, but is accomplished through a complicated multi-staged process. This is the third piece of evidence that the application of the vertical knowledge transfer method only is insufficient for the explanation of the benefits of basic research.

3.1.4 Time required for the results of basic research to be utilized

Subjects were also asked about the time taken for the results of basic research to be utilized. 53% of the respondents reported a time frame of 2 to 5 years, 33% a time frame of 1 to 2 years, 7% a time frame of less than one year and 7% a time frame of 5 to 10 years as shown in Figure 8. Thus it is evident that there is a time lag before the utilization of results of basic research.

Based on the survey results, it can be pointed out that in order to properly understand the benefits of basic research we need to understand the utilization of its results and its generation of knowledge transfer. Since basic research is not conducted for the purpose of a particular application, it suffers from built-in uncertainty and thus has a higher probability than applied research or development that results other than those anticipated will be obtained. However, based on the survey results, it was possible to find out that incidental results, which differ from the anticipated results, and even results that are considered failures, have an applicable value to further research. In addition, it was possible to find out that the results of basic research play a substantial role in the generation of interdisciplinary research by being transferred to and used in other science and technology areas. We confirmed that the knowledge transfer doesn’t only pass vertically to the next stages as planned prior to the execution of the basic research, but also plays the role of introducing new ideas to researchers, thus being the starting point for new research. Further, the researchers questioned responded that these series of processes take approximately 2~5 years before the results of basic research are utilized.

The process of utilization of basic research results and the process of knowledge transfer generated from basic research cannot be explained with the simple vertical knowledge transfer method only. The results of basic research are directly transferred to a series of innovation stages such as development, manufacturing and marketing for utilization, as explained in the vertical flow that is generally used in the innovation system models. However, the results of basic research as knowledge are also transferred between academic disciplines, and contribute to the expansion of knowledge stock. These aspects need to be focused on in order to understand the characteristics of basic research. These aspects are the features of basic research that are different from the direct effect (knowledge transfer to the applied research and development stage) and indirect effect (cultivation of manpower or development of new methodology, etc.) explained in the existing innovation system models. Although the direct effects of basic research can be measured, it can, as presented in the previous chapter, distort the role of basic research as well as the innovation system as a whole. Although the indirect effects of basic research are important characteristics, they are very difficult to measure and extremely abstract. What we therefore focus on is the role of the results of basic research as a starting point for new research though a transfer to other areas, rather than the commonly understood role of vertical transfer to the next stage. Such processes will be referred to as the horizontal knowledge transfer method.

In simple terms, the horizontal knowledge transfer method represents knowledge transfer to other academic areas. Primarily, this represents the expansion of knowledge stock, and secondly, the convergence of knowledge. As aforementioned, it also explains that the results of basic research present new ideas for further basic research rather than only vertically proceeding to applied research or development as planned. We believe that such characteristics of basic research account for a highly significant portion of the benefits of basic research. Further, the paper citation network analysis was carried out in order to verify this aspect through objective data.

3.2 Paper citation network analysis results: Mechanism of knowledge stock expansion and horizontal knowledge transfer

The main result of basic research is a research paper. Therefore, we carried out a paper citation network analysis between fields of science and technology in order to obtain objective data on the process of utilization of basic research results and knowledge transfer. Studies using the measurement of knowledge transfer through paper citation analyses were attempted in the past (National Science Board, 1998; Narin and Noma, 1985; Meyer, 2002; Rinia et al., 2002, etc.). Although the existing analyses of paper citation between fields or citation relation matrices explain the relationships between any two arbitrary fields, they are limitated in terms of providing a comprehensive understanding of the flow of knowledge in diverse directions through all the fields of science and technology. Therefore in this study, a network analysis of the extent of citation between fields of science and technology was undertaken. In particular, we tried to understand the knowledge transfer in the fields of science and technology in Korea in order to deduce implications for Korean national science and technology policies including the improvement of the efficiency of the innovation system.

The "nodes" of the network have been defined as the fields of science and technology, and "links" of the network as the citation relationships between fields, which have a direction. The centrality of each field and the proximities of fields in the network were analyzed.

3.2.1 Paper citation network (knowledge transfer) between fields of science and technology

The research papers in 1996 and in 2006 authored by Koreans in the Web of Science, and Science Citation Index Expanded (SCIE) of Thomson Scientific Company were analyzed. Two datasets were prepared to assess the differences between the networks of 1996 and 2006. The network was defined as follows.

Table 1 Field categories

	Field category
1	BIOLOGY & BIOCHEMISTRY
2	CLINICAL MEDICINE
3	CHEMISTRY
4	PHYSICS
5	MULTIDISCIPLINARY
6	ENGINEERING
7	MATERIALS SCIENCE
8	MICROBIOLOGY
9	MOLECULAR BIOLOGY & GENETICS
10	IMMUNOLOGY
11	NEUROSCIENCE & BEHAVIOR
12	PHARMACOLOGY
13	PLANT & ANIMAL SCIENCE
14	ENVIRONMENT/ECOLOGY
15	AGRICULTURAL SCIENCES
16	SOCIAL SCIENCES, GENERAL
17	COMPUTER SCIENCE
18	GEOSCIENCES
19	MATHEMATICS
20	PSYCHIATRY/PSYCHOLOGY
21	TELECOMMUNICATIONS
22	ENERGY & FUELS
23	NANOSCIENCE & NANOTECHNOLOGY
24	SPACE SCIENCES

The Web of Science provided the subject category for each academic journal. Further, the service referred to as the “Essential Science Indicator” (ESI) provided 22 field categories. We allocated the ESI categorization for each academic journal by matching more than 190 of their subject categories with the 22 ESI categories. Two particular subject categories (telecommunication and nanoscience & nanotechnology) were difficult to classify into any of the ESI categories. Therefore we established two more specific field categories as research in these fields is carried out very actively in Korea. Thus, the eventual number of 24 field categories (network nodes) was set. These 24 field categories are summarized in <Table 1>. Correspondingly, the same 24 field categories were applied to the references used in the papers. Then, the links were identified between the field of the paper and the fields of the references used in the paper. The direction of the link begins from the field of the reference and ends at the field of the paper, thereby indicating the direction of knowledge transfer. We referred the fields of the references as “knowledge donors” and the fields of the papers as “knowledge acceptors”.

In summary, the two paper citation networks for the fields of science and technology in Korea illustrate from which field the knowledge originated (the knowledge donor) and to which field knowledge was transferred and utilized (the knowledge acceptor). It also illustrates the extent of connection or proximity between the fields of science and technology. The results of the paper citation network in the fields of science and technology in 1996 and 2006 are as Figure 9 and Figure 10.

In-degree centrality and out-degree centrality of network for each field of science and technology in 1996 and 2006 are presented in Table 2 and Table 3.

The size of the node indicates the level of in-degree centrality, that is, the knowledge acceptance. A citation relation is indicated with an arrow and its direction represents the direction of the knowledge transfer. The thickness of the arrow is proportional to the frequency of citation. Biology & Biochemistry, Chemistry, Microbiology, Physics and Engineering were the central domains in the network in 1996. Biology & Biochemistry and Chemistry remain as the central domains in the network in 2006, thereby verifying their firm positions as knowledge acceptors. In addition, fields including Clinical Medicine, Materials Science and Physics gained the status of central domains in the network in 2006. These fields were characterized by a high level of both in-degree and out-degree centrality. In other words, fields such as Biology & Biochemistry, Chemistry and Physics, which are the fields of pure basic science rather than fields of applied science, are playing important roles as both knowledge acceptors and knowledge donors, and knowledge transfer to and from these fields occurs very actively

3.2.2 Composition of community in the fields of science and technology (analysis of association between fields)

We applied the composition method, which have high association from the paper citation network into a community. Thus, we composed communities with components that are divided by eliminating the links with high link-betweenness centrality one by one. Since the link-betweenness centrality signifies the number of appearances of a link on the geodesic path of all other node pairs, it can be said that the link with a high link-betweenness centrality carries out the role of a bridge in the network. Therefore, if the link with high link-betweenness centrality is eliminated, then the connection between two components held by such link is divided, thereby thereby composing community of nodes.

Network communities in the fields of science and technology in 1996 and 2006 are composed as shown in Figure 11 and Figure 12.

In 1996, fields including Material science, Immunology, Geosciences, Agricultural sciences, Telecommunications, Energy & fuels, Space sciences, Psychiatry/psychology, and Nanoscience & nano-technology formed separate communities while the remaining 15 fields formed a single main community. In 2006, the size of the main community grew bigger. Only the Space sciences remained as a separate community while the other 23 fields were bundled together. This can be interpreted as an intensification

Figure 9 Network of paper citations between the fields in 1996

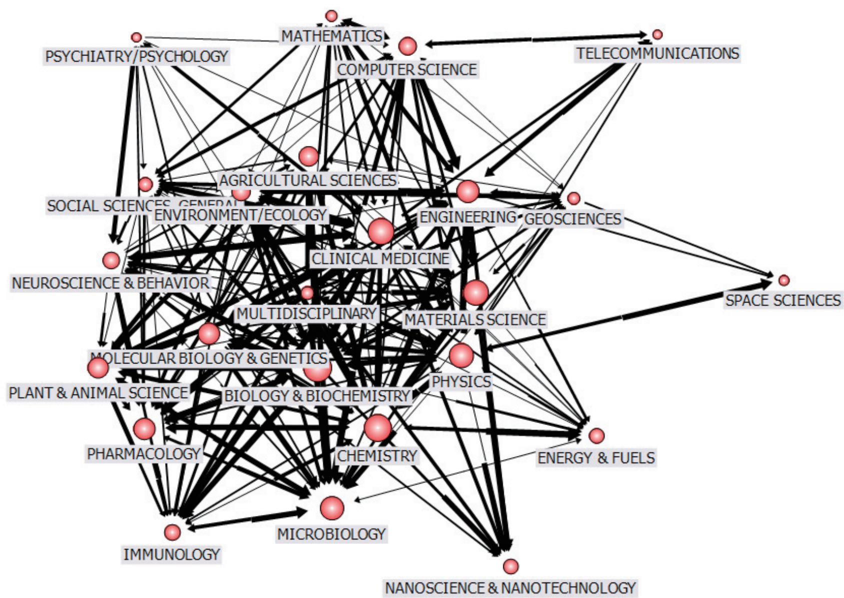

Figure 10 Network of paper citations between the fields in 2006

Table 2 In-degree centrality for each field of science and technology in 1996 and 2006

(in the order of the extent of in-degree centrality in 2006)

	Field Category (as knowledge acceptor)	In-degree centrality 2006	In-degree centrality 1996
1	BIOLOGY & BIOCHEMISTRY	3,474.90	760.8
2	CHEMISTRY	2,471.70	470.2
3	CLINICAL MEDICINE	2,099.00	272.2
4	MATERIALS SCIENCE	2,056.10	288.9
5	PHYSICS	1,987.20	386.9
6	MICROBIOLOGY	1,798.40	414
7	ENGINEERING	1,144.30	306.8
8	PHARMACOLOGY	1,041.10	161.6
9	MOLECULAR BIOLOGY & GENETICS	897	169.9
10	PLANT & ANIMAL SCIENCE	791.1	104.1
11	AGRICULTURAL SCIENCES	692.1	66.3
12	ENVIRONMENT/ECOLOGY	670.2	100.3
13	COMPUTER SCIENCE	544.3	89.7
14	NEUROSCIENCE & BEHAVIOR	526.3	72
15	IMMUNOLOGY	514.9	95.2
16	NANOSCIENCE & NANOTECHNOLOGY	446.5	28.4
17	ENERGY & FUELS	231.5	15.2
18	SOCIAL SCIENCES, GENERAL	228.4	54.8
19	MULTIDISCIPLINARY	217.8	35.2
20	GEOSCIENCES	215.9	34.3
21	MATHEMATICS	208.6	45
22	SPACE SCIENCES	165.8	48.9
23	TELECOMMUNICATIONS	158.2	28.1
24	PSYCHIATRY/PSYCHOLOGY	115.3	5.6

Table 3 Out-degree centrality for each field of science and technology in 1996 and 2006

(in the order of the extent of out-degree centrality in 2006)

	Field Category (as knowledge donor)	Out-degree centrality 2006	Out-degree centrality 1996
1	BIOLOGY & BIOCHEMISTRY	3,809.40	661.7
2	CLINICAL MEDICINE	3,175.40	524.2
3	CHEMISTRY	2,523.00	402.4
4	PHYSICS	2,017.10	435.7
5	MULTIDISCIPLINARY	1,762.00	376.1
6	ENGINEERING	1,293.30	275
7	MATERIALS SCIENCE	1,162.50	175.1
8	MICROBIOLOGY	1,072.10	240.7
9	MOLECULAR BIOLOGY & GENETICS	1,047.70	201
10	IMMUNOLOGY	755.2	92.1
11	NEUROSCIENCE & BEHAVIOR	685.6	81.2
12	PHARMACOLOGY	525.7	109
13	PLANT & ANIMAL SCIENCE	513.8	86.2
14	ENVIRONMENT/ECOLOGY	492.2	55.7
15	AGRICULTURAL SCIENCES	399.1	41
16	SOCIAL SCIENCES, GENERAL	369.3	69.8
17	COMPUTER SCIENCE	367.6	111.5
18	GEOSCIENCES	203.5	33
19	MATHEMATICS	184.7	42.5
20	PSYCHIATRY/PSYCHOLOGY	113	11.8
21	TELECOMMUNICATIONS	81.4	11.8
22	ENERGY & FUELS	72.1	14.2
23	NANOSCIENCE & NANOTECHNOLOGY	40.3	9.4
24	SPACE SCIENCES	30.7	0.2

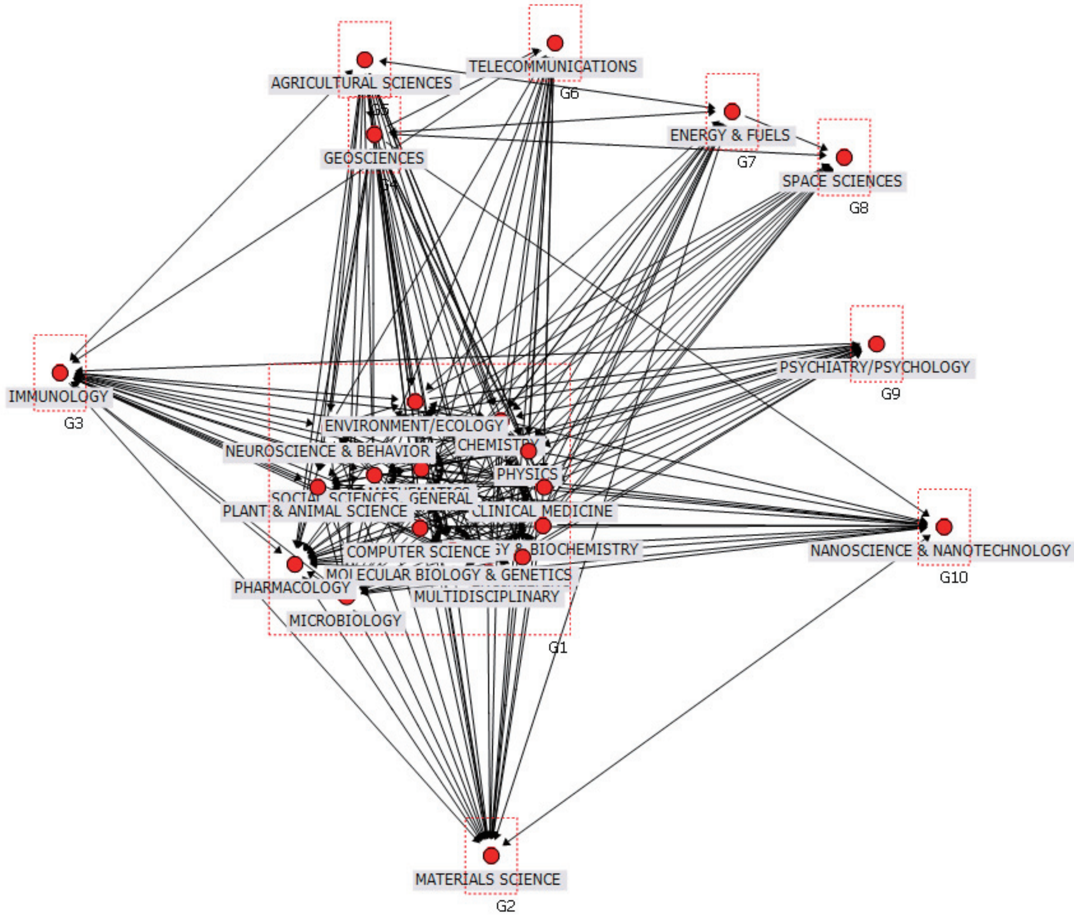

Figure 11 Network community in 1996

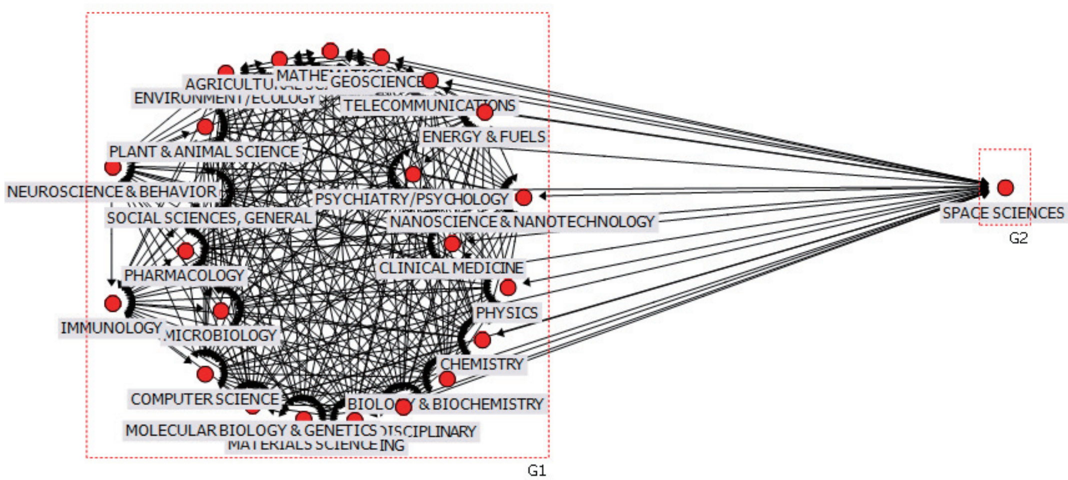

Figure 12 Network community in 2006

of the association between the fields with gradually increasing ambiguity of the field boundaries along with very active horizontal knowledge transfer between the fields. In particular, in the current era, in which multi-disciplinary research is being encouraged, the horizontal knowledge transfer between the fields of science and technology is important, as it can, among other things, provide incentives to create new academic fields. The birth of a new academic field signifies the birth of a new knowledge system. The birth of a new knowledge system can be seen as having the largest ripple effect of all events of knowledge creation. Ultimately, although horizontal knowledge transfer may have both a low level of immediate utilization and a low level of contribution towards the innovation system, it may result in the birth of a new knowledge system with a large ripple effect and radical innovation.

A field that deserves more focus is Nanoscience & nanotechnology, which is known to be a promising field as well as representing an interdisciplinary technology field. Similarly, the number of research papers in the nano-field in 1996 was too few to categorize it as a complete academic discipline and it was not included in the mainstream community due to a very low level of out-degree centrality. However, by 2006, the number of papers as well as the in-degree centrality and out-degree centrality of this field increased enormously, enabling it to be included in the main community. It is thus obvious that a new emerging field has matured into a complete field within science and technology.

3.2.3 Time lag (referencing timing)

In this part, the time taken for papers to be cited was analyzed. The time taken for a paper to be cited can be also interpreted as the time needed for knowledge transfer to occur. The time difference between the publishing year of the paper and the publishing year of the paper's reference was computed for both 1996 in Figure 13 and 2006 in Figure 14. This time lag was computed for the cases of citation within the same field (gray circle), for the cases of citation in other fields (black circle), and for all citations (white circle).

According to Figure 13 and Figure 14, the statistical time lag in the citation of papers in 1996 was approximately 3 years. Citations within the same field and to other fields appeared to exhibit approximately the same time lag. On the other hand, in 2006, the time lag to the peak citation frequency in the same field was 2 years, a slight increase in the speed of knowledge transfer in comparison to 10 years earlier. This was in contrast to citation in other

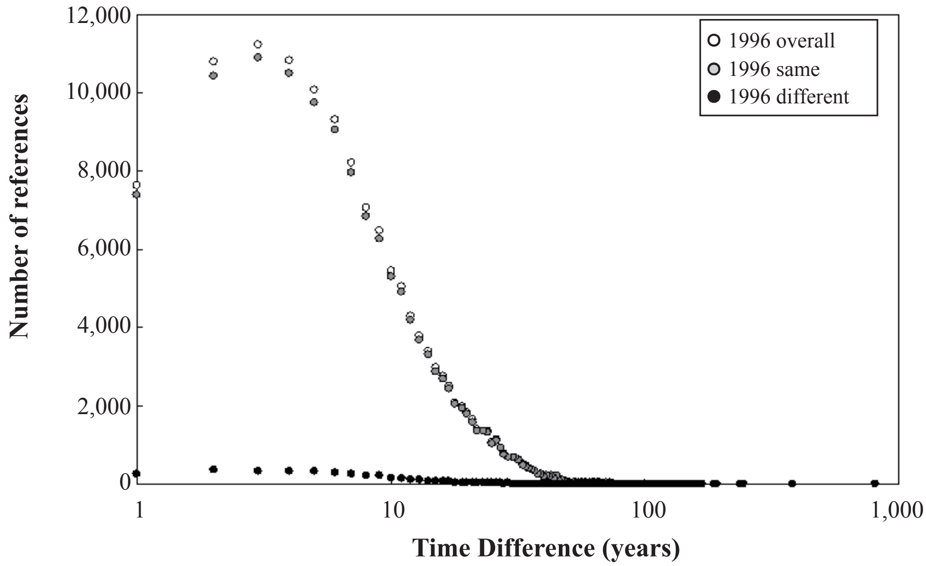

Figure 13 Time lag for referencing in 1996

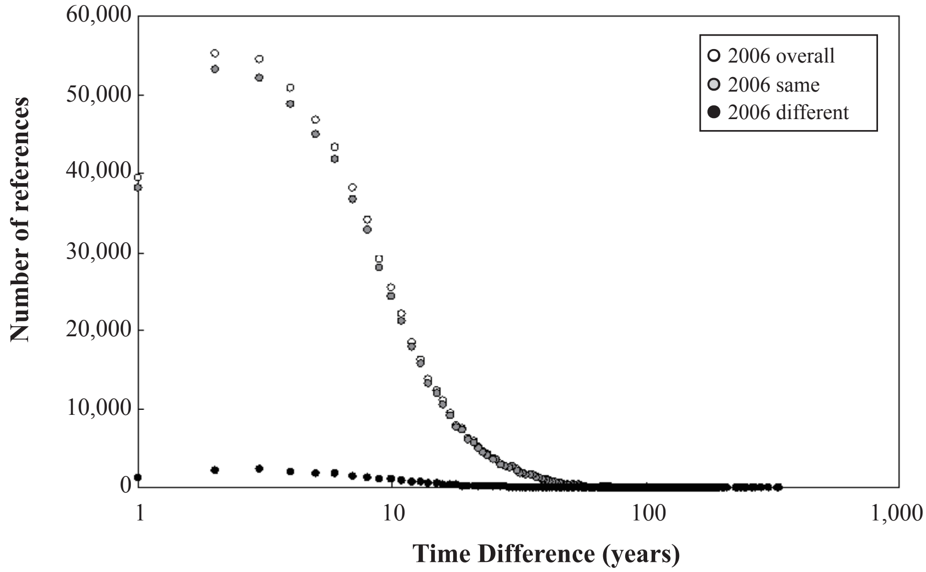

Figure 14 Time lag for referencing in 2006

fields in 2006, where a time lag of more than 3 years was most frequent. This signifies that the speed of horizontal knowledge transfer (knowledge transfer to other fields) is somewhat slower than the speed of knowledge transfer within the same field.

3.3 Implication: Horizontal knowledge transfer

Efforts to reinforce the efficiency of innovation systems can be explained by answering the following questions: "How fast is the knowledge transfer to the next stage?" and "How active is the association between the stages of research, development, manufacturing and marketing?" They can be rephrased as "How close is the distance between the stages of research, development, manufacturing and marketing?" Therefore, to evaluate the effectiveness of R&D programs, measurements are made of whether, and to what extent, the results of research have been transferred to the development stage, and whether, and to what extent, the results of the development stage have been transferred to the market through the manufacturing stage. However, as mentioned above, there is an uncertainty when utilizing basic research results since basic research aims to "acquire knowledge" rather than pursue immediate practical goals. Therefore, it is not possible to conclude that the effectiveness of the research is high just because the research managed to produce the anticipated results. Even if the research results had an outcome that was not anticipated or the research was even deemed to have been a failure, it may have a great ripple effect later. Therefore application objectivity need not and must not be emphasized for basic research. If efforts to improve the efficiency of the innovation system influence the basic research, then they can actually exert pressure to produce short-term results from basic research. This may reduce the uncertainty of basic research's results, which is one of its most important characteristics. The uncertainty of basic research results guarantees its creativity. Therefore, if the uncertainty of the basic research results are eliminated, then there is a concern that the creativity of basic research may be lowered, ultimately leading to lower quality results. Whereas in the case of applied research and development, it can be desirable to evaluate whether the planned results have been produced and utilized as planned, in the case of basic research, a different approach must be followed.

Among the characteristics of basic research that were analyzed in the previous chapter, we should pay high attention to the horizontal knowledge transfer method. If the planned results of basic research are obtained and then progressed into applied research and development, then the role of basic research can be understood easily with the vertical knowledge transfer method and can be explained by various innovation system models. However, we must always acknowledge the uncertainty of basic research results. Even when the planned results are not obtained, the other intrinsic roles of basic research must be remembered, such as expansion of knowledge stock, provision of new ideas for further R&D, and knowledge transfer to other fields of science and technology. This aspect is not possible to explain using the various innovation system models, such as the linear, chain-linked and open innovation models, that utilize the vertical knowledge transfer method as the fundamental framework. Therefore, we decided to refer to this aspect as the "horizontal knowledge transfer method". The overall creativity of the researchers can only be guaranteed if the same level of importance given to the vertical knowledge transfer method is also given to the horizontal knowledge transfer method, which, unlike the vertical knowledge transfer method, provides ideas for further R&D. Along with the uncertainty of basic research results, the horizontal knowledge transfer method has an enormous effect on the improvement of the level of basic research quality and the speed of expansion of knowledge stock. In the era of multi-disciplinary research, in which the associations between fields are continually increasing and the boundaries between fields are becoming increasingly blurred, such an understanding of horizontal knowledge transfer becomes even more important. Therefore, when reinforcing the efficiency of the innovation system, the distinct role of basic research must be understood differently to the role of applied research which is aimed at a "particular application" and is thus appropriate for the vertical knowledge transfer method. It is particularly desirable to acknowledge the role of basic research in the expansion of knowledge stock through horizontal knowledge transfer, in addition to vertical knowledge transfer.

4. Conclusion

In this study we discussed the possible distortion of the characteristics and roles of basic research when "reinforcement of efficiency of innovation system" and "promotion of basic research" is pursued simultaneously. In addition, it was explained that the role of basic research in the innovation system must be treated differently from that of applied research through analysis of the intrinsic characteristics of basic research. In various existing innovation systems, research does not properly distinguish basic research from applied research. Therefore, both basic research, aimed at the "acquisition of knowledge", and applied research, aimed at a "particular application", are situated within the innovation system as an element referred to as just research.

The innovation system is composed of research, which is an element that creates knowledge stock, development on the basis of this knowledge stock, and market-sided innovation elements such as production. However, efforts to improve the efficiency of the innovation system are accomplished by narrowing the distance between each of the innovation elements through active knowledge transfer between them. In other words, it aims to activate vertical knowledge transfer. In doing so, pressure to produce short-term application results for utilization in the next stage is also exerted on basic research, which may result in the unfavorable side effect of the distortion of the characteristics and the role of basic research. To prevent such a side effect and to clarify the role of basic research, the intrinsic characteristics of basic research must be understood. In this study, the questionnaire survey and paper citation network analysis were carried out to understand the characteristics of basic research. The analysis elucidated two intrinsic characteristics of basic research, namely the uncertainty of the basic research results and the horizontal knowledge transfer.

The uncertainty of basic research results were discussed previously along with the indirect effects of basic research. The desired horizontal knowledge transfer method cannot be explained in the majority of innovation system models that just follow the vertical knowledge transfer method as their fundamental framework. However, the horizontal knowledge transfer method can maximize the creativity of basic research by, for example, giving birth to new fields of science and technology. This birth of new knowledge systems is fundamentally different from the generation of fragmented knowledge. It is the process which creates the highest ripple effect of all methods of knowledge creation and can become a matrix of radical innovation. In addition, the perspective gained from the horizontal knowledge transfer method can help enormously to improve of the quality of basic research and the speed of expansion of knowledge stock by fostering the creativity of researchers and by not emphasizing the short-term applications of their results. Under the knowledge-based economic system in which knowledge creation including creativity and multi-disciplinary research play an important role, not only the existing vertical knowledge transfer method but also the horizontal knowledge transfer method has enormous significance. Therefore, when reinforcing the efficiency of the innovation system, it is necessary to distinguish the role of basic research from that of applied research which is the vertical transfer of knowledge towards a "particular application". It is desirable to define the role of basic research as the expansion of knowledge stock through both horizontal and vertical knowledge transfers. As such, if the role of basic research is considered separately, then the "reinforcement of the efficiency of innovation system" and "promotion of basic research" can coexist without side effects, and the expansion of knowledge stock system can be achieved efficiently in the innovation system.

5.. References

1. Bush, V. (1945), Science the endless frontier.
2. David, P., Mowery, D. and Steinmuller, W. (1988), The Economic Analysis of Payoffs from Basic Research-An Examination of the Case of Particle Physics Research, CEPR Publication No. 122, Center for Economic Policy Research, Stanford University, California.
3. Gibbons, M. et al. (1994), The new production of knowledge. London: Sage, 51.
4. Japan (2006), The 3rd Basic Plan for Science & Technology 2006~2010.
5. Kline, SJ., Rosenberg, N. (1986), An Overview of innovation. In: Landau R, Rosenberg N, editors. The positive sum strategy. Washington: National Academy Press, 275-304.
6. Martin, B., Salter, A. et al., (1996), The Relationship Between Publicly Funded Basic Research And Economic Performance.
7. Meyer, M. (2002), "Tracing knowledge flows in innovation systems", Scientometrics, 54(2): 193-212.
8. Narin, F. and Noma, F. (1985), "Is Technology becoming Science?", Scientometrics, 7: 369-381.
9. OECD (2001), The new economy: Beyond the hype.
10. Pavitt, K. (1990), "What makes basic research economically useful?", Research Policy 20, 793-805.
11. Rinia ED J. et al. (2002), "Measuring knowledge transfer between fields of science", Scientometrics, 54(3): 347-362.
12. Salter, A., Martin, B. (2000), "The economic benefits of publicly funded basic research: a critical review". Research Policy 30, 509-532.
13. USA (2008), Science Debate 2008, www.barackobama.com.
14. USA National Academies (2005), Rising above the gathering storm: energizing and employing America for a brighter economic future.
15. Chesbrough, H. (2003), The open innovation. Cambridge: Harvard University Press.
16. USA National Science Board (1998), Science & Engineering Indicators-1998. Arlington, VA: National Science Foundation, A287-A289.

Political Implications from Empirical Analysis of the Performance-Based Evaluation System in National R&D Programs

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Abstract

This study was conducted to draw political implications from an empirical analysis of performance-based evaluation systems of current National R&D Programs. For this, major issues on existing evaluation systems were identified through tracing and analyzing transition processes, investigating and analyzing related literature, and knowledge learned through experiences. Questionnaire research on how these issues are recognized by personnel concerned with R&D evaluation was conducted through empirical analysis. The result showed that the triennial evaluation system conducted from 2009 was generally recognized as helpful in alleviating evaluation pressures; however, the evaluated subject was still perceived poorly in terms of importance of R&D program evaluation and experience pressures in making evaluation data. Furthermore, there is plenty of room for improvement since evaluation does not reflect the characteristics of R&D activities and the result is not fully utilized for internal purposes.

1. Introduction

In many advanced countries, a large portion of investment from the government investment budget is focused on supporting the development of science and technology research capable of producing a significant economic ripple effect as a basis for creating knowledge and solving social problems. In Korea, there has been a constant effort since the 90s to expand the size of investment by nearly 10% to raise the R&D investment level to that of of advance countries. In 2009, it allotted a substantial budget of KRW12.3437 trillion – an 11.4% increase from the previous year (Comprehensive Guideline to National R&D Program, 2009). The size of government investment in R&D is expected to continue to rise in the future under the policies of the current government including the recommendations of the '577 Initiative' – a plan to expand investment by 5% of GDP with the goal to rank among the top seven science powers by 2012 – as part of the Science & Technology Basic Plan prepared by Myung-Bak Lee government.

With this large expansion in the R&D budget, the focus has shifted from the management of input and output to an emphasis on expanding performance-based investment efficiency. According to the Lee administration's Science & Technology Basic Plan, discussion has begun on system improvement plans to alleviate evaluation pressures of researchers by suggesting the "Establishment of Researcher Friendly R&D Management and Evaluation System" as a key task.

However, studies on the main factors that pressure researchers are still insufficient as we begin to go

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forward with these efforts to improve the system. In relations to institutional evaluation programs, Chan-Gu, Lee (2009) only presented the problems of current systems and system improvement plans in his in-depth interview. Existing studies failed to provide empirical verification through quantitative methods on the impact of government evaluation systems to actual researchers after legislating "Law on Performance Evaluation and Management of National Research and Development Projects". Therefore, it is necessary to understand how the evaluation system is perceived by relevant personnel and identify future improvement directions for gradual improvement of the evaluation system. The objective of this study is to examine how improvement of the evaluation system on national R&D activities is embraced in the field and in which direction improvement is required in the future through conducting and analyzing questionnaire research to evaluation personnel to present the problems of the new evaluation systems and suggest improvement plans.

This study analyzed the evaluation system to develop methodologies for measuring the effectiveness of the improved evaluation systems and, simultaneously, investigated and analyzed various evaluation related releases and dissertations on evaluation theories to highlight major issues relevant to existing R&D evaluation systems.

To investigate recognition by relevant personnel of major issues, a questionnaire was designed and its results analyzed. The normalization process was pursued through a discussion with experts regarding the major issues for detailed questionnaire questions and incorporating them into the general evaluation systems framework. Meanwhile, the questionnaire was conducted by categorizing evaluation personnel into evaluator and evaluation subjects to study current status of recognition as well as the difference of recognition between the parties. Finally, the results analyzed to ultimately draw political implications.

2. National R&D Program Evaluation System

2.1 National R&D Program Evaluation System

2.1.1 Transition Process of National R&D Program Evaluation Systems (Table 1)

Before legislating the "Special Act on Innovation in Science and Technology" (Apr. 10, 1997, Law No. 5340), the R&D projects were evaluated with other programs. With the legislation of the Special Act in 1997, the importance of R&D management was stressed and specialized evaluations on R&D programs

Table 1 Transition Process of National R&D Program Evaluation System

Type	1998~2000	2001~2004	2005~2007	2008~2009
Improvement Details	• Promotion in status from bureau to Department of Science and Technology (Feb. 98) • Installation of National Science and Technology Council (Mar. 99) • Establishment of '5-Year Science and Technology Innovation Plan' (Dec. 97) • Enactment of 'Special Act on Innovation in Science and Technology' (Apr. 98)	• Enactment of 'Basic Law on Science and Technology (Jul. 01) • Establishment of the 1st Science and Technology Basic Plan (May. 03)	• Implementation of system of Deputy Prime Minister of former Department of Science and Technology (Oct. 04) • Installation of Science Technology Innovation Division in former NSTC (Oct. 04) • Enactment of 'Law on Performance Evaluation in R&D Programs' (Dec. 05)	• Transfer of colligated authorities of evaluation planning from Ministry of Education to Ministry of Strategy and Finance through government restructuring (Mar. 08) • Establishment of the 2nd Science and Technology Basic Plan (Aug. 08)
Significance	Implementation of categorized evaluation on national research development program	Preparation of comprehensive coordination basis for R&D activities	Reinforcement of comprehensive coordination function and implementation of performance-based evaluation	Alleviation of evaluation pressures and reinforcement of evaluation efficacy
Emphasis	Prevention of duplicative investment in R&D activities	Validity evaluation of financial input and execution	Establishment of performance-based management systems	Implementation of triennial evaluation and in-depth evaluation

undertaken for the first time. The main focus of the R&D program evaluation at that time was on finding and arbitrating repeated programs or those that required relation among the programs. Furthermore, the basic framework of science and technology policy was constituted through establishing a '5-Year Science Technology Innovation Plan (1998-2002)' for the first time that incorporated mid to long term planning for science and technology and inaugurated the National Science & Technology Council (NSTC), the highest decision-making organization regarding national science and technology policies, in January 1999. At the same time, the former Science and Technology Bureau was elevated to the status of Department of Science and Technology in February 1998, attesting to the rise in importance of science and technology.

The most important changes in the current execution and management system of science and technology were presented through enactment of the "Basic Law on Science and Technology" (Jan. 16, 2001, Law No. 9089) (the 'S&T Basic Law'). The system of the 'Science & Technology Basic Plan' (1st: 2003-2007; 2nd: 2008-2012) was prepared through the legislation of subordinate laws to the Special Act, which also prepared the opportunity to establish and execute science and technology policies by identifying regulations for the 'Comprehensive Promotion Plan for Regional Science and Technology' and items regarding NSTC. Moreover, it established the basis for a national science and technology innovation system, including research development, and investment and human resources to ensure comprehensive and long-term development of science and technology. From this period, the evaluation system went further to consider the feasibility of budget input and execution process beyond the level of simple repeated investment arbitration along the expanded investment sizes. However, evaluation did not pay much attention to R&D performance until the legislation of the "Law on Performance Evaluation and Management of National Research and Development Programs (Dec. 30, 2005, Law No. 8852)" (the 'Performance Evaluation Law'). This law identified efficient management systems for evaluation and performance of R&D activities and divided the existing two categories of contracting institution evaluation and R&D business evaluation into self and meta evaluation and performance plan management and follow-up and specific evaluations and stipulated the basic principles of performance management for systematic management of the results. In addition, it identified the role of evaluation result for policy establishment, program execution and budget coordination and prepared the current performance-based evaluation system just as the most important event in the history of science and technology management system was the enactment of the 'S&T Basic Law', so too was the enactment of the 'Performance Evaluation Law' in the history of R&D activity evaluation. After this, many supplementing plans began to be proposed for the effective establishment of a performance-based evaluation system.

2.2 Current Status of 2009 National R&D Program Evaluation and Characteristics of System Improvement

2.2.1 2009 National R&D Program Evaluation System

Under the current evaluation system for the national R&D program, self-evaluation and performance management are conducted by each department and meta evaluation, follow-up evaluation and specific evaluation(in-depth approach) are conducted by the Ministry of Strategy and Finance. The characteristics of each evaluation program are as follows(shown in Figure 1).

First, for the self-evaluation system, the objective and details, execution systems, and performance evaluation systems are investigated considering whether the program created proper results according to the performance plan established by each department concerned. After the self-evaluation, meta evaluation is conducted on the result of the self-evaluation and evaluation system to judge whether the self-evaluation was conducted appropriately by the Ministry of Strategy and Finance. According to the result of meta evaluation, the evaluation result is confirmed for the final program and this confirmation is then used for establishing and revising budgetary and execution plans. At this point, the Ministry of Strategy and Finance, which plays comprehensive role, develops

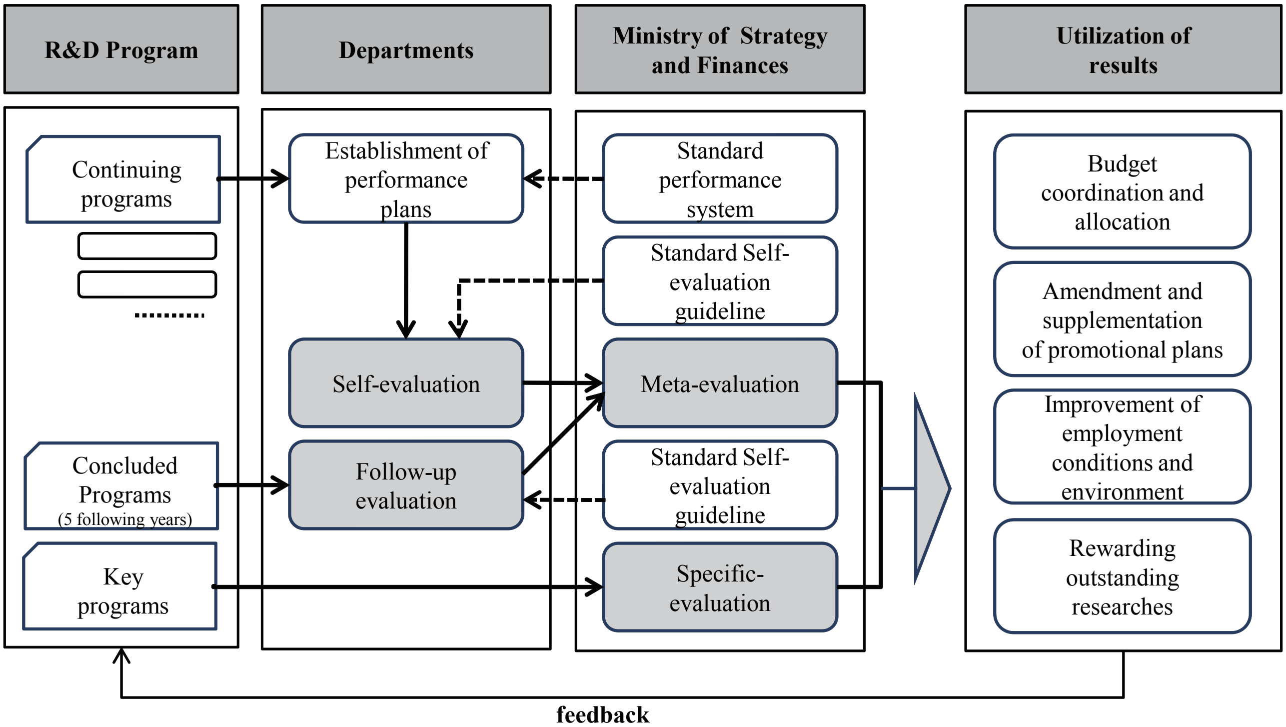

Figure 1 Transition Process of National R&D Program Evaluation System

Standard Performance Index Systems and Standard Evaluation Guidelines in support of the establishment of performance plans and providing unified directions in planning. In 2009, it conducted self and high ranking evaluation on 73 national R&D programs in 16 government ministries, including the Ministry of Education and Science, and the Ministry of Land, Transport and Maritime Affairs. This corresponds to about 1/3 of 207 national R&D programs in total (as of Jan. 2009).

The specific evaluation is hosted by the Ministry of Strategy and Finance for programs, including long-term and large sized programs, repetition arbitration and connection programs, multilateral departments' collaborative programs, and nationally and socially pending issued programs. In 2009, 10 programs and groups (8 ministries with programs totalling KRW820.4 billion) including a program to support an industry, university and research collaboration system, a program to enhance the material and components industry's competitiveness, and promote technology transfer commercialization groups, were selected and implemented.

Although follow-up evaluation is statutorily required, it is based on the evaluations of concluded programs. For this reason, it has never been executed due to issues of evaluation effectiveness. The Law stipulates a similar process for the self evaluation that the Ministry of Strategy and Finance develops and provides standard guidelines and each department conducts evaluation on this basis. But it evaluates only the programs within 5 years of conclusion and its focuses are on the perspective of management and utilization of the program's result.

2.2.2 Characteristics of 2009 National R&D Program Evaluation System Improvement Directions

The characteristics of the 2009 National R&D Program evaluation system improvement can be categorized into three: alleviation evaluation pressure on researchers, reinforcement of customized and consulting evaluation system through in-depth evaluation, and promotion of utilizing evaluation results. Each category is specified below.

First, as part of effective reinforcement plans through creation of results, a measure to alleviate researcher's evaluation pressures was undertaken. Formerly, the researchers had to go through selection evaluation, annual evaluation, stage evaluation, and follow-up evaluation and only then did the programs go through self and meta evaluation, specific evaluation, performance plan confirmation and inspection. On top of this, self and meta evaluation of the contracting institutions was conducted in which the individual researcher annually was pressured with annual evaluation, self and meta evaluation of the program, and self-evaluation for the affiliating institution at a minimum.

Therefore, the evaluation cycle of program self and meta evaluation was extended from 1 year to 3 years and the yearly evaluation subjects were reduced by 1/3 in an effort to alleviate evaluation pressures on the researcher. Under the former system, a total of 207 programs from 17 ministries (KRW8.1489 trillion) were subject to evaluation (as of Jan, 09); whereas, with the extension of its cycle to 3 years, the subject was reduced to a total of 73 programs for 16 ministries (KRW2.2109 trillion). The re-evaluation system, which repeated the self-evaluation when the result of meta evaluation was proved invalid, was also abolished and revised as a form to draw final evaluation results of the program at the meta evaluation level. The program evaluation, which often occurred three times a year in the worst case, was improved in that evaluation occured once in three years. This improvement is expected to alleviate researcher's evaluation pressures by mandating research and program performance evaluation for contracting institutions once in three years.

Measures to reinforce evaluation effectiveness accompanied those alleviating researcher pressure. The most important improvement was to bring in-depth analysis to in-depth evaluation. In contrast to the existing specific evaluation method, which conducted the inspection through a commonly applied checklists, the specific evaluation through in-depth analysis differed in that it establishes separate evaluation strategies, conducts performance analysis, and produces evaluation results accordingly. That is, the in-depth approach evaluation is a method that reviews whether the establishment of evaluation strategies and creation of mid and long term program performance were produced appropriately. In brief, it is an in-depth evaluation.

There have been changes to reinforce the effectiveness of not only for the in-depth evaluation but also for self and meta evaluation. The past practice of constituting a technology specialist oriented evaluation council was changed to include at least one specialist from the areas of economy, humanity and society in order to have an overall perspective on program execution systems as well as program performance.

Lastly, to maximize the utilization of evaluation results, measures were taken to reinforce connectivity to the budget. The former method of utilizing budget allocation as a point of reference was transformed to preparing a concrete connection standard to enable a direct and realistic budget connection according to the evaluation result. In other words, it stipulates the principle of downsizing the budget by 10% for insufficient programs, freezing the budget for average programs, and expanding the budget for superior programs.

3. Empirical Analysis on the Recognition of Evaluators and Evaluation Subjects

The performance-based evaluation system for National R&D programs is introduced to establish a performance management and evaluation system that is distinct from simple results-oriented measurement in order to expand public sector investment efficacy within the context of the global commencement of a knowledge-based economic system in the 21st and the expansion of R&D investment (Sang-Yup Lee, 2007). However, there has been no substantial intermediary evaluation on the performance evaluation system itself thus far.

This study plans to identify future improvement factors through a quantitative analysis of how broad evaluation results affect research management centered on National R&D Program evaluation. In addition, it will address the question whether the issue of expertise of evaluation counselors is an important topic through quantitative studies related to the expertise of evaluation counselors. It will also review issues related to evaluation systems such as the recognition of evaluators and evaluation subjects of current triennial evaluation systems through the questionnaire.

3.1 Investigation and Design of the Empirical Analysis Framework

There have been many preliminary studies on comprehensive evaluation systems and each individual element in evaluation system from academia. There also have been many formal or informal discussions on TF activities or evaluation sites although they were not publicized through provisional improvements or preceding studies. Assessing these two elements scientifically is essential to ensure the effectiveness of the performance-based evaluation system (Chan-Gu Lee, 2009).

As we have seen earlier, the government has continued its effort to improve the National R&D Programs evaluation system. The Related issues are presented and regulated through discussions with specialists to draft detailed questionnaire items.

Dong-Hoon Oh (2006) suggested a method of categorizing items relevant to the evaluation systems –evaluation philosophy, evaluator, evaluation organization, evaluation cost, evaluation process, evaluation system, evaluation management, result reflux plan, monitoring, related laws, and evaluation culture – into 5 categories: the evaluation paradigm, evaluation resources, evaluation activities, reflux systems, and evaluation environment. In this study, issues investigated using this framework were categorized and normalized(shown in Table 2).

Questionnaire items, for the questionnaire research were divided into evaluators and evaluation subject in recognition of supposed differences between the two groups. Table 3 shows derived questionnaire items.

The 5-Point Likert Scale was used to measure the questionnaire result and each variable was assessed through 4-6 multiple choice items (some short answer questions). From the Cronbach's Alpha Test, which measures reliability and validity of questionnaire questions for each concept, all of the above variables were above 0.7 showing a high level of reliability and validity of the questionnaire items created to measure each variable.

Table 2 Constituent of the Evaluation System

Constituent	Content
Evaluation Paradigm	Evaluation philosophy, objective, principle, subject, scope, etc
Evaluation Resources	Evaluator, evaluation organization, evaluation cost, etc
Evaluation Activity	Evaluation process, evaluation system, performance management, etc.
Reflux System	Reflux method, reflux subject, evaluation result monitoring
Evaluation Environment	Related Law, information system, evaluation culture, evaluator training, etc

※Dong-Hoon Oh (2006), 「Study on National R&D Evaluation System Establishment」

3.2 Composition of Questionnaire and Respondent Characteristics

The questionnaire was developed into a webpage by dividing the user into either evaluator or evaluation subject who were then sent emails with the URL through which the subject participates in the questionnaire. The term of research was 10 days from December 18 to 26, 2008 for the evaluation and 7 days from December 18 to 26, 2008 for the evaluation subject(Table 4). To raise the reliability of the questionnaire result, the questionnaire subject utilized the evaluation participation human resources information registered with NTIS – a government's National R&D Program management service – and selected from among the personnel that participated in the National R&D Program in 2008.

The evaluators were selected from personnel from each department and private evaluation counselors who participated in evaluation and management of R&D activities while the evaluation subjects were selected from personnel in national and public research centers, government subsidized research institutes, and university and private corporation institutions who were the subjects of program evaluations and task evaluations. A total of 680 personnel, including

Table 3 Derivation of Questionnaire Items for Recognition on Evaluation System

Constituent	Major Issues	Questionnaire Items	Subject	
			Evaluator	Subject
Paradigm	Disputes over recognition of level of importance on the evaluation system	Most important system among evaluation systems for R&D activities	O	O
		Evaluation system that imparts most pressures among evaluation systems	O	O
	Disputes over level of satisfaction on the evaluation system	Level of satisfaction of evaluation results	O	O
	Disputes over replicated evaluation systems	Experience of being subjected to multiple evaluations at the similar period	O	O
		Period of repeated evaluations	O	O
		Appropriateness of current evaluation periods and the time	O	O
	Disputes over replicated evaluation contents	Evaluation system which the evaluation content is thought to be repeated	O	O
		Necessity and method of data sharing between evaluation programs	O	-
		Degree of differences in contents and formats of evaluation data among evaluation systems	-	O
	Disputes over evaluation pressures	Degree of pressure of evaluation tasks on research tasks	O	O
		Most oppressive factors in conducting evaluations	O	O
		Time spent writing evaluation and data	O	O
Evaluation Resources	Disputes over expertise of evaluation counselors and fairness	Precedence between expertise and fairness of the evaluation counselor	O	O
		Level of expertise of the evaluation counselor	O	O
		Cause behind low profile expertise of evaluation counselors	O	O
		Level of fairness of the evaluation counselors	O	O
		Cause of unfairness of evaluation counselors	O	O
Evaluation Activities	Disputes on reflecting research characteristics	Level of evaluation methods in reflecting characteristics of R&D activities	O	O
		Cause of failure of evaluation methods in reflecting characteristics of R&D activities	O	O
		Level of desirableness of the verification management system after voluntary presentation of the performance plans	O	O
		Level of reflecting R&D activity characteristics in the performance plans	O	O
		Cause of failure of performance plans in reflecting R&D activity characteristics	O	O
Reflux System	Disputes over internal use of evaluation results	Level of researcher utilization of evaluation results	O	O
		Reliability and fairness of evaluation results	O	-
		Internal utilization contents of evaluation results	-	O
	Disputes over utilization of evaluation results	Opinions on integrating evaluation results in the budget for the following year	O	O
	Disputes over reliability of evaluation results	Experiences and causes of different evaluations results from different evaluation authorities	O	O
		Experiences and causes on different results on the data similar to the previous year	-	O
Environment	System improvement demands by concerned personnel	System improvement requirements (short answer)	O	O

Table 4 Ratio of Questionnaire Result Responses

Type		Evaluator	Evaluation Subject	Total
Respondent	N	110	570	680
	%	16	84	100

110 evaluators and 570 evaluation subjects responded during the research period. In the case of the evaluators, the questionnaire was requested by phone for a higher rate of response; whereas for evaluation subjects, it only analyzed the result of the collected questionnaires due to the large number of subjects.

Looking at the characteristics of the respondents, 47.2% were from metropolitan areas, 15.4% in Daejeon, and 37.3% in nonmetropolitan area. Age-wise, 18.4% were under 40 years old, 53.2% were between 40-50, 26.9% were between 50-60, and 1.5% were over 60. In regards to the affiliated institutions, 43.7% were from universities, 21.9% from corporations, 16.8% from government-subsidized research institutions, 6.0% from national and public research institutes, and 11.6% were from elsewhere. For duration of employment, 16.3% worked than 5 years, 20.6% worked between 5-10 years, 37.6% worked 10-20 years, and 25.4% worked more than 20 years. For the experienced evaluators, 55.0% participated in institutional evaluation, 32.4% participated in task evaluation and 12.7% participated in program evaluation (Table 5).

3.3 Questionnaire Result

3.3.1 Recognition on R&D Activity Evaluation Status (Table 6)

To the question on the importance of evaluation systems regarding R&D activities, the evaluators responded in the order of ‘Task Evaluation (47.3%) and National R&D Program Self Evaluation (44.5%). Among the evaluation subjects (the ‘subject’), the response, “task evaluation is most important” recorded the highest at 60.5% which was. This corresponds to the general recognition that evaluator involved in overall inspection of the National R&D Program would perceive the importance of self-evaluation higher. On the other hand, both evaluators and subject chose ‘self-evaluation’ as the most pressured evaluation (60.9% of the evaluator, 46.5% of the subject; same

Table 5 Respondent Characteristics

Type		Evaluator		Evaluation Subject		Total	
		N	%	N	%	N	%
Region	Metropolitan Area	80	72.7	241	42.3	321	47.2
	Daejeon	17	15.5	88	15.4	105	15.4
	Non-Metropolitan Area	13	11.8	241	42.3	254	37.3
Age	Under 40	59	53.6	66	11.6	125	18.4
	Between 40-50	41	37.3	321	56.3	362	53.2
	Between 50-60	9	8.2	174	30.5	183	26.9
	Over 60	1	0.9	9	1.6	10	1.5
Affiliated Institution	University	10	9.1	287	50.4	297	43.7
	Corporations (Research Institutes)	4	3.6	145	25.4	149	21.9
	Government Subsidized (RI)	23	20.9	91	16	114	16.8
	National and Public (RI)	11	10	30	5.3	41	6.0
	Others	62	56.4	17	3	79	11.6
Years of Employment	Less than 5 years	41	37.3	70	12.3	111	16.3
	Between 5-10 years	24	21.8	116	20.4	140	20.6
	Between 10-20 years	30	27.3	226	39.6	256	37.6
	More than 20 years	15	13.6	158	27.7	173	25.4
Evaluation Experience	Institution Evaluation	87	79.1	511	89.6	598	55.0
	Task Evaluation	46	41.8	306	53.7	352	32.4
	R&D Program Evaluation	34	30.9	104	18.2	138	12.7

Table 6 Recognition on R&D Activities and Government Subsidized Research Institutions Evaluation Status

Questions	Subject	Responses									
		Item1		Item 2		Item 3		Item 4		Item 5	
Most important evaluation	Evaluator	Task Evaluation	47.3	Program Evaluation	44.5	Institution Evaluation	8.2	-	-	-	-
	Subject	Task Evaluation	60.5	Program Evaluation	31.4	Institution Evaluation	8.1	-	-	-	-
Most burdensome evaluation	Evaluator	Task Evaluation	13.6	Program Evaluation	60.9	Institution Evaluation	25.5	-	-	-	-
	Subject	Task Evaluation	21.2	Program Evaluation	46.5	Institution Evaluation	32.3	-	-	-	-
Level of satisfaction over evaluation results	Evaluator	Very high	1.8	High	30.9	Average	42.7	Low	22.7	Very low	1.8
	Subject	Very high	3.0	High	39.6	Average	42.3	Low	13.2	Very low	1.9
Experience and time of being subjected to multiple evaluations during similar period	Subject (N=182)	Yes	31.9	None	68.1	-	-	-	-	-	-
		1st Quarter	21.4	2nd Quarter	20.3	3rd Quarter	12.1	4th Quarter	46.2	-	-
Appropriateness of current evaluation periods and time	Evaluator (N=24)	Highly appropriate	0.9	Appropriate	27.3	Average	50.0	Inappropriate	20.0	Highly inappropriate	1.8
		1Quarter	29.2	2Quarter	45.8	3Quarter	8.3	4Quarter	16.7	-	-
	Subject (N=65)	Highly appropriate	1.2	Appropriate	29.6	Average	57.7	Inappropriate	9.8	Highly inappropriate	1.6
		1Quarter	33.8	2Quarter	20.0	3Quarter	33.8	4Quarter	12.3	-	-
Evaluation system which the evaluation content is thought to be repeated	Evaluator	Task/ Program	44.5	Task/ Institution	5.5	Task/Task	5.5	Program/ Institution	22.7	Not repeated	21.8
	Subject	Task/ Program	43.3	Task/ Institution	10.4	Task/Task	10.0	Program/ Institution	8.4	Not repeated	27.9
Necessity of data sharing between evaluation programs	Evaluator	Highly necessary	12.7	Necessary	60.9	Average	22.7	Unnecessary	3.6	Highly unnecessary	0.0
Method of data sharing between evaluation programs	Evaluator	Convert in DB	44.4	Unification of formats	34.6	Disclosure of data	17.3	Shared among counselors	3.7	-	-
Degree of differences in contents of evaluation data among evaluation systems	Subject	Very different	0.9	Different	28.4	Average	45.4	Similar	24.4	Very similar	0.7
Degree of differences in formats of evaluation data among evaluation systems	Subject	Very different	2.6	Different	41.2	Average	42.6	Similar	15.8	Very similar	0.4

order applies hereinafter). It can be resumed that the evaluator feels burdened with reviewing a heavy data load and the subject feels additional pressures since it is conducted regardless of the task evaluation.

On the question asking the level of satisfaction over the evaluation result, more respondents were generally satisfied (32.7%, 42.6%) than unsatisfied (24.5%, 15.1%) and the subjects showed a somewhat higher level of satisfaction than the evaluators. It is judged that the higher level of satisfaction among subjects over evaluators is very unique where the subjects recognized that they achieved satisfactory result; whereas, the evaluators judge that the overall evaluation was higher than what they expected. This could be resulted from overstated markings due to the solicitous judgment of some evaluators.

The result of inquiry into the experience of repeated evaluations on more than two National R&D Program evaluations at the same time showed that 31.9% had the experience and that they occurred most frequently in the 4th quarter (46.2%). This corresponds to the general speculation that the evaluation would be concentrated in particular time.

About the appropriateness of evaluation period, more people answered that it was appropriate, but 24 evaluators and 65 subjects answered 'inappropriate.' The evaluators chose 2nd quarter (45.8%) and 1st quarter (29.2%); while the subject answered 1st quarter and 3rd quarter (both 33.8%). It appears that they chose to avoid the 4th quarter since it overlaps with the conclusion period of programs and tasks and many evaluation programs such as HR evaluation are all concentrated in that period.

To the question on repetition among evaluation programs, the respondents thought that task evaluation and program evaluation is highly repetitive (evaluator: 44.5%; subject: 43.3%). This appears to be the result of their experience of submitting identical data on both task evaluation and program evaluation. It can be deduced that the level of difference in contents of evaluation submitted to each evaluation system and the answer 'different' was lower (29.3%); whereas, the level of difference in the format showed that the answer 'different' was higher (41.2%). That is, the subject experienced difficulty in writing similar contents in a different format.

Next, in terms of evaluators, many felt that the program evaluations and institution evaluations were redundant (22.7%). It seems that, since there are comment elements in partial indices in program evaluation and institution evaluation, they would have identified some repetition. The question on the necessity of sharing evaluation data among evaluation systems to the evaluators proved the need to share (73.6%)

3.3.2 Recognition on Pressures of the National R&D Program Evaluation (Table 7)

On the question whether the evaluation task pressures the research task, 41.8% of the evaluators and 47.4% of the subject responded positive, which shows that it is burdensome for both parties. Moreover, the subjects felt more pressured than the evaluators, illustrating that subjects feel more pressured. Also, among those who answered the evaluation task on being pressured (46 evaluators, 270 subjects), both parties chose various evaluation data (78.3%, 57.8%) as the most pressuring element followed by writing the report (19.6%, 34.1%), revealing that writing evaluation data was very burdensome.

As for time consumed in conducting evaluation, the evaluators answered 'less than 3 days' most frequently (26.4%), followed by10-19 days (20.0%) and 5-9 days (19.1%) for an average of 15.1 days. Subjects

Table 7 Recognition on Pressures of National R&D Program Evaluation

Questions	Subject	Responses											
		Item1		Item 2		Item 3		Item 4		Item 5		Item6	
Level of evaluation task pressure on the research and the cause of pressure	Evaluator	Highly burdensome	4.5	Burdensome	37.3	Average	40.0	Not burdensome	16.4	No burden at all	1.8	-	-
	(N=46)	Evaluation data	78.3	Report	19.6	Meeting	0.0	Business Trip	0.0	Others	2.2	-	-
	Subject	Highly burdensome	51.0	Burdensome	42.3	Average	36.7	Not burdensome	14.7	No burden at all	1.2	-	-
	(N=270)	Evaluation data	57.8	Report	34.1	Meeting	4.4	Business Trip	3.3	Others	0.4	-	-
Time consumed in evaluation and evaluation data	Evaluator	Less than 3 days	26.4	3-4 days	10.9	5-9 days	19.1	10-19 days	20.0	20-49 days	16.4	More than 50 days	7.3
	Subject	Less than 3 days	20.9	3-4 days	25.3	5-9 days	16.3	10-19 days	13.0	20-49 days	10.4	More than 50 days	14.2

answered 3-4 days the most (25.3%), followed by less than 3 days (20.9%), and 5-9 days (16.3%) for 12.5 days on average. Considering that the number of days that actually are available for research annually is around 250 days, some 5% of research days are spent in evaluation.

3.3.3 Recognition of Reflecting Research Characteristics on the Evaluation (Table 8)

For the question regarding the level of evaluation method that reflects the characteristics of research activity, many evaluators (40.9%) felt it is reflected and subjects chose 'average' (43.7%) the most. Among the respondents who answered that it did not reflect that characteristics (21 evaluators, 128 subjects), they chose discerning technological characteristics (38.1%, 44.5%) and the characteristics in R&D phase (33.3%, 40.6%).

Next, for the question whether it is desirable to voluntarily provide performance goals and indices and verify it, the answer "it is positive (55.4%, 63.99)," greatly outweighed the negative (9.1%, 8.7%) illustrating that both parties generally found desirable voluntary provision and preliminary verification system on the performance plans.

For the question as to whether the performance goals and index reflect objectives and characteristics of the activity, the opinion that it is reflected (40.0%, 51.2%) was higher and subjects found it more positive than the evaluators. Among the respondents who answered that it does not reflect the objectives and characteristics (16 evaluators, 59 subjects), many people chose "inappropriate method of verification" (50.0%, 40.7%) followed by lack of expertise of the verifier (31.3%, 37.3%).

3.3.4 Recognition Regarding Utilization of Evaluation Results (Table 9)

The level of researcher's use of evaluation results among the evaluators were in the order of 'average' (50.0%), 'used' (26.3%) and 'not used' (23.7%) revealing that the majority used the result but the

Table 8 Recognition of Reflecting Research Characteristics on the Evaluation

Questions	Subject	Responses									
		Item1		Item 2		Item 3		Item 4		Item 5	
Level of evaluation method reflecting R&D activity characteristics and the cause of failure in reflecting	Evaluator	Well reflected	0.9	Reflected	40.0	Average	40.0	Not reflected	15.5	Not reflected at all	3.6
	(N=21)	Technological characteristics	38.1	Development stage	33.3	Industrial characteristics	19.0	Regional characteristics	9.5	Others	0.0
	Subject	Well reflected	1.2	Reflected	32.6	Average	43.7	Not reflected	20.5	Not reflected at all	1.9
	(N=128)	Technological characteristics	44.5	Development stage	40.6	Industrial characteristics	9.4	Regional characteristics	3.9	Others	1.6
Current performance plan verification system	Evaluator	Highly desirable	3.6	Desirable	51.8	Average	35.5	Inappropriate	9.1	Highly inappropriate	0.0
	Subject	Highly desirable	6.5	Desirable	51.8	Average	27.4	Inappropriate	8.2	Highly inappropriate	0.5
Level of performance goals and index reflecting the characteristics of R&D activity and the cause of failure in reflecting	Evaluator	Well reflected	1.8	Reflected	38.2	Average	45.5	Not reflected	14.5	Not reflected all	0.0
	(N=16)	Verification method	50.0	Verifier's Expertise	31.3	Verification period	6.3	External environment	0.0	Others	12.5
	Subject	Well reflected	3.7	Reflected	47.5	Average	38.4	Not reflected	9.6	Not reflected all	0.7
	(N=59)	Verification method	40.7	Verifier's Expertise	37.3	Verification period	11.9	External environment	5.1	Others	5.1

Table 9 Recognition Regarding Utilization of the Evaluation Result

Questions	Subject	Responses									
		Item1		Item 2		Item 3		Item 4		Item 5	
Level of researcher's utilization of evaluation result	Evaluator	Highly used	4.5	Used	21.8	Average	50.0	Not used	18.2	Not used at all	5.5
Reliability of evaluation result	Evaluator	Very high	2.7	High	26.4	Average	52.7	Low	13.6	Very Low	4.5
Fairness of evaluation result	Evaluator	Very high	4.5	High	28.2	Average	46.4	Low	16.4	Very Low	4.5
Level of internal use and utilization details of evaluation results	Subject	Highly used	4.7	Used	44.0	Average	34.0	Not used	19.6	Not used at all	2.3
	(N=251)	Program planning	65.3	Individual evaluation	21.9	Incentive	10.8	Following year's salary	1.2	Others	0.8
Opinion on associating evaluation results to the following year's budget	Evaluator	Highly agreed	6.4	Agreed	40.9	Average	33.6	Not agreed	19.1	Not agreed at all	0.0
	Subject	Highly agreed	6.8	Agreed	51.4	Average	30.2	Not agreed	10.7	Not agreed at all	0.9
Experiences of different results according to the host of evaluation and the cause	Subject	Positive	51.2	Negative	15.1	N/A	33.7	-	-	-	-
	(N=292)	Evaluation counselor	71.6	Evaluation method	18.2	Performance planning	8.9	Others	1.0	-	-
Experiences of different results despite similarities with previous year's data and the cause	Subject	Positive	31.4	Negative	28.8	N/A	39.8	-	-	-	-
	(N=179)	Consistency	82.1	Other conditions	11.7	Performance planning	6.1	-	-	-	-
Experiences of different results according to the host of evaluation and the cause	Evaluator	Positive	55.5	Negative	24.5	N/A	N/A	-	-	-	-
	(N=61)	Evaluation counselor	77.0	Performance planning	14.8	Other conditions	6.6	Others	1.6	-	-

percentage that did not using was still high.

The question on the reliability of the evaluation result for the evaluators showed the following order: 'average' (50.0%); 'reliable' (29.1%), and 'not reliable' (18.1%). In regards to fairness, results were in the order of average (46.4%), fair (32.7%) and not fair (20.9%),illustrating the general recognition that there is no problem in reliability and fairness.

Results for the question on the level of internal use of the evaluation result were in the following order: used (44.0%), average (34.0%) and not used (21.9%). The 251 respondents who used the result responded in the order of program planning (65.3%), individual evaluation (21.9%), and incentive (10.8%).

For opinions on associating the evaluation result on the budget, a majority of the respondents (47.3%, 58.2%) agreed on the idea, with average (33.6%, 30.2%), and negative opinion (19.1%, 11.6) following next.

Results of responses to experiences of different evaluation results according to the host of evaluation showed that 51.2% of the subjects had the experience and 71.6% chose lack of expertise and fairness of the evaluation counselor as the cause, revealing that reliability of the evaluation result was low. Similarly, about the experience of achieving different results even though it is similar to the evaluation data of the previous year, many respondents (55.5%, 31.4%) had the experience and chose lack of consistency (77.0%, 82.1%) as a cause, which also shows low level of reliability.

When a question about the experiences of different results according to the evaluation host was asked to the evaluator, 55.5% answered positive and also pointed out a lack of consistency.

3.3.5 Recognition of the Evaluation Council (Table 10)

On the question "which is more important between the expertise and fairness of the evaluation counselors," the answer, "expertise is more important" (50.0%, 48.2%) was highest, "fairness is more important" (37.3%, 39.6%) came next, and "the same" (12.7%, 12.1%) trailed behind. Both parties found expertise more important than fairness.

Regarding the expertise of the evaluation counselor, 'average' (47.3%, 42.5%) was the highest, 'high level of expertise' was next (34.5%, 38.2%), and 'low level of expertise' (18.2%, 19.3%) came last. Also, the respondents who chose low level of expertise were asked to identify the cause. Evaluators responded as follows: lack of experience (45.0%); lack of understanding (20.0%) and standards of choosing professionals (15.0%). For the subjects, the response, "lack of experience in related fields and standard of choosing professionals" was the highest at 36.4%, non-specialized area was next (16.4%), and lack of understanding the data (8.2%) followed next, showing difference in perspectives among personnel beyond mere lack of experience.

As for fairness of evaluation counselor, the answer 'average' (57.3%, 43.5%) was the highest; 'high' (30. 0%, 43.5%), and 'low' (12.7%, 20.5%) followed next, which illustrates the judgment that there is no significant problems in fairness. Also, among the respondents (14 evaluators, 117 subjects) who chose 'low in fairness,' the majority of respondents chose 'absence of systems' (50.0%), and 'lack of qualification' (both 29.9%), school ties (29.1%), and regionalism (5.1%), revealing showing differences in perspectives.

3.3.6 Improving the Performance Evaluation System

3.3.6.1 Recognition of Improving the Evaluation System (Table 11)

Table 10 Recognition of the Evaluation Counsel

Questions	Subject	Responses									
		Item1		Item 2		Item 3		Item 4		Item 5	
Important element between 'expertise' and 'fairness' of the evaluation counselor	Evaluator	Expertise	50.0	Fairness	37.3	-	-	-	-	-	-
	Subject	Expertise	48.2	Fairness	39.6	-	-	-	-	-	-
Level of expertise of evaluation counselor and cause of low level of expertise	Evaluator	Very high	3.6	High	30.9	Average	47.3	Low	17.3	Very low	0.9
	(N=20)	Lack of experience	45.0	Standard of choice	15.0	Non-specialized	10.0	Lack of understanding	20.0	Others	10.0
	Subject	Very high	4.0	High	34.2	Average	42.5	Low	16.5	Very low	2.8
	(N=110)	Lack of experience	36.4	Standard of choice	36.4	Non-specialized	16.4	Lack of understanding	8.2	Others	2.7
Level of fairness of evaluation counselor and cause of low fairness	Evaluator	Very high	3.6	High	26.4	Average	57.3	Low	11.8	Very low	0.9
	(N=14)	Qualification	14.3	Absence of systems	50.0	School ties	14.3	Regionalism	7.1	Others	14.3
	Subject	Very high	4.2	High	31.8	Average	43.5	Low	17.5	Very low	3.0
	(N=117)	Qualification	29.9	Absence of systems	29.9	School ties	29.1	Regionalism	5.1	Others	6.0

Table 11 Recognition on Improving the Evaluation System

Questions	Subject	Responses									
		Item1		Item 2		Item 3		Item 4		Item 5	
Most important element regarding improving the evaluation system (multiple choice)	Evaluator	Alleviating the pressures on materials	97.3	Merging similar evaluations	70.9	Reducing the number of evaluations	83.6	Shortening of evaluation periods	41.8	Others	6.4
	Subject	Alleviating the pressures on materials	89.1	Merging similar evaluations	81.8	Reducing the number of evaluations	76.7	Shortening of evaluation periods	45.4	Others	6.3
Level of helpfulness of triennial evaluation system for alleviating evaluation pressures	Evaluator	Very helpful	29.1	Helpful	45.5	Average	18.2	Not helpful	4.5	Not helpful at all	2.7
	Subject	Very helpful	27.0	Helpful	51.9	Average	13.7	Not helpful	6.7	Not helpful at all	0.7

As for improvement of evaluation systems, respondents regarded reduction of submission burdens (97.3%, 89.1%) most importantly, and evaluators responded in the order of reduction of the number of evaluations (83.6%) and merging similar evaluation programs (70.9%); whereas the subject chose merging similar evaluation programs (81.8%), reduction of the number of evaluation (76.7%), and shortening of period (45.4%) which showed that they found alleviating the pressures in submitting data was important.

On the question whether to revise the evaluation cycle from one year to three years, the answer that it is helpful (74.6% of evaluators, 78.9% of subjects) was highest.

3.3.6-2 Evaluator Inquiries on Improving Evaluation Systems (Table 12)

The result of investigating opinions on improving current evaluation systems among the evaluators indicated that the voices that require ‘evaluations according to program characteristics’ (15.4%) was highest. Other answers included ‘diversification of evaluation methods’ (9.1%), ‘requires concrete evaluations’ (3.6%), and ‘index development through grouping’ (2.7%). In sum, rather than have a unified system of evaluation with identical standards, it is better to diversify the evaluation methods by taking diverse environments, i.e. type, process, period and size, into consideration since the subject of evaluation has diverse characteristics according to program, task and institution. Meanwhile, merging needs to enable the absorption of unique characteristics of individual evaluation subjects with a conception that the evaluation by its program characteristics is a trade-off to the merging of evaluation systems or utilization of comprehensive data.

Moreover, responses related to alleviating evaluation pressures totalled 15.4%, including merging of identical/similar evaluations (7.3%), simplification of evaluations (4.5%), and improvement of evaluation cycles (3.6%). In contrast, a minority opinion (2.7%) was concerned about the side effects of triennial evaluations that could actually aggrevate the burden.

Next, 14.5% of the respondents demanded assurance of expertise during evaluation, indicating a demand for reinforcing the reliability of evaluation results. On

Table 12 Evaluator Inquiries on Improving Evaluation Systems (For Evaluators)

Majority Responses (%)			
Evaluations according to program characteristics	15.4	Reinforcement of consulting function	3.6
Alleviation of evaluation pressures	15.4	Insurance of evaluation fairness	2.7
Insurance of evaluation expertise	14.5	Providing benefits by evaluation results	2.7
Merging of identical/similar evaluation systems	7.3	Concerns on triennial evaluations	2.7

the other hand, only 2.7% sought greater fairness, indicating a higher overall demand for expertise over fairness.

3.3.6.3 Evaluation Subject Inquiries on Improving the Evaluation System (Table 13)

The results from an examination of the opinions of 570 subjects showed substantial differences from those of the evaluators. First, the respondents who demanded 'ensuring expertise of the evaluation' were highest (19.3%). Insurance of evaluation fairness followed next (18.4%), showing the desperate need for improvement in both expertise and fairness. The demand for enhancement of expertise was higher than the need for fairness, a matter that is directly associated with the reliability of evaluation results. This could stem from the uncertainty regarding the level of expertise among evaluators due to the characteristics of the research institution recognized as a group of experts in the specific research area.

The answers – simplification of evaluations (10.0%), improvement of evaluation cycle (3.2%), and merging of identical/similar systems (2.5%) – followed, showing concerns on evaluation burdens. Then there were the demands for satisfying the diversity of evaluation subjects– diversification of evaluation methods (6.0%); and detailed evaluation (3.2%). This is different from the responses of the evaluators, who presented higher demands for diversification of evaluation methods. It appears that the subjects found the reduction of evaluation pressure to be more urgent Other opinions included satisfaction with the current evaluation system (4.0%). The cause of this response could have derived from the fact that the evaluation pressure is actually aggravated due to the lack of consistency and change of detailed directions, although improvement evaluation systems is taking place annually.

4. Implications for Developmental Settlement of Performance-Based Evaluation Systems

We have looked at the current status of evaluation systems through analysis and reference reviews of National R&D Program evaluation systems, composed issues from experiences as a questionnaire, and investigated and analyzed the status of recognition of evaluators and evaluation subjects. Through this process, it was possible to grasp the level of recognition of concerned parties as well as the current status of evaluation systems on National R&D Programs. This chapter is intended to derive political implications and methods of improvement to be referenced in future system revisions through comprehensive analysis of questionnaire results.

4.1 Political Implications on National R&D Program Evaluation Systems

4.1.1 Necessity of Improving Self and Meta Evaluation Systems

In contrast to the evaluators, 60.5% of the subjects imparted more importance on task evaluations than program evaluations. On the other hand, both parties chose program evaluations as the most pressured evaluation system. Subsequently, the subjects recognized the self and meta evaluation systems as highly pressured with a low level of importance.

This might have caused by the problem of where the responsibility lies since the result of program evaluation is directly considered as the evaluations

Table 13 Evaluation Subject Inquires on Improving the Evaluation System (For evaluation subjects)

Majority Responses (%)			
Assurance of evaluation expertise	19.3	Satisfied with current evaluation systems	4.0
Assurance of evaluation fairness	18.4	Unification of evaluation standards	1.9
Alleviation of evaluation pressures	15.7	Selection of evaluation counselor through establishment of a evaluation counselor pool	2.7
Evaluations according to the program characteristics	9.2	Providing incentives according to evaluation results	1.1

on personnel in charge of the department; whereas, the task evaluation directly affects the personnel in charge of the research. Moreover, the fact that the result of evaluation on the program is biased toward performance evaluation and fails to provide necessary information to the parties that conduct particular research tasks could be another factor.

However, it is necessary to enhance the level of recognition on the program evaluation through active promotion in the future. This is because the program is a R&D management unit on the national level, and at the same time, a means of policy execution and the feedback on evaluation results has significant impact on the program unit, not to mention the task unit

Furthermore, there are cases of repeated submission of data since the meta evaluation takes place as a format to re-review the self-evaluated programs. This is because the meta evaluation is conduced as a form to revaluating self-evaluation results. Thus, it is necessary to devise a plan to improve systems for more effective evaluations since this could bring disputes regarding redundancy in evaluation.

4.1.2 Need for preparing plans to alleviate pressures in writing evaluation materials

A large number of personnel who felt pressured answered that the recording of evaluation data and writing the report were the most burdensome. Moreover, the average time consumed in writing the evaluation was 15.1 days for the evaluators and 12.5 days for the subjects, showing that a large amount of time is spent in writing evaluations. By simple calculation, it means that if a person were evaluated twice a year, the person would consume approximately one month per year in writing the evaluation, which could impede research. Moreover, the subjects felt that the similarity in content but disparity in formats added to of the perception of redundancy.

Although written evaluations are unavoidable, avoiding redundancy is desirable. For this, determining a similar constituent among evaluation systems through analysis and investigation is required. If at all possible, developing standardized formats for similar data and minimizing repeated writing through shared data should be undertaken.

Dissertations, patents and technology transfers are representative of repeated and similar data. As of now, the performance information created by each research host is managed comprehensively and shared through NTIS. There lie the limitations in which the subject of sharing is limited to only some performances and it is utilized only in self and meta evaluations without any particular regulators. Therefore, expanding scope of sharing in the future and preparing related regulations is necessary.

4.1.3 Necessity of establishing evaluation systems for each program type to reinforce expertise in evaluation systems

The majority of the respondents answered that evaluation systems reflect research characteristics; whereas, 19.1% of evaluators and 22.4% of the subjects still feel they are insufficient. Moreover, both the evaluators and subject found expertise is more important than the fairness in evaluation. Considering this result, reinforcing evaluation expertise to reflect characteristics of the program in current evaluation systems is essential.

As the evaluation system is improved in the direction of reinforcing qualitative evaluations, more customized and consulting type evaluations are being carried out. For this, the portion of quantitative evaluations has increased recently; whereas, the qualitative evaluation elements which enables customized evaluation is decreasing. However, to reinforce professionalism in the program evaluation, development and introduction of qualitative evaluation elements is required to integrate the quantitative and qualitative evaluations of the experts.

Currently, the evaluation result is derived by calculating the relative ranking to the overall programs. This underlies the risk of inhibiting the individuality of each program. Thus, systematic improvement must take place to complement the relative evaluation systems of today. For instance, categorizing similar programs and drawing relative rankings within those rather than comparing them with entire programs can be considered. There is a good example which similar programs are grouped into one program group in in-depth evaluations.

On the other hand, in-depth evaluations are conducted by developing specialized performance creation logical models, and comprehending and analyzing the performance in depth. Doing so could contribute to enhancing evaluation professionalism that does not discern program characteristics. Nonetheless, since in-depth evaluation involves enormous time and cost as well ashuman and research resources, it to putting more effort in expanding those gradually is necessary.

4.1.4 Enhancement of Evaluation Results Utilization

Although the majority of the respondents utilized the evaluation result internally, more than 20% of the respondents answered that they do not utilize the results. Considering that the current 'Law on Performance Evaluation' stipulates arbitration and allotment of program budgets, amendment and supplementation of program promotion plans, improvement of researcher's employment conditions and research environment, and rewards on outstanding outcomes, the level of result utilization is still very low.

When divided into internal and external use, in terms of external use, it is used effectively by the government where budgets are concerned such as increasing or decreasing the budgets according to the results of the self and meta evaluation; while the use inside each department and project groups largely stays at mere reformation of criticized elements, apart from active utilization concerning execution of program restructuring or coordination of research portfolio.

One of the main reasons behind the low level of utilization is that the focus of evaluation is concentrated on reflecting the results on budgets. As the Ministry of Strategy and Finance, the primary department authorizing national finances, executed the role of evaluation colligation, budgetary usage has been amalgamated but other parts has been stagnated or has not shown marked advances.

However, it is not pertinent to associate evaluation results directly with budgetary considerations in the case of programs with national gravity – development of original technology that requires long-term investment or green technology – and programs that should be perceived from comprehensive science technology – consolidation programs or next generation food creation programs. Rather than simply associating evaluation results with budgetary decisions, it is important to improve program structures or operations according to criticism or recommendations. Thus an effort should be taken by the department to submit particular execution planning according to the evaluation result and the colligating department to establish a monitoring and supervising system by establishing a system that coerces program restructuring according to evaluation results.

4.2 Differences in Recognition of Evaluators and Evaluation Subject (Table 14)

In this study, the questionnaire sheet was composed and questioned each party separately with the assumption that there would be difference in recognition between the parties as well as the current status of overall recognition. As a result, the respondents illustrated different opinions on 7 items from a total of 37 items (18.9%); however, generally, they appear to be similar.

The summary of areas of difference in recognition is as follows. First, for the question on the important system, subjects imposed more importance on task evaluation compared to the evaluators. For the question on the appropriate period of evaluation, evaluators chose the 2^{nd} quarter, while the subject chose the 1^{st} and 3^{rd} quarters. Also, the time consumed in writing evaluation materials was longer by 2.6 days on average for evaluators compared to subjects. On the question whether the method of evaluation reflects program characteristics, the evaluator responded positively, while the subjects responded with a response of average. For the cause of low level of expertise among evaluation counselors, the evaluators chose lack of experience; whereas, the subjects chose lack of experience and problems with the selection standard. For the reason of low level of fairness, the evaluator identified problems with the system, while the subject indicated problems

Table 14 Differences in Recognition of Evaluators and Evaluation Subject

Item	Evaluator	Evaluation Subject	Remarks
• Important evaluation	Task/self evaluation	Task evaluation	-
• Appropriate evaluation period	2nd quarter	1st and 3rd quarter	-
• Time consumed in preparing evaluation materials	15.1 days	12.5 days	-
• The level of reflection of program characteristics in the evaluation method	Reflected	Average	-
• Cause of low level of expertise of evaluation counselors	Lack of experience	Lack of experience and selection standard	-
• Cause of low level of fairness of evaluation counselors	Problems with evaluation systems	Evaluation systems and quality of evaluation counselors	-
• Urgent improvement request particulars	Specialization, alleviation of pressure, expertise	Expertise, fairness, alleviation of pressure	Short answer

with the system and qualifications which showed difference in their selection.

Lastly, for the short answer question on contents that requires urgent reformation of systems, the evaluator chose reflection of program characteristics, alleviation of evaluation pressures, and enhancement of expertise; whereas, the subject selected enhancement of evaluation expertise and fairness, and alleviation of evaluation pressures presenting difference in recognition.

The results of this study could be used as basic information to reference and utilize systemic improvement of National R&D Programs to settle performance-based evaluation systems in R&D program evaluation. It is expected that there will be a high value of utilization as basic information in understanding how the recognition of concerned parties are changing and in what direction it is flowing according to the reformation of systems when the transition process of recognition is investigated and analyzed regularly in the future.

Table 15 Main Reponses from the Questionnaire Result and Result of Statistic Significance Analysis

Class	Question	Subject	Main Responses (%)		Difference in Recognition	Statistics
R&D activities and government subsidized (RI) evaluation status	The most important evaluation	Evaluator	Task evaluation, Program evaluation	47.3, 44.5	None	χ^2=7.525*
		Subject	Task evaluation	60.5		
	The most burdensome evaluation	Evaluator	Program evaluation	60.9	None	χ^2=78.064***
		Subject	Program evaluation	46.5		
	Level of satisfaction on evaluation results	Evaluator	Satisfied	32.7	None	F=5.913*
		Subject	Satisfied	42.6		
	Experience of being subjected to multiple evaluations at the similar period	Subject	Yes	31.9	-	-
		(N=182)	4^{th} Quarter	46.2	-	-
	Appropriateness of current evaluation periods and the time	Evaluator	Inappropriate	21.8	None	F=3.52(n.s)
		Subject	Inappropriate	11.4		
		Evaluator(N=24)	2^{nd} Quarter	45.8	Quarterly difference	χ^2=8.934*
		Subject(N=65)	1^{st} ,3^{rd} Quarter	33.8 each		

Table 15 Main Reponses from the Questionnaire Result and Result of Statistic Significance Analysis (cont'd)

Class	Question	Subject	Main Responses (%)		Difference in Recognition	Statistics
R&D activities and government subsidized (RI) evaluation status	The evaluation system which the evaluation content is thought to be repeated	Evaluator	Task evaluation and Program evaluation	44.5	None	χ^2=23.244***
		Subject	Task evaluation and Program evaluation	43.3		
	Necessity of data sharing between evaluation programs	Evaluator	Necessary	73.6	-	-
	Method of data sharing between evaluation programs	Evaluator	Converting into a DB	44.4	-	-
	The degree of differences in contents of evaluation data among evaluation systems	Subject	Average	45.4	-	-
	The degree of differences in formats of evaluation data among evaluation systems	Subject	Average	42.6	-	-
Evaluation Pressure Factor	The degree of pressures of evaluation tasks on research tasks	Evaluator	Pressured	41.8	None	F=1.03(n.s)
		Subject	Pressured	47.4		
	The most pressured factors in conducting evaluations	Evaluator(N=46)	Various evaluation material	78.3	None	χ^2=10.900*
		Subject(N=270)	Various evaluation material	57.8		
	The time spent in writing evaluation and data	Evaluator	15.1 days (avg.)	100.0	3 days	-
	The time spent in writing evaluation and data	Subject	12.5days (avg.)	100.0		
Reflection of Research Characteristics	Level of evaluation methods in reflecting characteristics of R&D activities	Evaluator	Reflected	40.9	Reflected	F=0.988 (n.s)
		Subject	Average	43.7		
	Cause of failure of evaluation methods in reflecting characteristics of R&D activities	Evaluator(N=21)	R&D characteristics of each technology	38.1	None	-
		Subject(N=128)	R&D characteristics of each technology	44.5		
	Current performance plan verification system	Evaluator	Desirable	55.4	None	F=2.026 (n.s)
		Subject	Desirable	63.9		
	Level of performance goals and index reflecting the characteristics of R&D activity	Evaluator	Reflected	40.0	None	F=4.597 *
		Subject	Reflected	51.2		
	The cause of failure in reflecting the characteristics of R&D activity	Evaluator(N=16)	Inappropriate verification method	50.0	None	-
		Subject(N=59)	Inappropriate verification method	40.7		

Table 15 Main Reponses from the Questionnaire Result and Result of Statistic Significance Analysis (cont'd)

Class	Question	Subject	Main Responses (%)		Difference in Recognition	Statistics
Utilization of evaluation results	Level of researchers' utilization of evaluation results	Evaluator	Average	50.0	-	-
	Reliability of evaluation results	Evaluator	Average	52.7	-	-
	Fairness of evaluation results	Evaluator	Average	46.4	-	-
	Level of internal utilization of evaluation results	Subject	Used	44.0	-	-
	Contents of internal utilization of evaluation results	Subject(N=251)	Reflected on program plans	65.3	-	-
	Opinions on integrating evaluation results onto the budget of the following year	Evaluator	Positive	47.3	None	F=4.514 *
	Opinions on integrating evaluation results onto the budget of the following year	Subject	Positive	58.2		
	Experiences and causes on different evaluations results from different evaluation authorities	Subject	Yes	51.2	-	-
		Subject(N=292)	Problem of evaluation counselor	71.6		
	Experiences and causes on different results on the data similar to the previous year	Subject	Yes	31.4	-	-
		Subject(N=179)	Lack of consistency	82.1		
	Experiences and causes on different evaluations results from different evaluation authorities	Evaluator	Yes	55.5	-	-
		Evaluator(N=61)	Lack of consistency	77.0		
Evaluation Counsel	Important element between 'expertise' and 'fairness' of the evaluation counselor	Evaluator	Expertise	50.0	None	-
		Subject	Expertise	48.2		
	Expertise of evaluation counselors	Evaluator	average	47.3	None	F=0.015 (n.s)
		Subject	average	42.5		
	Cause of low level of expertise of evaluation counselors	Evaluator(N=20)	Lack of experience	45.0	Expert Selection	-
		Subject(N=110)	Lack of experience, expert selection standard	36.4 each		-
	Fairness of evaluation counselors	Evaluator	average	57.3	None	F=0.143 (n.s)
		Subject	average	43.5		
	Cause of low level of fairness of evaluation counselors	Evaluator (N=14)	Evaluation system	50.0	Qualification	-
		Subject(N=117)	Evaluation system, qualification	29.9 each		
Improving the Evaluation System	Most important element in regards to improving the evaluation system (multiple choice)	Evaluator	Alleviating the pressures on materials	97.3	None	-
		Subject	Alleviating the pressures on materials	89.1		
	Level of helpfulness of triennial evaluation system on alleviating evaluation pressures	Evaluator	Helpful	74.6	None	-
		Subject	Helpful	78.9		

n.s=non-significance, * p<.05, ** p<.01, *** p<0.001, N : Evaluator - 110, Subject - 570

4. Reference

1. National Science and Technology Council (NSTC) (1999), "Results of research, analysis and evaluation of Government R&D Program"
2. Ministry of Education, Science & Technology (MEST) (2005), "Research on examination, analysis and evaluation support for Government R&D program in 1999"
3. Ministry of Education, Science & Technology (MEST) (2005), "Law on evaluation and management of performances in Government R&D Program"
4. Seol, Sang-Su (2005), "National science and technology evaluation system establishment planning", Korea Institute of Science & Technology Evaluation and Planning (KISTEP)
5. Yang, Hee-Seung (2002), "Status of National R&D Programs (2002)", Korea Institute of Science & Technology Evaluation and Planning (KISTEP)
6. Oh, Dong Hoon; Son, Byeong Ho, et al (2007), "Study on compilation of textbook on theories and practical aspects of evaluation of R&D Program", Korea Institute of Science & Technology Evaluation and Planning (KISTEP)
7. Oh, Dong Hoon (2006), "Study on establishment of National R&D Evaluation System", Korea Institute of Science & Technology Evaluation and Planning (KISTEP)
8. Lee, Ki-Jong; Hwang, Deok-Gyu; Kim, Seong-Jin; Kim, Seung-Tai (2008), "Exploratory study on enhancement of efficiency of evaluation system for R&D performances – with focus on examination of recognition of researchers on evaluation system", 2008 Autumn Seminar of Korea Technology Innovation Society
9. Lee, Sang-Yeop; Jeong, Geun-Ha (2007), "Study on deduction and analysis of issues for efficient evaluation of Government R&D Program", Korea Institute of Science & Technology Evaluation and Planning (KISTEP)
10. Lee, Chan-Gu (2009), "Empirical analysis of evaluation of research institutes: with focus on the differences in the recognition of the participants in evaluation", Journal of Korea Technology Innovation Society, Volume 12, No. 1, pp.36~69
11. Lee, Chan-Gu (2008), "Study on the analysis of differences in and integrated goals of evaluation of government subsidized research institutions"
12. Lee, Hyung-Hu (2005), "Analysis on evaluation systems on National R&D Programs", Korean Association for Policy Studies, pp. 541-565
13. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2001), "Investigation, analysis, and evaluation result of 2001 National R&D Programs", National Science and Technology Council (NSTC)
14. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2004), "Investigation, analysis, and preliminary arbitration result of 2004 National R&D Programs", National Science and Technology Council (NSTC)
15. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2005), "Investigation, analysis, and evaluation result of 2005 National R&D Programs: Evaluation" National Science and Technology Council (NSTC)
16. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2006), "Basic plan for evaluation of R&D performances, and basic plan for management and utilization of research performances", National Science and Technology Council (NSTC)
17. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2008), "Basic Science & Technology Basic Plan towards becoming a global leader - 577 Initiative", Ministry of Strategy & Finance (MOSF), Ministry of Education, Science & Technology (MEST) and Ministry of Education & Science Technology, et al
18. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2009), "2009 Comprehensive guideline for National R&D Programs"
19. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2009), "2009 National R&D Program Meta Evaluation Plans", Ministry of Strategy & Finance (MOSF)
20. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2009), "2009 Performance Evaluation Execution Plan", Korea Institute of Science & Technology Evaluation and Planning (KISTEP).
21. Korea Institute of Science & Technology Evaluation and Planning (KISTEP). (2009), "2009 National R&D Program Self Evaluation Manual", Ministry of Strategy & Finance (MOSF)
22. National Technical Information Service (NTIS): http://www.ntis.go.kr

Book Reviews

Program Evaluation and Performance Measurement: An Introduction to Practice, James C. McDavid & Laura R. L. Hawthorn, SAGE Publications, Inc (2006), 496 pages, ISBN: 9781412906685

This book deals with the theories and practices of evaluation. It extensively covers useful information on concepts and methodologies that are actually demanded of in carrying out evaluation and performance measurement of programs in public sector, and it is expected to play the role of textbook or guideline for the readers. For these reasons, this review examines contents of the book without stepping out of the boundaries of marring the essence of the contents.

This book, compose of total of 12 Chapters, begins with comprehensive consolidation of concepts and issues that will be the requisites in understanding the theme to be dealt with later, and continues on with discussions on individual themes.: key concepts and issues in program evaluation and performance measurement, understanding and applying program logic models, research designs for program evaluation, measurement in program evaluation, applying qualitative evaluation methods, assessing the need for programs, concepts and issues in economic evaluation, performance measurement as an approach to evaluation, design and implementation of performance measurement systems, using and sustaining performance measurement systems, program evaluation and management: joining theory and practice, and the nature and practice of professional judgment in program evaluation.

Although conclusions are not deduced comprehensively, it was possible to verify the directionality asserted by the authors in the process of their deployment. The following is the summary of this:

- Selective application of quantitative and qualitative analysis methods
- Maintenance of understanding and balance on the political practices of an organization
- Integration of performance measurement and evaluation practice
- Development of sound professional judgment

Logic Model categorizes and explains the causal linkages of program. This is essential in program evaluation.

The program is in open-systems, that is, it is in interactive relationship with its environment. Logic model visually represents[1] the program in such open-systems. It illustrates how the resources of the program has been converted into activities and intended results. It is possible to categorize the program and identify it with the external environment by disclosing the causal linkages of its construct through this. Categories presented here are as follows: inputs, components, implementation objectives, and outcomes.

Logic model is essential in program evaluation. Logic model that relies on the qualitative research method is an important foundation in understanding whether effectiveness of program exists or how it is produced, and it is also very useful in developing performance measurement system for monitoring of program outputs and outcomes. However, one must bear in mind that the logic model cannot contain all the aspects of the program in detail.

Process of visual representation of program in logic model is iterative and combines with various other activities. In such process, the relationship with the

1) From such meaning, it has been disclosed that utilization of flow charts is also effective, which is in complementary relationship with logic model.

organizational goal is an important issue. Since the organization ecologically pursues behavioral goals – for example, putting priority on the survival of the organization – it may not coincide with normative goals, and, eventually, they could be conflict between the program goals and behavioral goals. In addition, there is time-limitation due to environmental changes in the program. For these reasons, efforts to structuralize the performance measurement system are being emphasized.

Experimental design is main tool in research design and the linkage with program logic model is important.

The key to evaluation is judging whether the program was effective. Therefore, research design must be able to examine the linkage with outcomes related to program.

There is need to pay attention to statistical validity, internal validity, construct validity and external validity that Cook & Campbell presented. These eventually results in the issue of variable and generalization. Research design must focus on constructing and completing evaluation that can be trusted, and experimental design is seen as a main tool - randomized experimental design and quasi-experimental design.

Examination method that can exclude other factors that can impart influence on causal linkages at program evaluation must be chosen. Research design plays important role in segregating such causal linkages, and the linkage with program logic model is required. However, research design that examines all the causal linkages within the logic model requires enormous resources and has limitations on control. These limitations mean that other observations and professional judgment other than the evidences can be considered together. There is need for evaluator to definitively assess particularly the logic and conditions of experimental design.

Focus on verification of measurement validity in the process of measurement.

Measurement is defined as the process of translating constructs into procedures for data collection. Again, the constructs are manifested as the levels of measurement by being translated into variables via the measurement procedures – at the levels of nominal, ordinal, and interval/ratio. Here, the measurement procedures act very importantly because variables rely on them and because they affect the reliability of variables.

Validity of measurement is important in deciding whether the program evaluation and performance measurement system are appropriate. The validity is required in measurement method for program constructs, in selection of variables to measure constructs, and in relationship with other variables.

Much care must be exercised in selection and usage of data in measurement. When the management of outputs is the main concern, it is not easy to directly collect outcome related data, and proxy measurement that employs outputs as proxies also could be problematical in that it entails assumptions. In addition, there is a tendency to rely on already existing data in performance measurement system. Therefore, there is a need to focus on verification of validity of the measurement data and utilization of surveys as a key means of measurement.

Qualitative method based on constructive paradigm is an effective means of describing and conveying the results.

Qualitative method, unlike quantitative method, pursues things other than positivist approach method. The underlying base for this is the so called constructive paradigm that emphasizes the sense-making of human beings. Although debates on paradigm is continuing, methodological pluralism could be the current solution.

Although both methods is being used complementarily in evaluation regardless of whether which one is used ahead of the other, their differences are clearly distinguished. Qualitative method that pursues the things that are naturalistic is focused on seeking the answer to how social experiences are created and accepted as being meaningful. Qualitative method within the limitation of data utilization provides realizable and effective method in describing and conveying results.

Evaluator can construct conceptual frameworks that can lead evaluation. Credibility and generalizability of findings are the key tasks in executing this. Comparative measurement with other data and verification of coincidence through feedback from other provider are the means of enhancing the credibility and generalization.

How is qualitative method linked with performance measurement? Although the performance measurement has the tendency of relying on quantitative method, format in which stories on the performances is additionally verified is employed. Using cases and qualitative evidence can render findings more credible and useful. But precautions are required in order to be methodologically defensible as well as being persuasive.

In needs assessment for program, benchmarking through comparison is emphasized.

Needs assessment is one of core areas in the public sector. It can be carried out in diverse range of domains in the performance management cycle, and the needs here can be variable in reflecting our values and as support for particular programs and policies. That is, reflecting of needs onto program or policy presents the problem of having to accompany political choice. The concept of needs in our society has been changing and there are differences in the concepts of public needs. Such differences may arise from the insufficiency in the resources needed in describing problems.

Comparison concept is reflected onto all needs assessments. This signifies the comparison for measurement of scope and types of needs, and benchmarking is emphasized as the standard for measurement. The subjects of benchmarking are diverse. All the theories, models, frameworks, ethical values, service providers, and current and prospective clients can be the subjects.

Because the needs assessment, which is completed through various stages, can be contentious, format that can be methodologically defensible must be chosen. Survey is used frequently in order to obtain information from the current and prospective clients. Design and implementation of survey requires caution in extracting issues. Bias in the responses is assessed as a significant problem. This can be mitigated through careful survey design and triangulation of survey results with other sources.

Economic evaluation requires caution on the validity of the assumptions and its need will continually increase.

Economic evaluation is based on the principles of welfare economics that consider the benefits and costs from societal perspectives. In general, cost-effectiveness analysis and cost-utility analysis are executed rather than cost-benefit analysis because it is difficult to convert the outcomes in the public sector into monetary values, and it can be obtained by focusing on finding the answer to how to accomplish the chosen outcomes.

These analytical methods have powerful appeal to the evaluators and policy decision makers because the most rational choice can be sought in providing information necessary in allocation of resources and decision-making particularly through decision-making on profitability (bottom line) by comparison of alternatives. There are limitations to be overcome here. Evaluation of the costs and practical benefits of a program is a difficult task. Since these in general cannot be evaluated directly, thereby frequently requiring assumptions and the validity problem of the assumptions may be presented.

In economic evaluation, the issue at hand is whether it is possible to predict the actual outcomes of program and policy alternatives being compared. In order for the outcomes of program to be measured or computed easily, certain program technologies[2] are necessary, and precautions are required in understanding the actual causal linkages and in validly measuring the inputs and outcomes.

Along with growing costs and demands for services, proving the expenditure in the public sector is being emphasized. Accordingly, the need for economic evaluation is also increasing. However, the quality of the studies thus far is evaluated to be insufficient.

2) It is defined as means-ends relationships that are used in programs to accomplish the program objectives.

Performance measurement requires approach from the viewpoint of new public management.

Historically, the performance measurement has been connected with the financial accountability. As the interest in the efficiency of public sector increased, the importance of performance measurement has also been receiving highlights. Succession of numerous cases - Programmed Planed Budget System(PPBS), Management By Objective(MBO), Zero-Based Budgeting(ZBB) – are a part of these procedures and is based on the cognizance that it is desirable to put focus on the results in performance measurement system.

In the 70's and the 80's, people became aware of the importance of balance of budget due to enormous financial losses and inflation they have experienced, and people, as tax-payers changed their viewpoints on the resources inputs in the public sector[3)]. Such situations brought about changes in the viewpoints and realities on the management of public sector, which were expressed through emphasizing of downsizing, reduction of red tapes, efficiency and effectiveness.

Such concept of New Public Management exists as the governing concept in designing, execution and operation of government programs and services, and reflects the key metaphors of the public sector for performance measurement. That is, business-like practices are emphasized for the government, organizations are recognized from the perspectives of open-systems in which they biologically interact with the surrounding environment and assessed as machines consisted of complex systems.

Performance measurement being accomplished on such foundation exists as a part of performance management cycle along with program evaluation. These are mutually complementary in acquiring and analyzing intended information in order to reduce the uncertainty in program and policy decisions.

Key factors in elevating the possibility of success of performance measurement system – sustained leadership, communications, clear expectations for the system, sufficient resources, logic model and measurement process.

With generalization of performance measurement on public sector, the sustainability of performance measurement system has become an important issue. The key factors in elevating the possibility of success in designing and implementing the performance measurement is presented below.

1) Sustained leadership. In particular, in the case of performance measurement at the government level, leadership is required at the 2 levels, namely high level officials of the departments who were appointed and the officials who were elected as the end users. 2) Communications. This increases the common understanding and participation on the performance measurement process. Diverse range of benefits of the multi-channel such as top-down, bottom-up and horizontal sharing of information must be sought after. 3) Clear expectations for the system. In general, performance measurement aims to improve program through provision of information on managers. Therefore, there is a need to be open and honest about the purposes in order for stakeholders and problems to be dealt with properly. 4) Sufficient resources. Under the situation of limitations on resources, performance measurement resources of other programs must be utilized assertively. 5) Logic model. This identifies the key programs and organizational constructs. Its process is important in choice of the constructs and performance measurement. 6) Measurement process. Valid measures that can entice the confidence of stakeholders must be produced.

Fulfillment of the presented criteria does not guarantee the success of definitive performance measurement. Performance measurement is also a craft and has considerable room for creativity and professional judgment.

Consider rational/technical factors as well as political/cultural factors, and reduce the possibility of gaming on performance measurement.

Although the performance measurement model is based on rational and technical processes, in reality, considerations for all political and cultural factors within the organization are required.

Performance measurement has always been at

3) Institutionally, the Proposition 13 in California in 1978 is considered as its starting point in the United States.

the center of the process of conversion into result-based performance management - The Government Performance and Results Act (GPRA), Program Assessment Rating Tool (PART), etc. As the value of performance measurement for budgetary and resource allocation is increasing, improving accountability for the program has become as important as the efficiency and effectiveness. However, there are several problems and issues in securing this. Among these, the complicated accountability and gaming on the performance measurement are situated at the center.

Under the democratic culture, there are two types of accountability model, namely, the hierarchical accountability and accountability of result. However, such accountability must consider the organic functions with other public organizations and private sector organizations as partners in accordance with complexity of accountability relationships, that is, dispersion of the accountability.

Performance is on target and gaming occurs when there are effects linked with this. Gaming that exists in the organizational life imparts influence on the validity of performance information and the behaviors of organizational participants (individual influence including managers and government official). Efforts are required to reduce such gaming. Multiple measures, each with its own validity and reliability profile can be means of reducing focal point on the gaming behaviors.

Cooperative combination with evaluation and management. Establish learning organization and develop professional judgment.

The purposes of evaluation impart influence on relationships between evaluators and managers. Formative evaluation focused on providing program-improvement information is recognized as being friendly to the managers, and enables win-win strategy between the two. On the other hand, the summative evaluation is quite different from above as it in general determines the future of programs. Therefore, ability to evaluate with considerations for both the rational/technical perspectives and political/cultural perspectives is important.

It is believed that the best evaluation can be made through cooperative combination with management rather than considering evaluation as an activity against management. Having evaluation as an external function can be an alternative in solving political problems from the perspective of the organization. In spite of this, the internal evaluation is a dominant execution method in public sector. However, the securing of reliability must be presumed.

Here, learning organization based on self-evaluation is emphasized. As the key methods, double-loop learning, that is, learning how to learn, and empowerment evaluation are presented. The former signifies behavioral correction to attain objectives and learning to assess the appropriateness of them, while the latter signifies that managers improve practice and foster self-determinant through evaluating their own programs.

How should the relationship between the evaluators and managers be formed? Excessive approach to the managers can hinder the objectivity of the evaluation process. In particular, it is more so for the objectivity of evaluation findings and conclusions. The objectivity coincides with the repeatability through repetition. However, in reality, repetitive evaluation itself is not easy. Evaluation is a craft that combines methods and artistry, and professional judgment is important. Stakeholders must acquire confidence through securing of ethical value system, honesty, accuracy, fairness, impartiality, competence, high skill and credibility.

Professional judgment has integrated meaning in evaluation practice.

Professional judgment has integrated meaning in evaluation practice. It acts on overall aspects of evaluation ranging from evaluation questions, research design, conduct, information analysis and interpretation to conveyance of results. There is no methodology in evaluation without room for dispute. In addition, the practice of the evaluation is more diverse than normative approaches. Findings, conclusions and recommendations based on evidences and professional judgment can reduce the uncertainties in evaluation questions and relevant information. Such judgment is required not only of the evaluators but also of the managers.

Professional judgment can be categorized into technical judgment, procedural judgment, reflective judgment and deliberative judgment proposed by Fisher & Cole. Evaluator's values, beliefs and expectations create experiences by combining with shareable and practical knowledge, and such experiences form the professional judgment that influences the decision. Here, external environment is also a factor in determining the judgment.

To evaluate is to make judgment. It is possible to develop sound professional judgment through reflection on one's practice. This is based on evaluation competencies, that is, the professionalism, and implies core body of knowledge. However, the balancing is needed in application of theoretical knowledge and practical know-how. One's experience is essential in completely integrating the impersonal knowledge into professional knowledge by combining with tacit knowledge. Professional judgment substantially depends on developing and practicing evaluation craft. Training aimed at understanding their roles and stages of formation, and conscious development of such are needed on the basis of awareness of its importance.

In conclusion of the review

This book is meaningful in further progressing the theories and practices in the evaluation area, and contains notable assertions and grounds for argument. In particular, it is possible to see that the authors approached with interest in grafting the theories onto the realities, which appears to the reflection of knowledge experienced by the both authors in theory and practice.

Their assertions are based on numerous preceding researches and evaluation cases. Nonetheless, it can be seen that they are putting more weight on the practice than on the evaluation theories. Although they are presenting the importance of the issues that can arise in evaluation practices, in particular, political views and professional judgment, they leave the key judgment to the readers. In developing the contents, there were some confusion in dealing with the programs, policies and organizations. This could perhaps be understood as the limitations in comprehensively dealing with the government and public sector.

I feel that readers who are wishing to or is already working in the area of evaluation or performance measurement would be able to acquire indirect experiences through this book. I have no doubt that this book will be helpful in recognizing and establishment of judgment that can cope with political issues that one would confront ceaselessly throughout the process of evaluation from research design to selecting methodology, executing evaluation and deduction of results.

Under the reality in which discussions and debates on the reinforcement of accountability associated budget along with expansion of program, I hope that readers would be able to acquire more prudent interest and intellectual stimulation on evaluation and performance measurement.

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Scenario Planning: The Link Between Future and Strategy, Mats Lindgren & Hans Bandhold, Palgrave Macmillan (2003), 240 pages, ISBN: 9780333993170

Ten years have passed since the onset of the new millennium. Complexity and uncertainty of factors that impart influence on economic environment are further increasing as evidenced by the two economic downturns we have experienced in the new millennium. Countries throughout the world including enterprises are concentrating much efforts in scenario-based[1] strategic foresight that describes diverse range of images of future society and establishes strategies to cope with such environmental changes. Recently, Korea carried out scenario-based strategic foresight on renewable energy and energy efficiency in addition to Delphi-oriented forecasting.

As the interest in scenario is increasing, publication of literatures that introduce this is also becoming quite active. The standard of the books is highly diversified ranging from popular simple introduction to those with philosophical depth that are difficult to understand unless the reader is a specialist in the relevant area.

"The Art of the Long View" by Peter Schwartz, a globally renowned scholar on the future, is a leading introductory work on scenario planning[2]. The book emphasizes that scenario is an excellent tool to provide a long-term framework for perspective in the world of uncertainties. It offers insight through which those living with uncertain future can peak into the future by presenting history of scenario, his personal experiences and many examples. However, for the foresight practitioners, this book lacks somewhat in its application due to insufficient consolidation of the specific processes.

"Creating Futures, Scenario Planning as a Strategic Management Tool" by Michael Godet is also a good book that introduces scenario planning. It contains quantitative methodologies based on the system analysis that he and his fellow workers developed as well as many cases. This book offers new perspectives to readers who are familiar with intuition-oriented qualitative scenario planning. However, explanations on foresight that contains philosophical depth and wide range of analytical models such as morphological analysis are difficult for general readers to understand.

I strongly recommend readers who are interested in scenario to read "The Scenario Planning Handbook" by Bill Ralston and Ian Wilson. In particular, this book would be quite helpful for the foresight practitioners. The author with experience of having worked at the SRI Consulting has explained the SRI scenario process for each step in detail. However, it is not appropriate to enable readers who are introduced to scenario for the first time to understand the fundamental concepts as the book is composed mainly of practical aspects of rather than providing fundamental explanations on scenario.

Among the books on scenario, there is a book that provides substantial help in directly applying the processes and methodologies for pursuit of scenario for each stage by presenting them appropriately while explaining the scenario to the readers who are introduced to scenario planning for the first time in easy to understand terms. It is the book titled "Scenario Planning" with subtitle of "The Link between Future and Strategy". The joint authors of this book, Mats Lindgren and Hans Bandhold, have systematically consolidated the scenario planning on the basis of their experience of having worked at Kairos Future, a globally renowned forecasting institution in Sweden. In addition, brief descriptions of approximately 20 useful tools are given in the appendix of the book in order for hands-on workers to utilize them usefully.

This book consists of five chapters and the contents of each chapter are as follows. The first chapter mentions the need for scenario planning. It emphasizes the importance of establishment of flexible strategy that encompasses both the robustness and responsiveness under uncertain and rapidly changing corporate environment. In order for a company or an organization to be strategically flexible, it must be well-equipped equally with three dimensions, namely, 'Thinking', 'Playing'

1) Scenario is a forecasting technique that assists one to clearly understand diverse range of images of future by conveying various situations that can occur in the future in the format of 'story' similar to the script for theatrical play.

2) Scenario planning refers to combining of strategic planning process onto the scenario, and, currently, scenario and scenario planning are used indistinguishably.

and 'Gardening'. Organizations that are strong in the 'Thinking' dimension are able to anticipate the changes ahead of other organizations through environmental analysis and alternative thinking. Organizations skilled in the 'Playing' dimension are imaginative and innovative, and are not conventional. Such organizations explore the future in practice through continuous innovation and try to predict the future in order to create the future. 'Gardening', as a supportive dimension, emphasizes strategic communication in the organizations and leads the culture of avoiding office politics, which is a factor that may elicit conflict within an organization (Figure 1).

In the second chapter scenario planning is briefly introduced. Scenario is neither a forecasting nor vision. While the forecasting and vision deals with the probable futures and desired future, scenario explores all probable futures and describes them. While the forecasting and vision have the tendency to hide the risks, scenario enables management of risks.

Scenario is a strategic planning tool as well as learning tool. Scenario is a planning tool that refines the strategy under uncertain situations, establishes plans that can cope with sudden unexpected situations, and assists users to take caution in treading the proper path. In addition, scenario is also a learning tool that assists users to understand the development and motives of, and key players in a case. Although scenario is a strategic planning tool, it is different from the traditional strategic planning in that it considers the uncertain future. Scenario is an appropriate tool for medium to long term during which uncertainty increases, and, in particular, is suitable at the time of paradigmatic, non-linear change that traditional strategic planning cannot cope with. (Figure. 2)

The third chapter explains how the TAIDA™ framework, which the authors used in several hundreds of public and private sector projects more than ten years, is actually applied. TAIDA is a scenario planning process that signifies the five steps, namely, **T**racking, **A**nalyzing, **I**maging, **D**eciding and **A**cting.

Tracking is about finding trends, drivers and uncertainties that affect the theme. Although there are diverse methods for assessing the trends, it is advisable to utilize the simple and direct method of finding and analyzing by using those with relevant knowledge within the organization first. If there is no one within the organization with experiences on relevant theme, or in order to assess specific trends that need deeper analysis, more advanced methods such as media scanning, Delphi and expert panel, etc can be then used.

Analyzing phase is about assessing correlation between the trends. Trends are closely connected with each other with some trends as the drivers or results of other trends. It is important to assess the relationship between the trends by utilizing cross-impact analysis in order to understand the image of

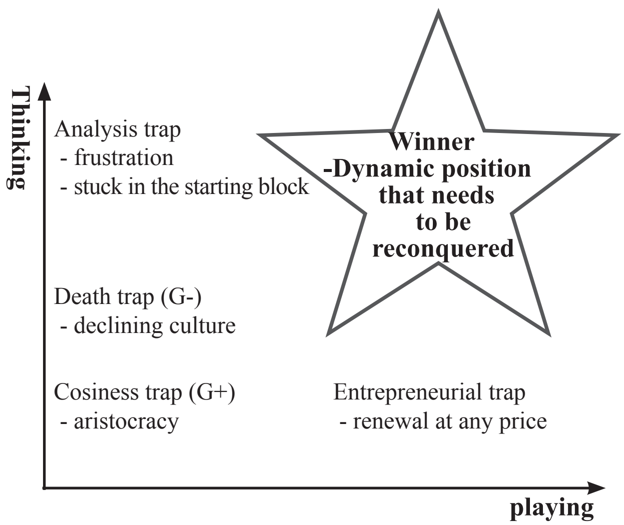

Figure 1 Different types of organizational anomalies

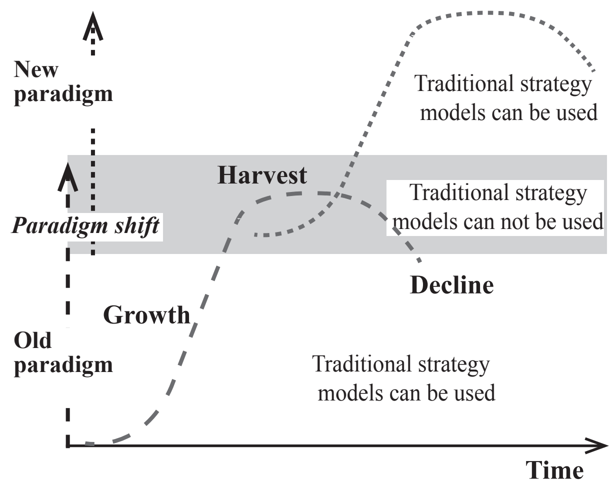

Figure 2 Scenario planning is well suited to the task of dealing with paradigmatic, non-linear change

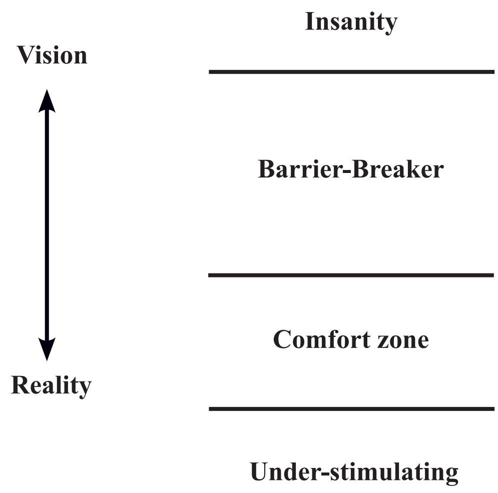

Figure 3 The tension between vision and reality

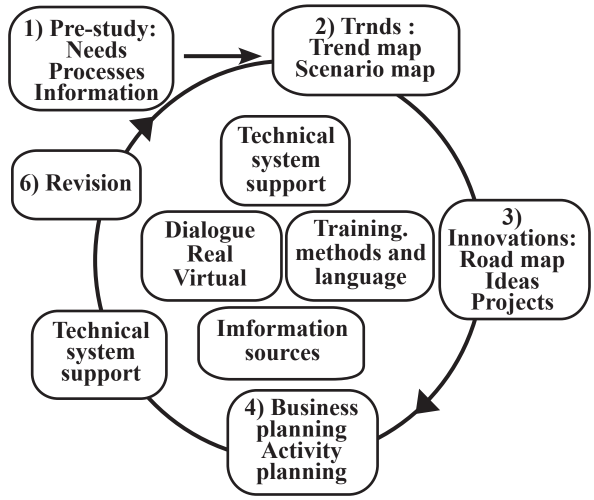

Figure 4 Example of a typical TRIM process

the future from overall viewpoint. Since scenarios change substantially for the trends, which are likely to have a great impact on the theme and are uncertain, it is important to identify them among the trends. If two important trends with high degree of uncertainties are identified, then, logically, four different scenarios can be developed. Of course, if many important trends with high degree of uncertainties are identified, then, much larger number of scenarios can be created. However, three to four scenarios are generally drafted because it would be very difficult to manage all the scenarios it there are too many. In order to effectively convey the scenario, the contents of scenario should not be a simple brief but, rather, must be expressed with a highly descriptive and memorable title and as a story with a narrative and vivid description.

Imaging phase is about drawing the desired image of the future, that is, the vision. Vision is composed of audacious goals over 10~30 year period, and vivid description of the image when such goals are accomplished. Vision is created through workshop that demands intuition and creativity from the participants. Such vision must be defiant without being insane to the point of being unachievable or must not be accomplishable easily without substantial efforts (comfort zone) (Figure 3).

In the **D**eciding phase, take advantage of the opportunities and avoid the threats of future environment by establishing strategies to accomplish the vision. Strategies are generated by considering trends, scenarios, core competences of the organization and visions as inputs. Ideas presented are integrated and adjusted, and the suggested strategies are evaluated by using methods including WUS analysis[3], cross-impact analysis and causal-loop diagram.

In the **A**cting phase, continuous follow up activities such as monitoring of environmental changes are carried out while executing the established strategies. Putting the strategies into action can be done by utilizing traditional implementation toolsets that most organizations are well accustomed to. Monitoring of environmental changes as a follow-up activity provides early warning that indicates where the environment is heading by comparing with the scenarios drafted in the analyzing phase.

Such scenario process is an essential element in acquiring long-term competitive advantages by organization. The authors are presenting the Trend and Innovation Management (TRIM) Process developed by the Kairos Future in order to link the scenario planning with the ideas and innovation that enterprises are seeking (Figure 4).

The fourth and fifth chapters present principles of Scenario Thinking and Strategic Thinking. For the

3) WUS analysis is an analysis method that determines the priority that needs to be concentrated and pursued through evaluation in accordance with the demands from the vision and future environment, and present strengths or assets of the organization among the proposed strategies.

scenario thinking, principle of ‘drama thinking’ that the future is shaped by the interactions of different actors is presented. Other principles of thinking on the future, system, uncertainty and actors are also described. Lastly, principle that thinking can be improved by diverse range of techniques, methods and tools is presented. For the strategic thinking needed for scenario planning, principles of thinking on paradoxes, visions, jamming, time, resources, life cycles, experiments and bets are presented.

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Science and Technology Trends

2010 National R&D Budgets in East Asia

CHINA

Yougui Wang[1] and Woo-Sung Jung[2]

1. 2010 R&D Budget Trend

According to the Ministry of Finance, People's Republic of China, the R&D budget of the year 2010 increases to about 163 billion Yuan by 8.0% comparing with the year 2009, 151 billion Yuan, while the total budget increases by 6.3%.

The R&D budget in China steadily increases. According to the statistics of the 2008 national investment in R&D, the expenditure was 461.6 billion Yuan, 1.54% of the GDP. The governments spent 108.89 billion Yuan and the enterprises 331.16 billion Yuan, accounting for 23.6% and 71.7% of the total R&D expenditure respectively. The expenditures in basic research, applied research, and pilot development as a ratio of the total were 4.8%, 12.5%, and 82.8% respectively. The R&D investment in 2008 increased by 90.58 billion Yuan, or 24.4%. The R&D expenditure as a proportion of GDP also was up by 0.1%. The per-capita expenditure on researchers and relevant personnel

Category	2009	2010	
R&D	151,202	163,285	8.0%
Education	198,139	215,990	9.0%
Social benefit and employment	329,666	358,225	8.7%
Health	127,714	138,918	8.8%
Environment	115,180	141,288	22.7%
Agriculture	350,124	350,124	7.9%
Defense	482,985	519,082	7.5%
Stockpile (grain and oil)	174,662	177,453	1.6%
Public safety	128,745	139,069	8.0%
Transportation	217,871	211,919	-2.7%
Public service	132,663	101,495	-23.5%
National bond	132,070	153,516	16.2%
Disaster recovery	96,999	78,001	-19.6%
Public administration	742,648	807,782	8.8%
Agrarian improvement	725,310	818,340	12.8%

Resource: Ministry of Finance, People's Republic of China

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was 235,000 Yuan, an increase of 21,000 Yuan over 2007.

2. The background of 2010 R&D Budget trend[1)]

The Five-Year Plans of China are a series of economic development initiatives. The eleventh five-year plan covers from 2006 to 2010. Among the main purposes of the Eleventh Five-Year Guideline are securing economic growth and economic structure, urbanizing the population, conserving energy and national resources, encouraging sound environmental practices, and improving education. During the eleventh period, the following are set to undertake as the major high-tech projects China.

- Integrated circuits and software: establishing integrated circuit research and development centers, industrializing the technology for 90-nanometer and smaller integrated circuits, and developing basic software, middleware, large key applied software and integrated systems.
- New-generation network: building next-general Internet demonstration projects, a nationwide digital TV network and mobile communication demonstration networks with independent property rights.
- Advanced computing: making breakthrough in technology for petaflop computer systems, building grid-based advanced computing platforms, and commercializing the production of teraflop computers.
- Biomedicine: Building a number of demonstration projects for commercial production of vaccines for major diseases and gene-modified medicines, improving the modern traditional Chinese medicine system, and enhancing the capability for new medicine invention and production.
- Civil airplane: developing planes for trunk and feeder lines, general-purpose planes and helicopters, as well as advanced engines.
- Satellite application: developing new meteorological, oceanographic, resource and telecommunication satellites, and poison- and pollution-free thrust augmented carrier rockets; building earth observation and navigation positioning satellite systems and facilities and application demonstration projects for civil satellite ground systems.
- New materials: building demonstration projects for commercial production of high-performance new materials badly needed in information, biological and aerospace industries.

In particular, the Ministry of Science and Technology and the State Development and Reform Commission jointly published China's national S&T development plan for the 11th Five-year period (2006-2010). The Plan, designed to implement the National Outline for Medium and Long Term S&T Development Planning (2006-2020), will work on the following missions and tasks. Surrounding the general goals defined by the Planning Outline for S&T development in the future 15 years, efforts will be made to raise the proprietary innovation capacity in the following five areas in next five years: 1) strengthening key technology innovations in the areas of energy, resources, and environment, and enhancing the capability of addressing bottleneck restrictions, in line with major national economic needs; 2) strengthening the technical innovation part of industry, with focus on acquiring proprietary intellectual property, and noticeably enhancing the core competitiveness of major sectors, including agriculture, industry, and service industry; 3) strengthening technology integrations, and enhancing S&T service for public good sectors, including population, health, public security, urbanization, and urban development; 4) responding to the new needs of defense modernization and to nontraditional security concerns, and enhancing S&T support for national security; and 5) making deployments in the visionary areas of basic research and cutting-edge technology, and enhancing the capacity building of sustained S&T innovations.

During the 11th Five-year plan period, step will be taken to establish a national innovation system, agreeable with the socialist market economy and the natural rhythm of S&T development, in an attempt to create a rational S&T development pattern, and strive for major breakthroughs and leaping development in the selected priority areas. The endeavor will raise China's R&D expenditure to 2% as a proportion of

1) Resource: The Chinese Ministry of Science and Technology

	2001	2002	2003	2004	2005	2006
Gross Domestic Expenditure on R&D/GDP (%)	0.95	1.07	1.13	1.23	1.33	1.42
Share in total government expenditure (%)	3.7	3.7	3.8	3.8	3.9	4.2
S&T personnel (10,000 persons)	314.1	322.2	328.4	348.1	381.5	413.2
Overseas Chinese students (10,000 persons)	8.4	12.5	11.7	11.5	11.5	13.4
Returnees (10,000 persons)	1.2	1.8	2.0	2.5	3.5	4.2
Chinese S&T papers indexed by SCI	35685	40758	49788	57377	68226	71450

Resource: China S&T Statistics Data book 2007

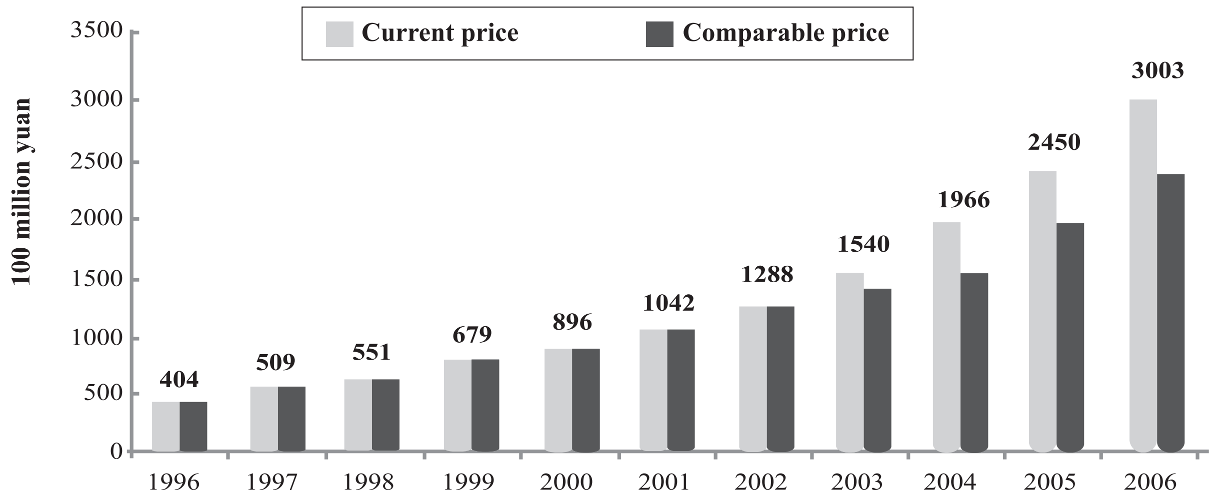

Figure 1 Gross domestic expenditure on R&D, Resource: China S&T Statistics Data book 2007

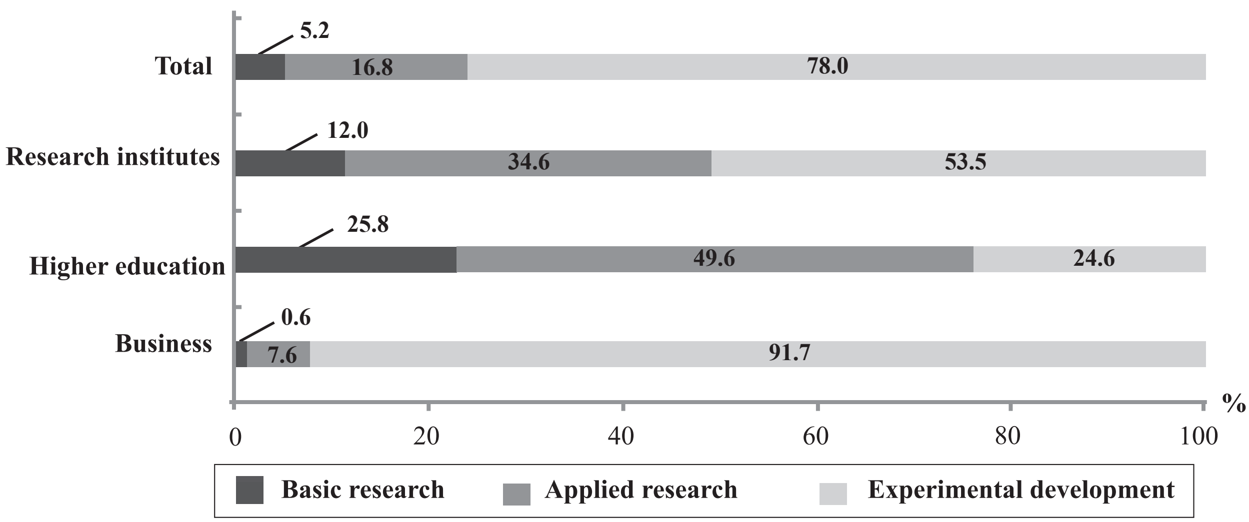

Figure 2 GERD by type of activity, Resource: China S&T Statistics Data book 2007

GDP, allowing China to become an S&T power with strong proprietary innovation capacity, and laying a foundation for making China part of innovation economies in the world.

The Plan also puts forwards eight tasks for implementing the Planning Outline, including 1) pooling up forces to implement major special projects defined by the Planning Outline, with focus on strategic objectives; 2) strengthening efforts to address urgent concerns in the fields of energy, resources, environment, agriculture, information, and health; 3) grasping future development opportunities, and making deployments in the visionary areas of cutting-edge technology and basic research; 4) enhancing sharing mechanism, and establishing platforms for sharing S&T infrastructure facilities and conditions; 5) implementing the strategy of high caliber personnel, and strengthening the capacity building of S&T workforce; 6) creating an environment agreeable with popular science activities and innovative cultures; 7) making industry a major player, and advancing the construction of a national innovation system of Chinese characteristics; 8) strengthening S&T innovation, and safeguarding defense security.

The Ministry of Science and Technology has more S&T Programs such as 863 Program and 973 Program. In 1986, to meet the global challenges of new technology revolution and competition, the National High-tech R&D Program (863 Program) was proposed. Objectives of this program are to boost innovation capacity in the high-tech sectors, particularly in strategic high-tech fields, in order to gain a foothold in the world arena; to strive to achieve breakthroughs in key technical fields that concern the national economic lifeline and national security; and to achieve "leap-frog" development in key high-tech fields in

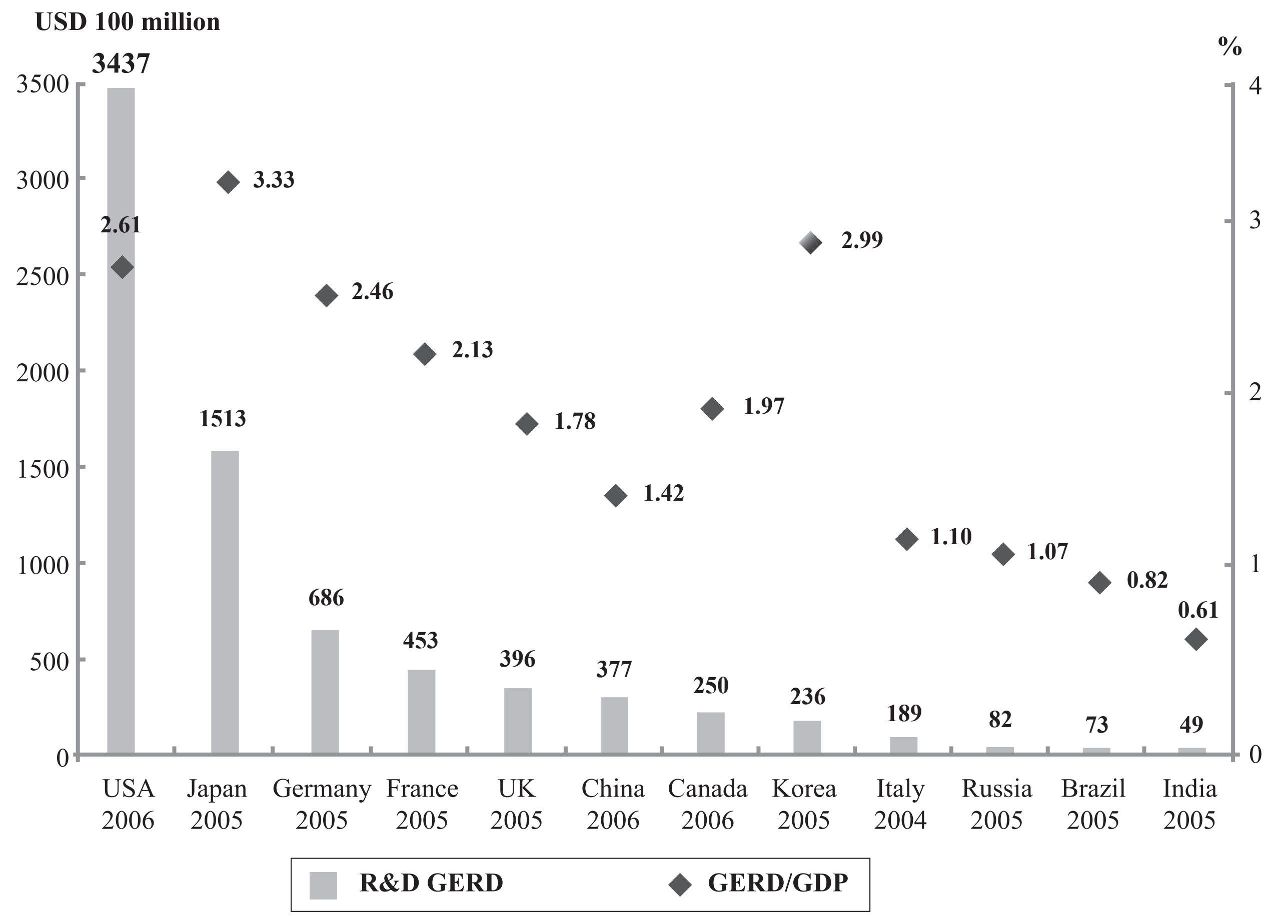

Figure 3 GERD in selected countries, Resource: China S&T Statistics Data book 2007

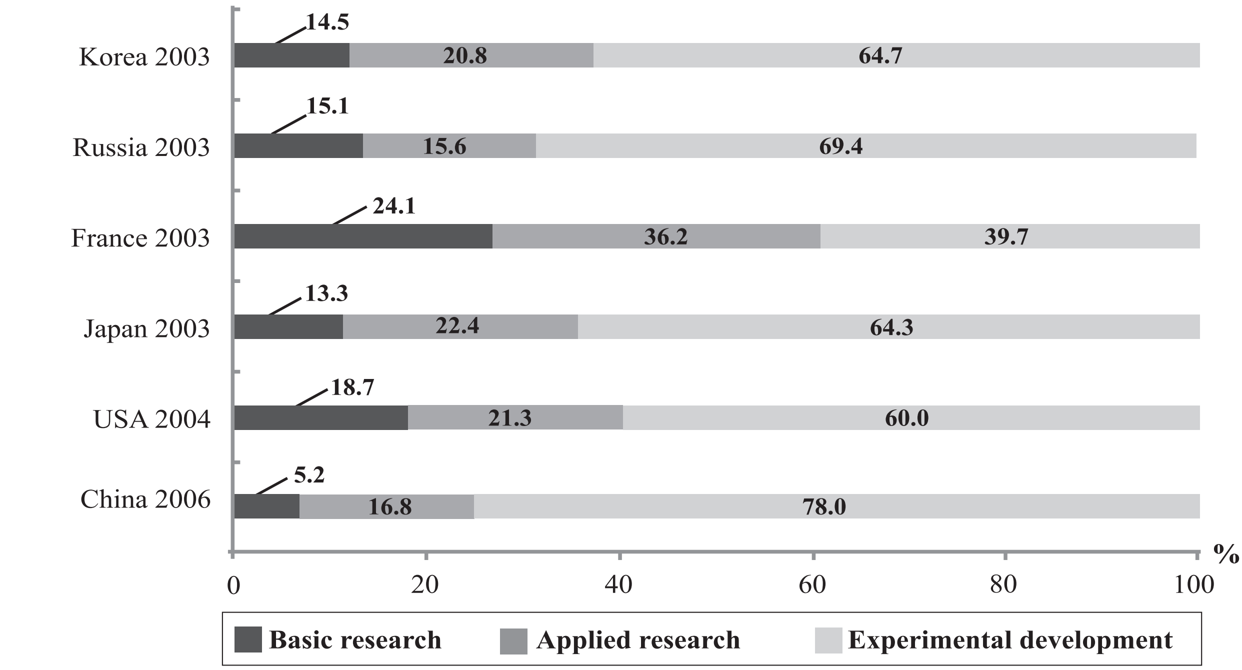

Figure 4 GERD in selected countries by type of activity, Resource: China S&T Statistics Data book 2007

which China enjoys relative advantages or should take strategic positions in order to provide high-tech support to fulfill strategic objectives in the implementation of the third step of our modernization process. In line with national objectives and market demands, the program addresses a number of cutting-edge high-tech issues of strategic importance and foresight. They are: 1) Develop key technologies for the construction of China's information infrastructure. 2) Develop key biological, agricultural and pharmaceutical technologies to improve the welfare of the Chinese people. 3) Master key new materials and advanced manufacturing technologies to boost industrial competitiveness. 4) Achieve breakthroughs in key technologies for environmental protection, resources and energy development to serve the sustainable development of the society.

China recognizes that basic research is a driving force for the progress of human civilization, a source and backbone of S&T and economic development, a precursor of inventions and new technology, and a cradle of S&T talents. Continuous fast socio-economic growth imposes increasingly higher demands on basic research while many scientific issues press for solutions derived from in-depth basic research. Significant breakthroughs from basic research often trigger remarkable changes in economic and social sectors. On June 4, 1997, the State Science and Education Steering Group decided to formulate "The National Plan on Key Basic Research and Development" and organize the implementation of the "National Program on Key Basic Research Project (973 Program)". The purpose of these two initiatives is to strengthen basic research in line with national strategic targets.

3. Implication

The R&D budget in China gradually increases recently. Interestingly, business sector, which occupies 69% of the total R&D budget, is the largest funding source. Business sector also accounts for 65.7% of the R&D personnel. In business sector, experimental development accounts for 96.1% with respect to GERD of business sector, while higher education focuses on basic research and applied research. China speeds up its industrialization through R&D, particularly, on industrial technology. However, it should be noted that basic science of China is also strong.

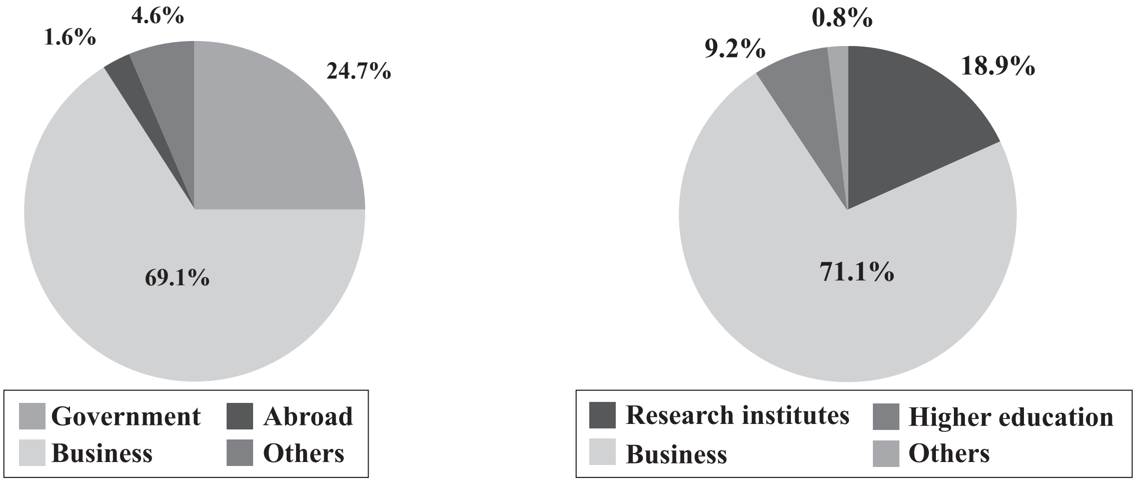

Figure 5 GERD by source of funds and by sector of performance (2006), Resource: China S&T Statistics Data book 2007

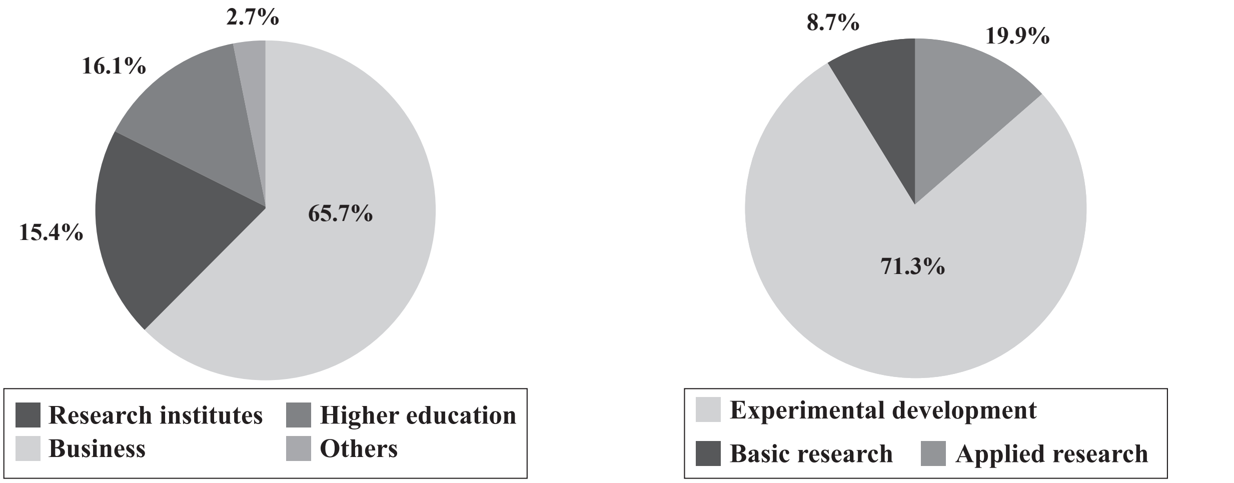

Figure 6 R&D personnel by source of funds and by sector of performance (2006), Resource: China S&T Statistics Data book 2007

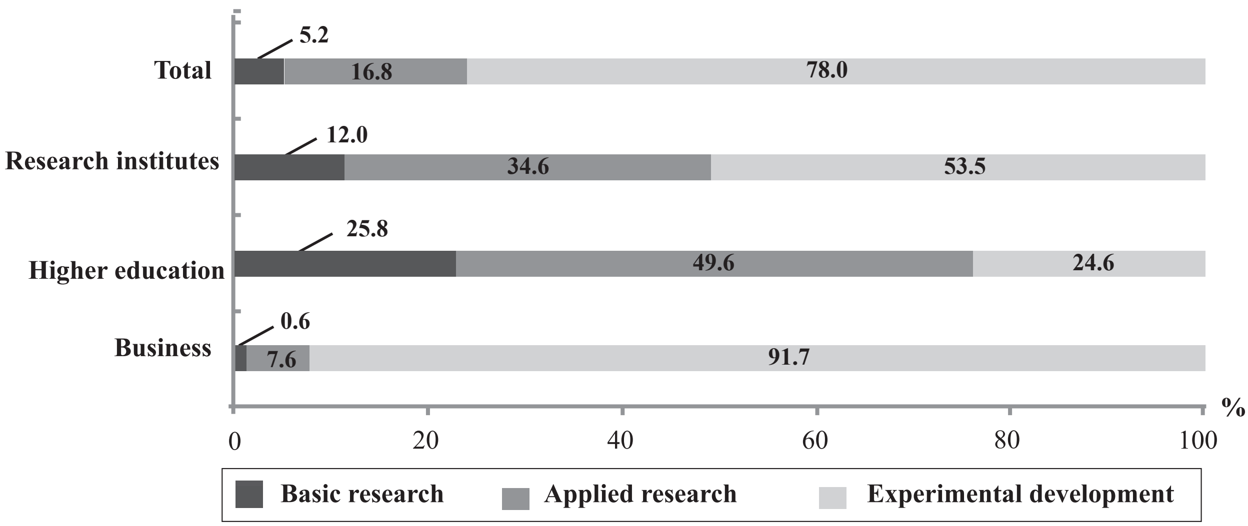

Figure 7 GERD by type of activity (2006), Resource: China S&T Statistics Data book 2007

JAPAN

Hideki IWABUCHI[1]

In December 2009, Japanese new cabinet led by Prime Minister Dr. Hatoyama decided the first budget (FY2010, governmental plan). The outline of FY2010 science and technology budget and the background of budget are described here. Finally, several implications, especially for Korean readers, are introduced.

1. Japan's Science and Technology Budget

1.1 Overview

1.1.1 FY2010 Governmental S&T Budget (planned)

In FY2010, the S&T budget of Japanese Government in FY2010 is 3,572 billion Yen (= 42,864 billion Won, when 1Yen=12Won). About two-thirds (65.0%) of the total S&T budget is allocated to *Ministry of Education, Culture, Sports, Science and Technology* (MEXT) which is mainly responsible for basic sciences, fundamental R&D and big sciences. Other than MEXT, 15.1% is allocated to *Ministry of Economy, Trade and Industry* (METI), 4.8% is to Ministry of Defense (MOD), 4.3% is to Ministry of Health, Labor and Welfare (MHLW), 3.5 % is to *Ministry of Agriculture, Forestry and Fisheries* (MAFF).

In Korea, at the same time, the R&D budget of Korean Government in FY2010 is 13,640 billion Won. 38.4% of them is allocated to *Ministry of Knowledge Economy* (MKE) and to *Small & Medium Business Administration* (SMBA) (the aggregated role of MKE and SMBA is similar to the role of METI). 31.9 % is allocated to *Ministry of Education, Science and Technology* (MEST), 13.2% is to *Defense Acquisition Program Administration* (DAPA).

Comparing to the R&D budget of Korea, you can easily find that Japanese budget has mainly three features; (1) basic and fundamental R&D is well funded, (2) governmental expenditure for industrial technology is small, (3) the portion of defense R&D budget is "very" small.

1.1.2 Time-trend of S&T budget

Japan's S&T budget in FY2010 shows 0.8% increase from FY2009. Over last 10 years, the total scale of S&T budget was quite stable in spite that the governmental budget was severely reduced in many areas other than S&T.

1.2 Highlights of FY2010 S&T Budget

1.2.1 MEXT Budget

MEXT's S&T budget in FY2010 focused on "green innovation" and "basic sciences". While the total amount of S&T budget is stable, the budget in these areas rapidly increased based upon the "selection & focus" principle.

Table 1 FY2010 Governmental S&T Budget – Japan and Korea

JAPAN Ministries	FY2010 [bilYen](a)	portion [%]	FY2010 [bil Won]	portion [%]	KOREA Ministries
MEXT (Education, Culture, Sports, Science & Technology)	**2,324**	**65.1%**	4,356	**31.9%**	MEST (Education, Science & Tech)
METI (Economy, Trade & Industry)	**539**	**15.1%**	4,967	**36.4%**	MKE+SMBA (Economy)
Defence	**171**	**4.8%**	1,796	**13.2%**	DAPA (Defence)
Health, Welfare & Labor	**154**	4.3%	308	2.3%	Health & Welfare
Agriculture, Fishery & Forest	**124**	3.5%	236	1.7%	Agriculture, Fishery & Food
Others	**260**	7.3%	1,977	14.5%	Others
JPN Gov. Total	**3,572**	**100%**	13,640	100%	KOR Gov. Total

Source for Japan: "FY2010 Governmental S&T Budget (planned)", Office of Science and Technology (S&T), Cabinet Office (CAO) (press release on Jan 07, 2010)
Source for Korea: Document of National S&T Committee on Nov 24, 2009

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Table 2 10-years trend of S&T Budget in Japan

Budget at the beginning of Fiscal Year

Unit: billion Yen	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
S&T Budget Total	3,469	3,544	3,597	3,608	3,578	3,574	3,511	3,571	3,544	3,572
- S&T Promotion Cost	1,121	1,183	1,230	1,284	1,317	1,331	1,348	1,383	1,378	1,332

Note: S&T Promotion Cost is a part of S&T Budget. The cost is defined as “cost whose main objective is the propotion of S&T”

- R&D towards Green Innovation
  - Budget: 9.8 billion Yen in FY2010 (3.7 billion Yen in FY2009)
  - Major items: Low-carbon cutting-edge technology development (2.5 billion Yen, new), Research on climate change adaptation strategy (development of platform for the collection & analysis of observation data) (1.6 billion Yen, new), Research on social scenario towards low-carbon society (0.3 billion Yen, new)
- Basic Sciences
  - Budget: 341.1 billion Yen in FY2010 (293.8 billion Yen in FY2009)
  - Major items: High performance computing infrastructure (22.8 billion Yen in FY2010 ← 19.0 billion Yen in FY2009), Cutting-edge R&D strategic fund (incl. fund for female and young researchers) (40 billion Yen, new)

1.2.2 METI Budget

METI’s S&T budget in FY2010 also focused on “green innovation” related items as following:

- Development of Energy-saving Semi-conductor
  - Budget: 2.0 billion Yen in FY2010 (new)
  - Major items: R&D on SiC semi-conductor (energy loss under 1/100, comparing with Si semi-conductor)
- Development of Super Light &High Tensile Strength Marterial
  - Budget: 1.5 billion Yen in FY2010 (new)
  - Major items: R&D on the fusion material combined by the carbon nano-tube (CNT) and the existing materials.

2. Situation around Japan’s S&T Budget

In Japan, new government led by Prime Minister Dr. Yukio HATOYAMA (Democratic Party of Japan: DPJ) launched on September 16, 2009. Hatoyama cabinet introduced new policy approaches different from the former Liberal Democratic Party (LDP)-led government. Major events which might affect on the FY2010 S&T budget was as following.

2.1 Key Ministers in Hatoyama Cabinet

At first, it is interesting to see that the key ministers in Hatoyama Cabinet, including Prime Minister himself, have S&T backgrounds. Dr. Hatoyama is the first doctor-holder Prime Minister from S&T field.

< Key ministers who have S&T background >

Dr. Yukio HATOYAMA, *Prime Minister*, graduated from Engineering Department, the University of Tokyo. He got the doctor degree from Stanford University in US. He had job experiences as researcher in Tokyo Institute of Technology and as associate professor in Sensyu University in Japan.

Mr. Naoto KAN, *Vice Prime Minister and Minister of Finance*, graduated from Physics Department in Tokyo Institute of Technology. He had worked as a patent lawyer (attorney). Until the beginning of January, 2010, his post was *Vice Prime Minister, Minister of State for National Strategy and Minister of State for Science and Technology Policy*.

Mr. Tatsuo KAWABATA, *Minister of Education, Culture, Sports, Science and Technology and Minister of State for Science and Technology Policy*, graduated from Engineering Department, Kyoto University. He had worked as a researcher in Toray Co.

Mr. Hirobumi HIRANO, *Chief Cabinet Secretary*, graduated from Engineering Department, Chuo University and had worked for Panasonic Co.

2.2 UN Summit on Climate Change

The first appearance of Prime Minister Hatoyama in diplomatic circle was UN Summit on Climate Change on September 22, 2009, at the NY headquarter of UN. In his speech, he expressed the strong message to the rest of world, that is, "*Japan will aim to reduce its (green house gass) emissions by 25% by 2020, if compared to the 1990 level, consistent with what the science calls for in order to halt global warming*." This target looks so ambitious, when we recall the target by Korean Government. Current Korean target is to reduce its emissions by 4% by 2020 if compared to the 2005 level, in other words, to permit 91% increase of its emission from 1990 to 2020. (Note: CO_2 emission per capita in 2007 [IEA, 2009] Japan: 9.68 ton-CO_2 (the 12th large among OECD 30 countries), Korea: 10.09 ton-CO_2 (the 9th large))

In order to realize this emission target, Hatoyama Cabinet put high priority on green innovation. Soon after the UN Summit, Vice Prime Minister and Minister of State for S&T Policy, Mr. Naoto KAN, expressed the vision of green innovation in STS *forum* in Kyoto on October 04. Concrete actions followed in "*New Growth Strategy*" as mentioned bellow.

2.3 Budget Screening by Cabinet Secretariat

Government Revitalization Unit in Cabinet Secretariat, which is newly established section in Hatoyama government, hold a series of "*Budget Screening*" (*jigyou-shiwake* in Japanese) meetings from November 11 to November 27, 2009. All of the meetings were open to public and broadcasted on live. These meetings attracted huge public interests for its "open" approach.

S&T budget was also included in agenda items of "*Budget Screening*", and was basically evaluated in a negative direction. For example, at the meeting on November 13, a mega science project (RIKEN's next generation super-computer development project aiming at the world-fastest computing speed: FY2010 budget request was 27 billion Yen) was evaluated as "*significant budget cut, nearly equal to termination of budget*". S&T related issues are not usually broadcasted in TV news in Japan, however, suddenly at this time, these negative evaluations on S&T budget were repeatedly broadcasted as top news.

This screening result invited huge reactions from scientists, industries and public. Soon after the screening, Dr. Noyori, President of RIKEN and Nobel Laureate, began claiming the necessity of basic and fundamental R&D. On November 19, members of Council of S&T Policy (CSTP) of Cabinet Office published the joint statement to request to keep the S&T budget certainly. Science Council of Japan (SCJ) (on November 20), Japan Business Federation (*Keidanren*) (on November 24) and four Japanese Novel Laureate scientists (on November 25) followed to claim the importance of S&T budget. Even public expressed the opinions supportive to S&T. For example, over 140 thousands opinions were sent to government on the screening result in MEXT fields [MEXT press release on Dec 16].

You may say that such a substantial debate on S&T budget at the level of public had never been done in the history of Japan. As a result, this process of screening became a good opportunity for public to think of the importance of S&T budget, and for scientists to think of the opinions of taxpayers.

Figure 1 Novel Laureate Dr. Tanaka (top, middle) watching Budget Screening meeting as an ordinary observer (Nov. 17, 2009) [source: Mainichi news]

Figure 2 Four Novel Laureates and One Fields Laureate presenting joint statement on Budget Screening result. (Nov. 25, 2009) [source: Jiji news]

2.4 FY2010 S&T Budget

Responsible ministers discussed the direction of S&T budget after the Budget Screening, considering public opinions which was relatively supportive to S&T. As a result, in spite of the Budget Screening result, FY2010 S&T Budget was finally set to be 0.8% increase from FY2009. In the case of the supercomputing project which invited central concerns from public, the project was not terminated, but got 22.8 billion Yen (although the requested budget was 27 billion Yen). Furthermore, affected by the Prime Minister's speech in UN Summit on Climate Change, green innovation related R&D budget showed a sharp increase in FY2010.

2.5 New Growth Strategy

Soon after FY2010 Budget was finalized by Cabinet, "*New Growth Strategy* (outline)" was also decided by Cabinet on December 30, 2009. "New Growth Strategy" is currently discussed in the government and is to be fixed in June 2010.

"*New Growth Strategy* (outline)" determined six strategic areas: (1) green innovation, (2) life/health innovation, (3) Asian economic collaboration, (4) Tourism and rural revitalization, (5) Science and Technology, (6) Employment and Education. Innovation, S&T occupied three national strategic areas among six. In detail, in the section of S&T, Cabinet set the target to enlarge the R&D expenditure to 4% of GDP by 2020.

"*New Growth Strategy*" would determine the direction of S&T budget in the mid-long term. Now, S&T people in Japan are seriously paying attention on "*New Growth Strategy*" to be fixed this June.

3. Implications

Based on the above description, it can be said that Japan's S&T Budget would have several implications for Korean readers.

(i) Japan's S&T Budget is intensively allocated to basic sciences, while Korean budget is rather allocated to industrial technology and to military use.

(ii) Even in the severe recession of Japan, S&T budget keeps 0.8% increase in FY2010. Especially, the budget on "green innovation" and "basic science" substantially increased.

(iii) In the process of deciding FY2010 budget, public paid huge attention on S&T budget, with stimulated by the relatively negative evaluation on S&T at the Budget Screening meetings. It would be the first time in Japanese history that public and media have daily debated on the direction of S&T budget.

(iv) Soon after the Budget Screening finished, Cabinet decided "*New Growth Strategy* (outline)" which emphasize the importance of S&T. The strategy to be fixed this June will include the mid-long term strategy of S&T.

(v) In the "*New Growth Strategy* (outline)", Asian economic collaboration is also one of six priority areas, as well as S&T. From this, we can expect that S&T cooperation in Asia would become a key policy for Japanese government. If Korea goes in the same direction, Japan and Korea would become two leading engines for establishing Asian S&T Area.

KOREA

Ik-Cheon Um[1]

1. Summary of Government R&D Budget FY 2010

1.1 Compilation Process of Government R&D Budget FY 2010

After the kick off of the new government, the Government research and development (R&D) budget has been organized as a dualistic structure between National Science and Technology Council (NSTC) and Ministry of Strategy and Finance(MSF) as shown in Figure 1. If we have a look at this compilation process briefly, it has began with a step of submitting ’09-’13 Mid-Term Program Plans to the MSF on Jan. 31, 2010. The MSF notified each government ministries on next year’s ceiling of Government R&D Budget according to this Mid-Term Program Plans by the end of April. Consequently, each ministry submitted a written request of the next year’s budget to the MSF within the settled limit. In addition, the direction of next year’s Government R&D Program Budget Allocation established at the NSTC was crucial information at the stage of budget compilation in Government R&D Budget. Government R&D appropriation bill in fiscal year(FY) 2010 was submitted to the National Assembly after the Cabinet Meeting on Sep. 28, 2010 and finally passed after the deliberation on Dec. 12, 31.[1)]

1.2 Status of Government R&D Budget Compilation FY 2010

The Government R&D Budget FY 2010 was allotted KRW 13.7014 trillion which was increased by 11.0% than FY 2009. This rate of increase comes third after foreign policy and unification department (14.7%) and culture, sports and tourism department (12.2%) among the Government Budget FY 2010. This policy which expands on the Government R&D Budget is in accelerating motion after the beginning of current government. The Government R&D Budget was increased by 10.8% which is almost double the annual average increase rate (6.5%) of overall financial scales in the Participatory Government (Roh Government). The current government also ran on an agenda to “Expand the R&D investment to 5% GDP level by the year 2012 from 3% GDP level” in the presidential election campaigns. To follow up with the campaign pledges, the current government provided the realization of world’s biggest Government R&D Budget by expanding the investment size by 1.5 fold during the term (’08-’12) as the key project. Especially, it is planned to expand more than 10.7% annually from 2008 to 2012, KRW 68.4 trillion in total, which is KRW 28 trillion more than the Participatory Government. This shows that the policy of expanding the R&D investment has been reflected on the 2010 Government R&D Budget.

2. Government R&D Budget Compilation Status by Each Area

2.1 Compilation Status by Each Accounting

By looking at the compilation status of Government R&D Budget by each account in FY 2010, the Government R&D Budget is KRW 11.9576 trillion, increased by 12.5% (KRW 1.3276 trillion) than FY 2009. The general accounting, among them, was composed as KRW 9.7711 trillion which is 13.8% increase (KRW 1.1854 trillion) than FY 2009. The national R&D Program ministered by the government R&D fund was composed as KRW 2.1865 trillion which is 7.0% increase (KRW 142.2 billion) than FY 2009 (Table 1). Especially, some part of general accounting has been transferred to Cultural Properties Protection Fund among the National R&D Program ministered by the Cultural Heritage Administration of Korea. As a result, the Cultural Properties Protection Fund has been newly included into the finance of

1) Especially, the government appropriation bill in FY 2010 failed to observe the regulation listed on the Constitution which stipulates 30 days prior to the beginning of next year’s budget due to the political issues on 4 Major Rivers Project and also, there has been worries on compilation of provisional budget

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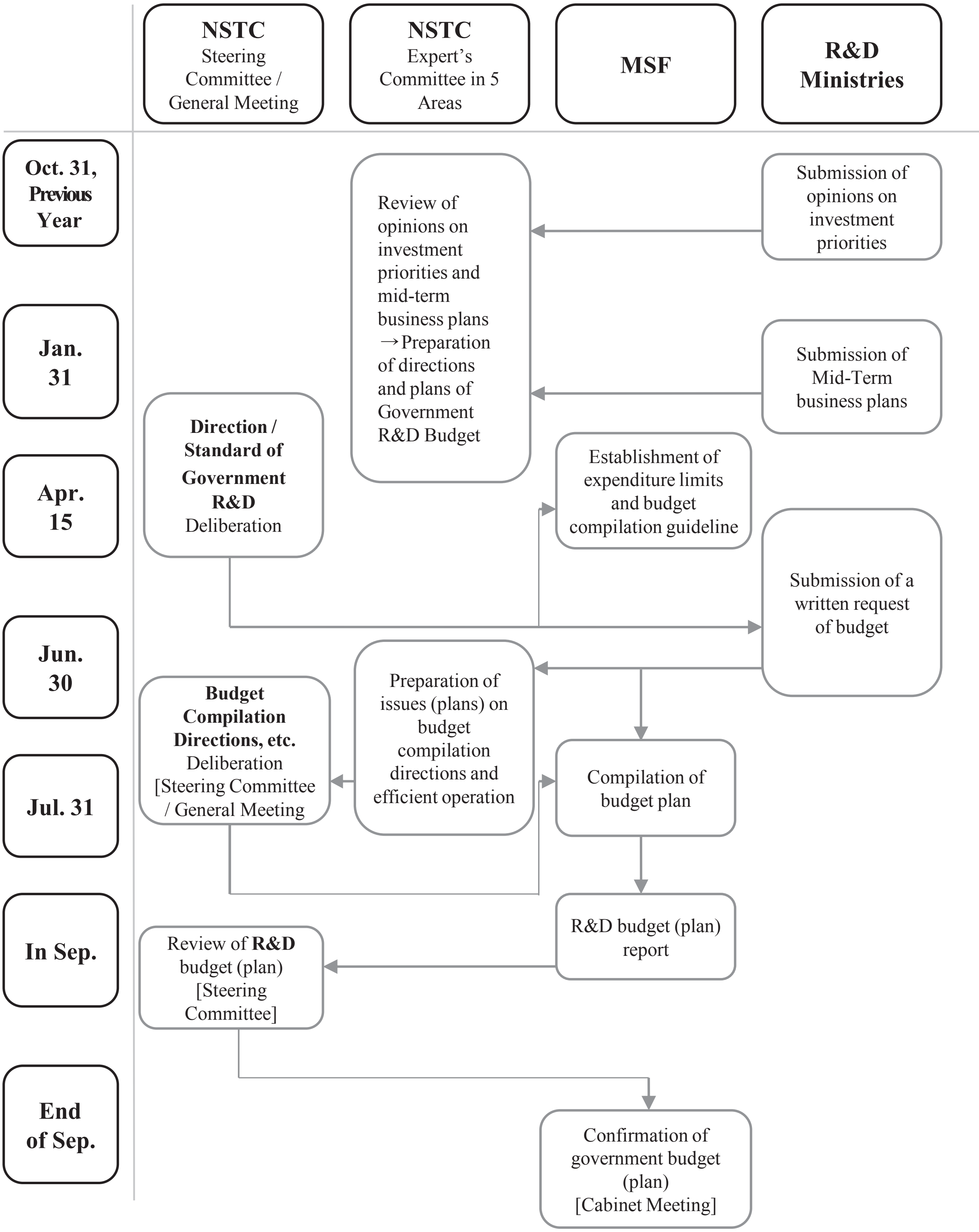

Figure 1 Main Process of Government R&D Budget Compilation

Table 1 The compilation status of Government R&D Budget FY 2010 by each accounting

(Unit: KRW 100 million, %)

Type	2006	2007	2008	2009 (a)	2010 (b)	Fluctuation (b-a)	Portion (%)
Government R&D Budget (A+B+C)	89,096	97,629	110,784	123,437	137,014	13,577	11.0
Government R&D (A+B)	72,283	81,396	93,461	106,300	119,576	13,276	12.5
- General Accounting (A)	61,094	65,907	75,725	85,857	97,711	11,854	13.8
- Special Accounting (B)	11,189	15,489	17,736	20,443	21,865	1,422	7.0
Government R&D Fund (C)	16,813	16,233	17,323	17,163	17,437	274	1.6

Table 2 The investment portion of Government R&D Budget in basic research

(Unit: KRW 100 million, %)

Type	2009 (A)	2010 (B)	Fluctuation (B-A)	Portion(%)
Investment Portion in Basic Research Area (%)	29.3	31.3	2.0	-
Support Individual Researchers	5,000	6,500	1,500	30.0
- The General Researcher Support Program	2,548	3,550	1,002	39.3
- The Middle-Management Support Researchers Program	2,100	2,450	350	14.7
- The Leader Researchers Support Program	352	500	148	42.0

Government R&D Budget FY 2010[2).

2-2 Compilation Status by Each Policy

In the basic research area, the size has been increased to 31.1% which is 1.8% increase from FY 2009 in Government R&D Budget FY 2010 (Table 2)[3). Mainly, it is originated from the increase in creative basic research projects of individuals in the university (KRW 5 trillion in ’09 → KRW 6.5 trillion in ’10, 30% increase). This type of investment on the basic research is showing constant increase after the Participatory Government in order to reinforce future oriented creative R&D strategies beyond the limit of follow-up R&D strategy. Especially, in this government, it is now promoting a national project with an intention to expand the financial investment on basic research and generic & radical research area to the 50% of the government budget by ’12 which includes the original areas further from the basic research area. In July 2009, 3 estimation measures for ‘Estimation of Generic & Radical Research Concept and Portion’ at NTSC had been provided. There should be measures to estimate investment portions of generic & radical researches in association with budge compilation of future government R&D (Um, Ik-Cheon, 2009)

Furthermore, the area of New Growth Engine was expanded largely with 22.0% increase to a size of KRW 1.9 trillion as an intention to reinforce the strategic aspects of Government R&D Budget and create potential for the future growth. In Jan. 2009, 17 New Growth Engines were selected from 3 areas. The basis of this policy corresponds to the Next Generation Growth Engine Programs promoted by the Participatory Government. Especially, the current government is focusing on developing green technology by establishing “Comprehensive Plans for Green Technology R&D (Jan. 13, 2009)” after announcing “Low-Carbon Green Growth Vision” in Aug. 2008 in order to support low-carbon green growth. The budget in the green technology area was allocated KRW 2.2 trillion which is 19.1% increase from FY 2009. It is planned to make firm support

2) The government budget in FY 2010 consists of general accounting, 18 special accountings and 63 funds. Among them, the Government R&D is funded from the general accounting, 7 special accountings and 8 funds.

3) However, the presentation of final confirmation in the basic research area is a matter of concern belonging to the Basic Science Research Promotion Council based on the Clause 3, Section 1 of the Article 15 on the Science Technology Basic Law during the end of this March to the middle of April.

in energy technology development and renewable energy technology development to improve efficiency on machines that consumes much energy such as boilers, lighting devices, air conditioning and heating devices. Moreover, in the converged and integrated cultural contents technology development, KRW 43.5 billion was allocated which is 45.0% increase and the area of supporting technology innovation medium size companies was increased to 560.7 billion which was 14.5% increase from FY 2009. The budget on expanding R&D outcomes and establishing commercialization basis was allotted KRW 136.7 billion which is 25.9% increase from FY 2009[4]. On the other hand, the Government R&D Budget was largely expanded in the area of improving people's safety and quality of life as well as in large scale technology. In an effort to take measures against the pandemic disease, A(H1N1) (Novel Swine-Origin Influenza), KRW 15 billion was allotted in immunity vaccine development which is 27.5% increase from FY 2009. Also, the areas of development of supplementary mechanicals for elderly and development of core original technology in public welfare and safety were recognized as a new government R&D Program being allotted of KRW 9 billion and 5 billion respectively. Especially, it is noticeable that KRW 20 billion was newly allocated in developing Korean space launchers in order to reinforce basis for independent space technologies after the partial success in launching NARO (Um, Ik-Cheon, 2009).

4) The number is a sum of Medium Business Commercialization Technology Development Program from Small & Medium Business Administration, Establishing Nano Convergence Technology Commercialization Platform Program from Ministry of Knowledge Economy, Establishing Intelligence Vehicle Commercialization Basis Program, and Technology Transfer Commercialization Promotion Program.

2.3 Compilation Status of Each Department

In the Government R&D Budget FY 2010,

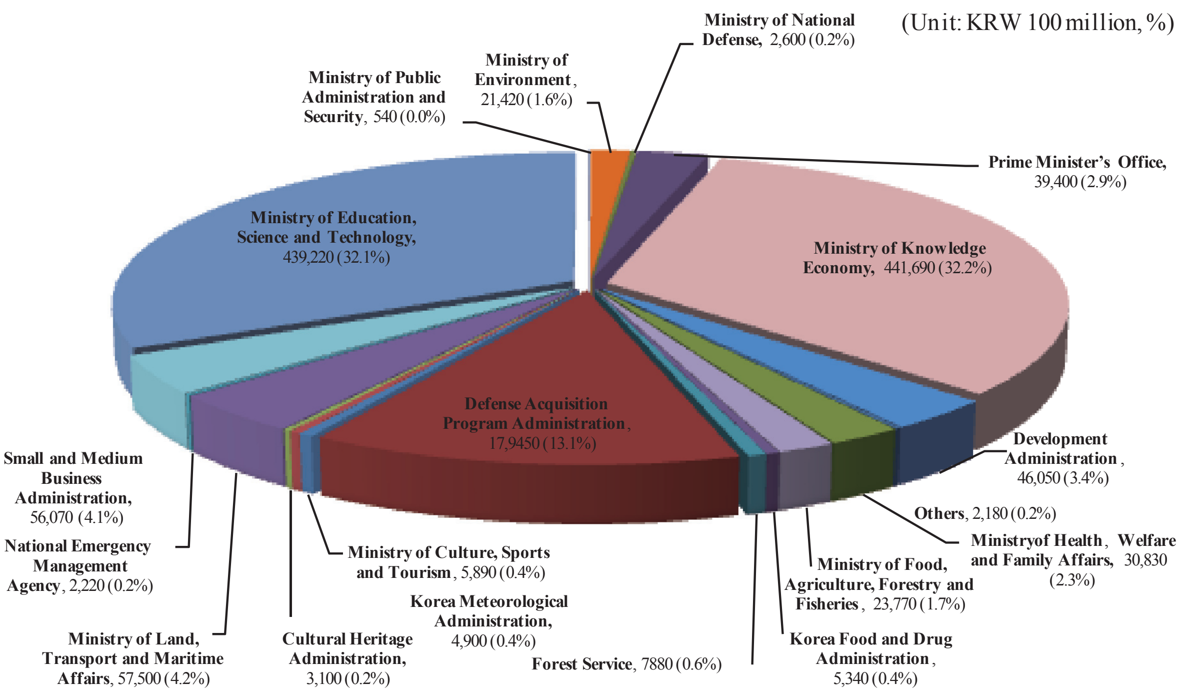

Figure 2 The compilation status of Government R&D Budget FY 2010 by each department

Other Departments: MSF, Ministry of Labor, Ministry of Foreign Affairs and Trade, Fair Trade Commission Korea, Ministry of Government Legislation, Ministry of Unification, Ministry of Gender Equity, Korea Coast Guard, Multifunctional Administrative City Construction Agency, Korea Communications Commission, National Police Agency and 12 other departments

Government R&D Budget FY 2010: KRW 137,014 trillion

Ministry of Knowledge Economy constituted the most portion of 32.3 (Figure 2). The main reason for this increase stems from large scale expansion in the investment relevant to new growth engines and green technology. The Ministry of Education, Science and Technology, 31.9% (KRW 4.3558 trillion), Defense Acquisition Program Administration, 13.2% (KRW 1.7692 trillion), Ministry of Land, Transport and Marine Affairs, 4.2% (KRW 576.0 billion), Small & Medium Business Administration 4.1% (KRW 5.607 billion) follow next. Although the Ministry of Education, Science and Technology took up the highest investment portions before the starting of the new government, the Ministry of Knowledge Economy takes up the most investment portions in government R&D in accordance with the concept of government convergence (a smaller number of larger sized departments) – department convergence between the Ministry of Industry and Resources and the Ministry of Information Communication; and transfers of Research Council for Industrial Science & Technology ministered government research institutes(GRIs)

2.4 Compilation Status of New Government R&D Program in FY 2010

52 Programs (KRW 2.584 billion) from 11 ministries and administrations were recognized as the new government R&D programs in FY 2010 (Table 3). In sizes of the program, the Ministry of Education, Science and Technology was the biggest occupying 41.3% (18 programs, KRW 1.179 billion), the Ministry of Knowledge Economy was next of 38.8% (16 programs, KRW 1.094 billion), and the Ministry of Food, Agriculture, Forestry and Fisheries came next with 6.6% (KRW 18.8 billion). These 3 ministries took up 86.2% of overall new government R&D programs.

In recent 5 years, the number of newly authorized government R&D program was 36.6 on average. This is the result of the significant expansion of Government R&D Budget. Along with this strategy basis of expanding R&D investment in the government, it is showing some form of budget strategy to ensure more budget by submitting applications for general financial programs as new government R&D programs. To prevent this, it is necessary to establish clear governance between NSTC, MSF, and R&D budget application relevant departments.

3. Major Characteristics and Implications of Government R&D Budget FY 2010

As we have discussed the compilation status of Government R&D Budget FY 2010, it can be summarized into 2 characteristics: constant expansion on the R&D investment; and reinforcement of strategic investment. This Government R&D Budget FY 2010 can be discussed from 3 typological perspectives: government leadership type; government-private sector cooperation type; and system type. The government leadership type is an area where the Government R&D Budget plays a crucial role in the areas which the private corporations find hard to participate due to the inclination to market failure or not formed market. In the government leadership type, the basic research area is most representative where it is difficult for the private corporations to operate. The government-private sector cooperation type is an area that promotes private R&D investment in a partnership to supplement R&D areas which is insufficient in the private sectors to create future growth engines and especially, to help private sectors during financial crisis. The technological advancement of major infrastructure businesses and R&D departments in technology innovation small and

Table 3 The compilation status of new government R&D programs in FY 2010

(Unit: KRW 100 million, %)

Type	2006	2007	2008	2009 (a)	2010 (b)	Fluctuation (b-a)	Portion (%)
Government R&D Budget (A)	89,096	97,629	110,784	123,437	137,014	13,577	11.0
New programs (B)	3,289	952	1,533	4,051	2,854	Δ1,197	Δ29.5
(B/A, %)	(3.7)	(1.0)	(1.4)	(3.3)	(2.1)	-	-
Number of New programs	(34)	(22)	(38)	(37)	(52)	(15)	-

medium, and venture companies are included in this type. The system type is a area that prepares systematic basis to promote cooperation between central and local sectors, and among industry, university, and research, to align technology innovation impediment such as taxation and banking, and to prevent systematic failures. Most typical example is the cooperative research among industry, university and research.

From the typological point of view, the Government R&D Budget FY 2010 is relatively successful with the reinforcement of investment expansion of basic researches. However, in Korea, the portion of basic research among the total R&D cost including government and private sectors is still lower than major powers such as USA and France. Moreover, the percentage of application and development research is higher; thus, the task distribution is insufficient with the private sectors.[5)] Therefore, it is necessary for the government to emphasize basic researches to fulfill its role in providing basis for applied and development researches conducted by the corporation (Um, Ik-Cheon, 2009).

Furthermore, the strengthening of strategic investment in new growth engines and green technology is very positive. However, the private sectors are already associated with advanced informant technology in new growth engines. Hence, it is urgent to establish specific mid-ranged Government R&D Budget strategies for clear role distributions between the government and private sectors. In 2007, the NSTC increased investment in basic science, life science, energy and resources, and environment. And in the information and electronic field, it suggested a total roadmap in macroscopic government R&D programs which gradually reduces the investment portions. This macroscopic investment strategy can only be utilized as the primary principle and standard in the actual Government R&D Budget compilation process but there is a long road ahead before it can be utilized as a concrete guideline. The information communication area is the representative primary industry in Korea. Therefore, the investment priority must be listed first on its particulars, that is, the precise role distribution on R&D investment between the government and private. In other words, if the information technology area is classified into 6 areas of digital contents, software solutions, semi-conductors, display, home networking and computers (Kim, Yun-Jong et al. 2009), it means that the role distribution between the government and private and its investment strategies in each area should be established in accordance.

Lastly, in the Government R&D Budget FY 2010, the system type investment including diffusion of R&D outcomes and establishment of commercial basis was somewhat increased. However, in comparing government leadership type and government-private sector cooperation type, it is the area which requires more emphasis in the future. Among the innovation actors in Korea, the rate of technology transfer in public research institutes only stays at around 20% level and the royalty revenue just got through KRW 100 billion in 2007 which is smaller than the royalty revenue of Columbia University in USA in 2002 of some KRW 167.0 billion (Korean Intellectual Property Office, 2005: 16). This may have originated from lack of systematic foundation that evaluates and commercializes technological values of research outcomes.

In the future, it is required to reinforce strategic investment on basic research and generic & radical research, new growth engines and green technology along with the constant expansion on investment. The Government R&D Budget is not only the key measures for overcoming the financial crisis but also it can be utilized as an important strategic means to ensure competitiveness after the depression (Um, Ik-Cheon, 2009).[6)] The Government R&D Budget FY

5) The total R&D budget is 16.1% in Korea (2008) which is higher than Japan (13.8%, 2007); however, it is still lower than USA (17.5%, 2007) and France (23.8%, 2006). Also, the percentage the applied and development area among 2008 government R&D programs was 74.5% and 83.9% in private sectors (Ministry of Education, Science and Technology, Korea Institute of S&T Evaluation and Planning, 2009; NSTC, Ministry of Education, Science and Technology, 2009)

6) Each country in the world is coming up with aggressive financial expansion policies in response to global depression including the bankruptcy of Lehman Brothers in Sep. 2008 and planned to invest 1.3~9.3% of 2009 revised supplementary budget onto the R&D department. Korean government also allocated 1.4% (KRW362.2 billion) of the total revised supplementary budget (KRW28.4 trillion) on the R&D department (Internal Data of Ministry of Education, Science and Technology, 2009)

2010 was instituted under the political and financial context to overcome financial crisis. As mentioned earlier, there should be more effort made in relations to the system type among the types of Government R&D Budget. In Korea, significantly low level of cooperative researches among industry, university and research has been pointed out repeatedly as the main factor of degrading investment efficiency of Government R&D Budget (Cho, Yoon-Ae et al, 2005; H.S. Moon & J.D. Lee, 2005 etc). In addition, the areas with possibility of coexistence of similar and overlapped programs in the local R&D field should be reinforced with pre-planning abilities such as preliminary feasibility investigation systems, and promote the improvement of similar and overlapped programs to bring investment efficiency of government R&D to the next level.

4. Reference

1. Kim, Yun-Jong et al (2009), A Study on the Investment Strategy of the IT R&D Using Portfolio Analysis and AHP Method, Management Science, Vol 26, No. 1: pp 37~51.
2. Internal Data of Ministry of Education, Science and Technology (2009), "R&D Investment Status among Revitalization Budgets".
3. Ministry of Education, Science and Technology, Korea Institute of S&T Evaluation and Planning (2009), 「Science Technology R&D Project Investigation Report」.
4. NSTC, Ministry of Education, Science and Technology (2009), 「2009 Government R&D Project Investigation and Analysis Report」.
5. NSTC (2009), "Estimation of Original Research Concept and Portion", No.41 Vol . 5(2009.7.28).
6. Um, Ik-Cheon (2009), "Analysis of Government R&D Appropriation Bill FY 2010 and Future Investment Direction", The Korean Federation of Science and Technology Societies, Science and Technology, Dec. 2009.
7. Cho, Yoon-Ae et al (2005), 「R&D Investment Efficiency Promotion Plan for Innovation Ability Reinforcement」, Korea Institute for Industrial Economics & Trade Research Report
8. Korean Intellectual Property Office (2005), 「Promotional Strategy and Homework for Realization of Intellectual Property Powers」, 2005.11.
9. H. S. Moon & J. D. Lee (2005), "A fuzzy set theory approach to national composite S&T indices", Scientometrics, Vol. 64, No. 1: pp67-83.