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Evaluation of national R&D projects in Korea

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Abstract

The Korean government has invested in national R&D programs since the early 1980s, and evaluation activities ensued. This paper is written (1) to explain the experience of evaluating projects of the national R&D programs, (2) to investigate the specific problems related to the present evaluation system, and (3) to recommend guidelines for future improvement in the evaluation practice.

The Korean experience should be of some reference value to other countries in designing or implementing national R&D project evaluation systems.

1. Introduction

During the past two decades industrial innovation based on R&D has been considered as a driving force for the socioeconomic development. This led policy makers of both developed and developing countries to formulate and implement R&D programs at the national level. To legitimize the programs' goals and expenditures evaluation activities prevail, and some of the experiences in the evaluation methods, procedures, and climates are reported (Meyer-Krahmer, 1988; UK Department of Trade and Industry, 1988; Ormala, 1989; Roessner, 1989; Tanaka, 1989; MeKeon and Ryan, 1989; Meyer-Krahmer and Montigny, 1989; Luukkonen and Stahle, 1990; Krull et al., 1991). Placed in the same context, this paper addresses (1) the Korean experience of evaluating the projects of the three national R&D programs, (2) the problems related to the present evaluation practice, and (3) some guidelines for R&D managers and policy makers to better manage the evaluation system.

R&D activities being at the infancy stage during the 1970s and 1980s, the government-sponsored research institutes (GSRIs) were the major research organizations responsible for the technological development. Since the establishment of Korea Institute of Science and Technology (KIST) in 1966, about ten major GSRIs in natural science and engineering have been set up. [1] Since early 1980s, Korea has placed emphasis on strengthening competitive advantage through technological innovations (Kim, 1987; Kim and Dahlman, 1992). In line with the emphasis the government initiated a series of na-

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[1] The exact number varies due to frequent merging and splitting of the organizations.

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tional R&D programs, [2] formulated a *long range development plan of science and technology toward the 2000s* (Ministry of Science and Technology, 1988), and organized the Presidential Advisory Council in Science and Technology. Technological innovation in the private sector has also been encouraged through government subsidies and incentives (Ministry of Science and Technology, 1988). The Korean government invested about US$6.22 billion during the period 1982–1992 (Ministry of Science and Technology, 1993b). Although the national R&D programs greatly contributed to the evolution of a national innovation system, the commercial performance was not altogether satisfactory (Shin and Kim, 1994).

Confronted with the dissatisfaction, the government organized an external expert panel in 1991 to undertake a collective evaluation of the GSRIs, the major recipient of the national R&D funds. The purposes of the evaluation were to diagnose project/program management systems and their operation in each institute, and, in so doing, to derive policy recommendations for the systems' improvement. The panel pointed out that the national R&D programs were managed inefficiently, and that largely the government officials who lacked appropriate understanding in R&D management and evaluation were to blame. The panel recommended that the related ministries establish organizations specialized in R&D planning, project selection, and evaluation (Task Force for Government-Sponsored Research Institutes Evaluations, 1991). The recommendation was accepted, and establishing such organizations is now one of the basic approaches in Korea. [3] These special organizations are now evaluating all the projects belonging to the national R&D programs. We will discuss three major national R&D programs: Special R&D Program, Generic Technology Development Program, and National Telecommunications R&D Program. These three consume most of the governmental R&D fund.

2. Special R&D (SRD) Program

2.1. Overview of the program

The Special R&D (SRD) Program was initiated in 1982 by the Ministry of Science and Technology (MOST), and is on-going. It was the first national R&D program launched by the government. The rationale for the SRD Program is threefold (Ministry of Science and Technology, 1991). First, during the 1960s and 1970s Korea had made a sizable investment in heavy and chemical industries resulting in a gradual shift from the primary industries to the secondary. The Korean government deeply recognized now the need for a national R&D program intended to bolster technological innovations needed in the heavy and chemical industries. Second, as the technological capability based on R&D activities has been recognized as a determinant of national competitive strength and economic growth rate, the developed countries compete more fiercely than ever for technological superiority and become increasingly reluctant to transfer key technologies to the developing countries. So the need for in-house development of the technologies has been increased. Third, as the private sector was still not equipped with the ability to lead technological innovations, it was necessary for the government to initiate government–industry collaborative R&D to induce industrial investment for the technological advancement.

The SRD Program is characterized by its emphasis on the large-scale complex projects which address technologies needed in the future. The program endeavors to provide a base for the technological innovation. It also stresses the cooperation among industries, universities, and GSRIs. The target technologies include information, mechatronics, bioengineering, new materials/energy, and medical/environmental technologies.

An investment of about US$1.47 billion over the period 1982–1992 for 2415 projects was made for

[2] In a program, there are many projects. Our interest is in the evaluation of the projects. Thus, when we say "evaluation of national R&D projects," we mean "evaluation of the projects belonging to a national R&D program."

[3] Stimulated by this collective evaluation, a few research works (Ministry of Commerce and Industry, 1992; Kim et al., 1992; Ministry of Science and Technology, 1993a; Institute of Information Technology Assessment, 1994a; Lee et al., 1994) were performed to develop more systematic R&D planning, management, and evaluation systems.

this program. The government accounted for US$0.88 billion of the investment and the private sector for US$0.59 billion. Two-thousand four-hundred and thirty-nine Korean private firms participated in the program and the number of participants from GSRIs, universities, and industries totaled about 30 000 (Min, 1993). In terms of visible returns, the outputs of 517 projects were commercialized, 390 know-how transfer agreements were signed, 28 venture firms were started, and total royalty income amounted to approximately US$39 million. Besides, about 10 000 scientists, engineers, and technicians were trained through the program (Min, 1993).

2.2. Evaluation practice

R&D evaluation can largely be divided into two types, ex ante and ex post, and there are significant differences between them in terms of evaluation purpose, criteria, timing, and so on. It does not necessarily mean, however, that the two types should follow entirely different procedures. Actually, with respect to the evaluation of the national R&D projects, an almost identical procedure is followed in Korea, and hence they are distinguished only when required in the following discussions.

There is no explicit ministerial statement on the objectives of the evaluation (Kim et al., 1992). The evaluation format, however, states that the purpose of ex ante evaluation is to assess (1) if the research goals and scope are appropriate in terms of the objectives of the program, (2) if research methods are reasonable, and (3) if expected research outcomes are desirable, and that of ex post evaluation is to review (1) if the scientific and/or technological goals are achieved, (2) if adopted research methods proved adequate, and (3) if the impacts to the national socioeconomic development are significant. The MOST has all the authority to coordinate and conduct the evaluation, but suffered from the lack of expertise on specific science and technology areas as well as on the evaluation know-how itself. Hence, Korea Science and Engineering Foundation, authorized by MOST, reviewed the R&D projects, and Korea Technology Development Company, a venture capital company, assessed the commercialization projects on behalf of MOST from 1986 to 1990. MOST has entrusted the evaluation work to Science and Technology Policy Institute (STEPI) since 1991. STEPI [4] now evaluates about 900 projects a year. All the projects are subject to ex ante and ex post evaluations, while the multiyear projects are also subject to interim evaluations (annual reviews).

The projects used to be evaluated only on the basis of written records like proposals and annual or final reports. This document-based evaluation has merits of reduced time and cost, but shortcomings of imprecision and incredibility. Both internal and external evaluations are employed to ensure objectivity and expertise. The internal evaluations are made by the program directors belonging to STEPI. For the external evaluations, experts from academia, research institutes, and industries are invited. For both internal and external evaluations, a weighted scoring method is adopted. At times, mail peer review is used to guarantee confidentiality of reviewers. It is verified that external reviewers sometimes lack proper knowledge and expertise about projects in specific high-tech areas. Also such problems inherent in peer review persist, such as the 'old boys' network to protect established fields, leniency effect, halo effect to fund more visible scientists, universities, and institutions, and partiality based on other non-technical reasons.

Other problems of the evaluation system emerged (Ministry of Science and Technology, 1992a). First, as for interim and ex post evaluations, the discriminating power of the evaluation system was so low that it contributed little to go/no-go or success/failure decision making (Kim et al., 1992). Second, the objectivity and credibility of both ex ante and ex post evaluations were problematic. In a nation where the pool of qualified scientists/engineers is small, experts in a particular area are not easily found, and, as a result, it was nearly impossible to avoid the above-mentioned problems of peer review. Besides, identical evaluation criteria and weights were applied to all the project types, and, hence, evaluation results were often challenged.

[4] STEPI is an affiliate of KIST, and in charge of R&D policy development, R&D planning and evaluation, and R&D managers' training.

Third, ex post evaluation results were not closely linked to subsequent project selection, project/program modification, and R&D policy making, because actual evaluation activities were limited to informing evaluation results to the government (Kim et al., 1992), and the government and the research organizations were not seriously concerned about the use of the evaluation information (Institute of Information Technology Assessment, 1994a). Since 1984, MOST, however, has imposed a sanction on the researchers whose performance is extremely poor. The researchers are prevented from participating in the program for the next 3 years and given a penalty in individual performance appraisals at their own organizations. But the projects classified as poor or extremely poor have been rare, reflecting bias in the evaluation and underutilization of the results.

Recently MOST has formulated *basic directions for evaluation* (Ministry of Science and Technology, 1992a). Under the basic directions, projects are classified into basic/applied research, development, and commercialization, and evaluated with differentiated criteria and weights. The scoring method is supplemented with descriptive sections for the items which are difficult to quantify. Self-appraisal is introduced and reflected throughout the stages of evaluation to compensate for the limitations of reviewers. Evaluation on the process of research is also stressed as well as on the output. Site-visit is included in the ex post evaluation process to reduce superficiality and imprecision of the evaluation. A data base covering all the information related to the projects is to be constructed so that evaluation results may be reflected in the subsequent project selection and policy making.

The five stages of the present evaluation procedure are as follows. [5] At the first stage researchers assess their own proposals or outputs for themselves as guided by the evaluation formats. To discourage arbitrariness, a self-appraiser is requested to write ground information for his or her judgment. At the second stage the self-appraisals and the evaluation formats are mailed to each member of the expert panel consisting of six experts who are selected by STEPI from universities, industries, and research institutes, two persons from each. At the third stage a program director [6] employed by STEPI integrates the results of the first and second stages and draws up the *director's opinion*. For the project selection and mid-term evaluation, the program director first checks how the panel members answered the 'prerequisite' items, which is part of the mailed evaluation formats. The panel members are requested to answer eight 'prerequisite' items. For project selection, four items are related to feasibility of the project, two to qualifications of the applying researchers, and two to expected impediments in performing the project. For mid-term evaluation, four items are related to changes in R&D environment, and four to the possibility of goal achievement when continued. If a specific prerequisite item for a project is indicated to be inappropriate by more than one panel member, or the number of items indicated to be inappropriate (by one or multiple members) is more than three, then the project is rejected in the case of project selection, and put under scrutiny in the case of mid-term evaluation. The fourth stage is comprised of site-visit which is made only for ex post evaluation. The visitors, consisting of an official of MOST, a program director of STEPI, and a panel member, identify and test outputs of the project, and compare them with the written report. They also gather detailed information about the project through open communication with the researchers. The last stage is for the SRD Program subcommittee [7] established by MOST in the related technology area to critically investigate, modify, and approve the project, aided with the director's opinion and the site-visit report. Though it still is not verified whether this multistage approach is effective in view of precision and impartiality of evaluation, it well reflects the strong intent of the Korean government to ensure fairness in the national R&D project evaluation and to use R&D resources more efficiently.

[5] In the ex ante evaluations, site-visits are not required.

[6] There are six program directors at STEPI presently.

[7] There are 20 program subcommittees presently, and each committee consists of about ten external experts invited by MOST.

3. Generic Technology Development (GTD) Program

3.1. Overview of the program

The Generic Technology Development (GTD) Program was started by the Ministry of Commerce and Industry (MOCI) in 1987. While the SRD Program emphasizes the basic technologies and long-term large-scale projects, this program gives priority to technologies required urgently by the small- and medium-sized firms, and which are to be commercialized within 3 years after the project is completed. In selecting projects, research for the small- and medium-sized firms and cooperative research are favored. The program supplies maximally 80% of the total budget until a prototype is developed, and the commercialization and production are to be funded by other sources. The technologies to be developed through this program are identified through the yearly industrial technology demand survey. [8]

There are stipulated qualifications for the applicants. A project should be undertaken by a supervising research institute paired with participating firms. A supervising research institute should retain enough research capabilities for the project and is given full accountability for administration, execution, and reporting results of the project. In contrast, participating firms bear the expense incurred more than government support, and have both the right to utilize the research results and obligation to pay the royalty. One of the distinctive characteristics of the program is that it is a rule for participating firms to reimburse the entire or a part of the governmental fund in the form of royalties for 5 years from the project completion time.

The National Industrial Technology Institute (NITI), an affiliate of MOCI, was authorized to administer the program during the period 1987–1991, and now the Korea Academy of Industrial Technology (KAITECH), a venture capital company, has been entrusted for the management and evaluation of the program since 1992 and conducts what STEPI does for the SRD Program.

By the year of 1992, 1143 projects had been undertaken [9] spending US$3.09 billion. Regarding economic impact of the research results, the program gained US$1.45 billion in balance of international payments through the 377 completed projects [10] (Woo, 1993). In terms of technical areas, electric/electronics had taken up 32% of the total expenditure, mechanics/automation 26%, and materials 18% by the end of 1991. The 772 projects out of 936 projects undertaken by the end of 1991 were performed by the consortia of small- and medium-sized firms, 89 projects by the consortia of large firms, and small- and medium-sized ones, and the rest by the consortia of large firms (Ministry of Commerce and Industry, 1992). It is shown that 88% of the supported projects had been completed successfully, but only 64% of the funded projects had been commercially successful by the end of 1991 (Ministry of Commerce and Industry, 1992).

3.2. Evaluation practice

We can find from the evaluation formats that criteria concerning research goal and method, composition of participating organizations in a project team, possibility of commercialization, and expected trickle-down effects of outcome were considered important in ex ante evaluation, and possibility of commercialization, applicability in the production line, and accumulation of know-how were considered important in ex post evaluation (Kim et al., 1992).

The basic guidelines for the evaluation are fourfold (Woo, 1993). First, objectivity and professionalism in evaluation should be maintained. For this, evaluation procedure, related provisions, and profile of needed projects are publicized in the newspapers and magazines. Reviewers having linkage to a researcher are not allowed to participate in the evaluation. A data base of 1500 experts largely from the

[8] It purports to understand the nature and kinds of technologies urgently demanded in the industries. Korea Academy of Industrial Technology (KAITECH) is in charge of the entire survey process, and about 8000 experts participate.

[9] The number of completed projects is 377, continuing projects 743, and discontinued projects 23.

[10] Import substitution amounted to US$910 million and export to US$540 million.

private firms is built, allowing rapid identification of the most relevant reviewers. Second, independence among reviewers and in-depth evaluation should be realized. External reviewers are guided to assess a project on the basis of personal expertise and conscience, and not to be influenced by any external interest. To achieve quality evaluation, details about the projects are provided to the reviewers at least 7 days before the subcommittee meeting. At the meeting, the secretary [11] in a specific technology area at KAITECH supplies the subcommittee [12] members (reviewers) with pre-evaluation results based on his or her site-visit. Third, demand of industries and commercialization possibilities should be emphasized. The program follows a demand-pull strategy rather than technology-push. Fourth, follow-up of the projects should be made until the time of field utilization. The funded projects are subject to interim, ex post, and follow-up evaluations. Follow-up evaluation examines the degree of the firms' utilization of the project results and the level of royalty to be collected.

At the subcommittees, a weighted scoring method is used in ex ante and ex post evaluations as in the case of the SRD Program, and only a descriptive method is employed for mid-term reviews to make go/no-go decisions. A project is stopped on account of poor performance, and in this case participants of the project should pay back the governmental fund and are prevented from taking part in the program for a few subsequent years. If the project is found to have been sincerely executed in spite of the poor performance, then a sanction may be curtailed (Korea Academy for Industrial Technology, 1993). The representatives of participating firms are asked to submit their opinions about the research results on project completion for the subcommittee's reference. The reviewers can summon and question project supervisors, and representatives of the firms also.

[11] A KAITECH employee is designated as secretary for each subcommittee by KIATECH.

[12] There are 37 subcommittees for 37 technology areas at KAITECH presently. A subcommittee consists of about seven experts (minimum four) and it is required that reviewers from industry account for more than half. The chairman is co-opted among the experts.

In the follow-up evaluation which is held within 6 months from the ex post evaluation, the amount of royalty to be levied to the participating firms is determined by the related subcommittee. When the research result cannot be utilized by a firm, the firm can express *intention of no utilization.* If arguments against the utilization prove to be recognizable, then payment delay, payment reduction, or payment exemption is determined (Korea Academy for Industrial Technology, 1993). If the arguments are not accepted, then royalty corresponding to the governmental fund is fully charged as in the ordinary cases.

For both ex ante and ex post evaluations, the decisions made by the subcommittees are finally authorized by the GTD Program committee [13] established at MOCI.

4. National Telecommunications R&D (NT) Program

4.1. Overview of the program

The telecommunications R&D programs sponsored by the Ministry of Communications (MOC) are the National Telecommunications R&D (NT) Program, Industrial Competitiveness Promotion Program, and Academia Supporting Program. The Industrial Competitiveness Promotion Program was initiated in 1991 to promote technology development and competitiveness of the manufacturing firms in telecommunications, so the underlying rationale and management process of the program are very similar to the GTD Program of MOCI. The program was arranged to be continued until 1996 funding US$25 million a year. The Academia Supporting Program was initiated in 1992 with the purpose of financially supporting academic societies in telecommunications, and, hence, its main recipients are professors. In 1994, the budget assigned to this program was US$3.1 million. The NT Program is the major program sponsored by MOC, and the R&D budget was US$123 million for 59 projects in 1994. We will explain the NT Program only.

[13] The committee is composed of about 15 external experts invited by MOCI.

The administration of the NT Program has been entrusted to the Institute of Information Technology Assessment (IITA) [14] since 1992. IITA deals with six areas, [15] and for each area there is a subcommittee. [16] Top management of IITA consists of experts dispatched from organizations like MOC, Korea Telecom, Data Communications, Korea Mobile Telecommunications, Electronics and Telecommunications Research Institute, and Korea Information Society Development Institute, reflecting the intent of the government to integrate diverse interests and to keep objectivity in spending governmental funds. [17]

4.2. Evaluation practice

From the evaluation format we can infer that the ex ante evaluation aims to review relevance to the program objectives, urgency, adequacy of research strategy and method, and expected impact of outcome, and the ex post evaluation to measure achievement of R&D goals, adequacy of research method, and quality and practical value of research results.

The project evaluation procedure is quite similar to that for the SRD Program. Every project leader assesses his own project descriptively following the guide of given formats. Then, a program director at IITA conducts pre-evaluation for each project in his area, summarizes the evaluation results of the subcommittee, and draws up the *director's opinion.* The R&D management committee [18] integrates and approves the evaluation results of the six subcommittees based on the evaluation opinions provided by the six program directors.

In doing ex ante pre-evaluation, a program director checks if the proposed project is not being supported by another governmental branch or already completed elsewhere, and if the goal of the proposed project is consistent with the goal of the program. One notable feature of the procedure is that, for the mid-term and final evaluation, *milestone reports* are to be appended. At the time of project contract, the time points of checking mid-term performances are agreed between IITA and the project leader, and the mid-term throughputs should be demonstrated according to the schedule.

On the basis of mid-term and ex post evaluations, excellent projects are recommended for awards conferred by the minister of communications. In contrast, poorly scored projects are subject to a sanction administered by IITA. Of the poor projects, those considered to have been conducted faithfully are ordered to complement the outputs, but those undertaken unfaithfully are to be terminated earlier than the schedule and the researchers are to be excluded from the future programs. In 1993, 57 projects were subject to annual review, and of those, seven projects were awarded and four projects were ordered to complement the results (Institute of Information Technology Assessment, 1994b). No project was prematurely terminated.

5. Korean practice and the developed countries

The R&D 'evaluation' system of a nation is largely determined by the specific social role of scientists and engineers, and the structure of the national R&D system. At the same time, policy orientation (mission-oriented or diffusion-oriented) and institutional environment (pluralistic or centralized), which characterize the basic form of technology policy, are also varied nation by nation (Crawford, 1992), and this diversity of technology policy implies variety of approaches to national R&D evaluation (Meyer-Krahmer and Montigny, 1989; Averch, 1990). In this context, a comparative analysis of the Korean practice with those in the developed countries would be of some value. With the

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[14] IITA was established in 1992 to plan, assess, manage, and evaluate the NT Program more systematically and comprehensively, and to coordinate R&D projects conducted by the key companies in telecommunications such as Korea Telecom, Data Communications, and Korea Mobile Telecommunications.

[15] They are exchange systems, transmission systems, radio systems, semiconductor development, computer development, and telecommunications R&D policy.

[16] A subcommittee consists of about 15 experts who are invited from universities, R&D institutes, and public organizations, and private firms. One of the 15 experts is invited as a program director to lead the subcommittee.

[17] Before the establishment of IITA, R&D in telecommunications was handled by a section of MOC.

[18] This committee consists of the six program directors, director of IITA, and other designated external experts.

information which is quite sparingly known to us, we want to try a brief comparison.[19]

To begin with, an apparent difference is to be identified in the basic approaches to R&D project evaluation between Korea and Japan despite the geographical and cultural proximity. While the Korean system employs mainly peer review, Japan depends on in-house self-assessment (Tanaka, 1989). The social contexts in which the evaluation systems have evolved seem to provide some clue for the contrast. In the course of technological development in Japan, the government encouraged knowledge sharing and consensus seeking among key members through the operation of various committees. As a result of the efforts to share and cooperate, they were able to use limited resources effectively and respond to changing industrial technologies rapidly. In this climate of sharing and consensus, reinforced by the social culture of abstaining from criticizing others, an objective evaluation system could not be adequately established (Tanaka, 1989). In contrast, the Korean government had been blamed for inefficient management of national R&D programs, and the organizations specialized in R&D planning, management, and evaluation emerged as a response. In this context of objectivity and control, the peer review approach relying upon independent external experts and emphasis on the ex post evaluation may be a natural evolution.

In the United States as well as in Europe, peer review is used most frequently by research-sponsoring organizations, but also various approaches are adopted to assess proposals and monitor the quality and potential impact of ongoing research (Cozzens, 1993; Kostoff, 1994). They emphasize ex ante evaluation, and have taken pains to enhance credibility of evaluation results. An example is the dual proposal review system for grant applications developed by the National Institutes of Health (NIH) (Kostoff, 1994). In the NIH process, a proposal is firstly sent to a scientific review group, composed mainly of active researchers at colleges and universities, where it is reviewed for scientific and technical merits. Then, the proposal is delivered to an advisory council for a program relevance review. The council also assesses quality of the review of the scientific review group, and prepares recommendations to NIH staff on funding. Finally, the NIH staff rank the proposals, and initiate a funding strategy. Another example is found in the evaluation of proposals by the Office of Naval Research (ONR) program (Kostoff, 1994). A key component of the process is the use of mixed reviewers. By including bench-level researchers, research managers, technicians, systems specialists, and naval officers in one panel, they assured depth and breadth of comprehension of the different facets of the research impact. Furthermore, other methods like non-quantitative case study, anecdotal approach, and quantitative approaches (cost–benefit analysis, bibliometrics, etc.) have been seriously considered to complement drawbacks of peer review evaluations (Roessner, 1989, Roessner, 1993; Lootsma et al., 1990; Kostoff, 1993). Besides, Sweden invites international peer reviewers (Ormala, 1989).

Thus the variety of approaches adopted and the emphasis on ex ante evaluation are different characteristics found in the United States and Europe. These practices in the developed countries apparently imply improvement directions for the Korean system.

On the other hand, the Korean system seems to have some notable features barely found in the developed countries. A wide range of information sources is mobilized. Self-appraisal by researchers themselves is adopted to make up for the limitations of reviewers. Site-visit is included in the evaluation process to minimize superficiality and imprecision of the ex post evaluation. And a pre-evaluation result made by a program director or a secretary is provided to facilitate the peer review process.

It is worth noting that, in the United States, while they put enormous emphasis on ex ante evaluation of R&D projects/programs, attention given to ex post evaluation is relatively negligible. The structural conditions of the US R&D system seem to make retrospective evaluation nearly unnecessary (Cozzens, 1993). This emphasis on ex ante evaluation may be the most important direction that Korea has to follow. The reality in Korea, however, is that SRD and NT Programs require exact ex post evaluation to

[19] An anonymous referee suggested that a comparison of the Korean practice with those of other countries would deepen the understanding of the Korean situation. This section is added along his or her kind suggestion, for which we are very grateful.

discriminate projects to be awarded and to be punished, and the GTD Program also requires follow-up evaluation to decide royalties to be levied to the participating firms. Thus ex post evaluation is important in Korea for the present because the evaluation system is based on the concept of control as mentioned above.

6. Inherent problems and recommendations for improvement

The limited utilization of ex post evaluation results, and the lack of objectivity and credibility in all the evaluations are two major problems inherent in project evaluation of the three national R&D programs in Korea (Lee et al., 1994). In this section, we want to explain the causes of these problems, and to present some recommendations for minimizing them.

Extensive utilization of evaluation results is essential to enhance efficacy of an evaluation system (Ministry of Commerce and Industry, 1992; Lee et al., 1994). That is, an efficacious R&D evaluation system should discriminate exactly among excellent, average, and poor performances, and its results should be linked to subsequent decisions regarding project continuation, project selection, rewards and penalties, commercialization, and program modification (Lee et al., 1994). The present evaluation system is, however, discriminating so poorly that it contributes little to the decision making. It is well shown by the fact that few of the projects evaluated so far have been classified as 'no-go' or 'failure.' [20] There are also complaints that evaluation results are not properly utilized. In one recent report (Institute of Information Technology Assessment, 1994a), more than 37% of respondents indicated dissatisfaction with the scarce utilization of evaluation results in modifying programs and policies, in rewarding good performances, and in commercializing excellent outputs. [21]

For the effective and extensive utilization, (1) the utilization plan should be included in designing the evaluation system, (2) evaluations should be organized in such a way that the relevant decision makers and information users become involved in the evaluation process, and (3) communication between evaluators and important stakeholders should be raised (Ormala, 1989; Luukkonen and Stahle, 1990). Also, the explicit formulation of evaluation purposes seems to be critical for the effective utilization (Ormala, 1989). To legitimate evaluations and ensure support from the stakeholders, a consensus building on the evaluation purposes at each evaluation stage among related parties seems to be an effective strategy (Rossi and Freeman, 1989). Also, reward plans for projects funded by the government should be established at all the research organizations. In order to devise these reward plans, an explicit agreement regarding the rewards between the government and each research organization should be made. Awards for excellent projects and researchers given directly by the government itself as in the case of the NT Program should be expanded.

Another major problem of the national R&D project evaluation is that the objectivity and credibility of evaluations are problematic (Lee et al., 1994). The uncertainty and complexity of R&D and the subjective nature of evaluation imply that R&D evaluation cannot always produce definite and accurate results. "It utilizes methods which are similar to those of science, but the conduct of an evaluation and the utilization of evaluation results are governed

[20] For example, more than 86% of 938 projects of the SRD Program (425 projects were subject to ex ante evaluation, 356 projects to interim evaluation, and 157 projects to ex post evaluation) evaluated during the period 1990–1992 were classified as 'excellent' or 'good' and no project was classified as 'extremely poor' on the five-point scale of excellent, good, average, poor, and extremely poor (Kim et al., 1992). And only seven out of 377 projects of the GTD Program completed by the end of 1992 were classified as 'poor' on the three-point scale of good, average, and poor, and only 23 out of 1143 projects funded by the end of 1992 were discontinued due to poor score (Woo, 1993). Also, not one of the 57 projects of the NT Program evaluated in 1993 (44 projects were subject to interim evaluation and 13 projects to ex post evaluation) was classified as 'poor' or 'extremely poor' on the five-point scale of excellent, good, average, poor, and extremely poor (Institute of Information Technology Assessment, 1994b).

[21] In a questionnaire survey using five-point Likert scales to measure perceptions about the degree of the utilization of evaluation results regarding the NT Program, more than 35% of 158 respondents gave '1' (extremely low) or '2' (low) points and only less than 14% gave '4' (high) or '5' (very high) points to the questionnaire items (Institute of Information Technology Assessment, 1994a; Lee et al., 1994).

by principles characteristic of administration'' (Ormala, 1989, p. 340). Three reasons can be discussed about this lack of the objectivity and credibility of the evaluation (Kim et al., 1992; Lee et al., 1994).

The first reason is the lack of impartiality and expertise of the reviewers. A common feature of the Korean evaluation system is external peer review using panels or mails, in contrast to Japan where in-house self-assessment is mainly used (Tanaka, 1989). The Korean system can be called 'traditional peer review', categorized by Bozeman (1993), as peer experts' judgment is the most important factor. But other factors come into play, especially the *evaluation opinions* of those administering the evaluation system and the self-appraisals of researchers. In these external peer reviews, objectivity and credibility are primarily based on the acknowledged impartiality and expertise of the reviewers. In contrast to the Western countries, however, there are few professional evaluators contributing to the evaluation through independent and objective analysis (Ministry of Science and Technology, 1992b; Lee et al., 1994). It is difficult to identify and select appropriate peer experts because the pool of qualified scientists and engineers is small and there is often no expert in particular high-tech areas. This problem of insufficient domestic experts is indicated in a recent report (Ministry of Science and Technology, 1992a). [22] Also, the oriental cultural characteristics (Tanaka, 1989) such as reluctance to criticize others and paternalism are obstacles to the objective evaluation. In a recent survey (Ministry of Commerce and Industry, 1992), [23] more than half of the respondents indicated negative perceptions about the appropriateness, objectivity, and expertise of external evaluators.

Many previous studies (Domsch et al., 1983; Niiniluoto, 1987; Chapman and Farina, 1988; Bozeman, 1993; Chubin, 1994; Kostoff, 1994) have identified the bias problem inherent in the peer review method and suggested some approaches for improvement. Especially, Bozeman (1993) presented seven guidelines for the application of peer review to R&D evaluations. Our recommendations to improve the present Korean practice are suggested along his seven guidelines as follows.

1. ''Since the subjectivity of peer review is inherent, it is best to supplement a subjective evaluation with less subjective components, rather than seeking to reduce the subjectivity of peer review'' (Bozeman, 1993, p. 91). Thus we need to use peer review in conjunction with less subjective evaluation techniques. Self-appraisal and site-visit evaluation were recently incorporated into the national R&D evaluation process. Self-appraisal is a useful auxiliary instrument because noone has as much knowledge about a project as the researchers themselves, but, they are liable to pursue self-interest. Site-visits can provide rich information, but, as the reviewers are usually not prepared to devote more than 1 or 2 days to a site-visit, the contribution of site-visits is limited. Therefore, approaches based on objective indicators, such as bibliometric approaches (Narin and Rozek, 1988; Melkers, 1993; Narin et al., 1994), patent analyses (Grupp et al., 1990; Ormala, 1994), and economic approaches (Averch, 1989, Averch, 1994), should be considered.
2. Peer review evaluation is likely to be inappropriate for development or commercialization projects where success is related to developing prototypes or commercializing technologies (Bozeman, 1993). ''In such cases peers are often competitors and the application of the technique has, at best, potential for hard feeling and, at worst, potential for litigation'' (Bozeman, 1993, p. 91). Also, it is difficult to identify appropriate peers (Bozeman, 1993). Modification of the evaluation system is needed to reflect this point, especially in the case of the GTD Program where most of the projects are to be commercialized and the subcommittees consist of reviewers mainly from private firms.

[22] In a questionnaire survey using a five-point Likert scale to measure perceptions about the sufficiency of domestic experts, 42% out of 575 respondents gave '4' (insufficient) or '5' (very insufficient) points to the questionnaire item (Ministry of Science and Technology, 1992b; Lee et al., 1994).

[23] In a questionnaire survey using five-point Likert scales to measure perceptions about the appropriateness, objectivity, and expertise of evaluators regarding the evaluation of the GTD Program, more than half of respondents (53%, 55%, and 55% of 193 respondents, respectively) gave '1' (strongly disagree) or '2' (disagree) points to the questionnaire items (Ministry of Commerce and Industry, 1992; Lee et al., 1994).

3. The identification and selection of appropriate reviewers must be an important success factor for the peer review method. However, it is difficult to invite appropriate reviewers because of the limited size of qualified experts in specialized technology areas. Program managers and staff charged with selecting peer reviewers should make a constant effort to stay in touch with the specialized communities of scientists and engineers to accumulate information about who works in what area, the nature and quality of the research, etc., and furnish a complete data base. The reviewers should be constantly asked to be impartial. Also, foreign experts can be invited as in Sweden (Meyer-Krahmer and Montigny, 1989), even though the language barrier should be lifted in advance.
4. In the evaluation of R&D, especially government funded R&D, the advantage of external review is even greater (Bozeman, 1993). It is advisable to avoid 'internal peers.'
5. Subcommittee meetings are held for GTD and NT Programs unlike the SRD Program which uses the mail peer review. The subcommittee meetings are likely to experience dysfunctional group dynamics such as groupthink, bandwagon effect, and domination by more vocal participants (Bozeman, 1993). To guard against these dynamics, it is useful to have a peer reviewer provide a separate, individual assessment before beginning discussions (Bozeman, 1993). Also, it is preferable to adjust the composition of reviewers for the different project types (Lee et al., 1994).
6. It is possible to evaluate the reviewers' reliability and performance, if the evaluation activities of reviewers are well recorded. Then, it will be possible to identify and exclude unreliable reviewers in the future evaluations.
7. It will be helpful to provide reviewers with an explanation about personal biases and potential conflicts occurring in the peer review process (Bozeman, 1993). "While such a bias statement hardly addresses all the possible pitfalls of biased peer review, it can provide a partial remedy" (Bozeman, 1993, p. 94).

The second reason is that the evaluation criteria and the weights for them were not appropriately chosen and adjusted to the changes of R&D environment and to the types of R&D projects. This point was well taken into account in the recent effort to improve the evaluation system of the SRD Program (Ministry of Science and Technology, 1992a). Different criteria and weights are applied along their types (basic/applied research, development, and commercialization). With respect to GTD and NT Programs, this point is not yet considered.

The third reason is that it is not well established (1) to make the evaluation method, criteria, and procedure open to researchers prior to the start of projects, (2) to let evaluation results be known to the researchers, and (3) to provide opportunities for the researchers to appeal.

The fact that researchers are negative about the impartiality of the evaluation is pointed out in a report,[24] and the reasons we present here may be part of the sources of the negative perceptions. It is also argued that responding to this impartiality problem is essential for establishing the positive attitude toward the evaluation.[25]

7. Conclusion and policy implications

As the history of national R&D programs is short in Korea, the R&D evaluation is still in a primitive

[24] A five-point Likert scale was used in measuring perceptions about the impartiality of ex ante, interim, and ex post evaluations in a questionnaire survey on the evaluation of the GTD Program (Ministry of Commerce and Industry, 1992). More than half (59%, 55%, and 50% respectively) of 210 respondents gave '4' (unfair) or '5' (very unfair) points and only less than 15% (11%, 11%, and 14% respectively) gave '1' (very fair) or '2' (fair) points to the questionnaire items (Ministry of Commerce and Industry, 1992).

[25] In a study to identify suggestions regarding the establishment of researchers' positive attitude toward the evaluation (Institute of Information Technology Assessment, 1994a; Lee et al., 1994), an open-ended question was used, and the respondents recommended the following in a descending order: open system, that is, announcement of evaluation criteria and methods in advance, feedback of evaluation results, and opportunities to appeal (29 out of 128 responses), active utilization of evaluation results (26 responses), credible and objective evaluation methods (23 responses), detailed specification of evaluation criteria and adjustment of weights to fit project characteristics (13 responses), fair and objective composition of review panels (11 responses), and communication between reviewers and researchers (10 responses) (Institute of Information Technology Assessment, 1994a; Lee et al., 1994).

stage, and the organizations responsible for R&D planning and management were established only recently. Before the establishment of these entrusted organizations, a section of a ministry had all the authority to manage and evaluate the related national R&D programs, and problems like shortage of experts in program management and evaluation, unfair resource allocation, and non-transparency of the governmental decision-making process had been consistently pointed out.

Increased global competition for technology development urged more efficient use of national resources than ever, and the understanding about acute impact of failure of large national R&D projects on the national economy made the government and relevant interest groups pay more attention to the effective management of national R&D programs. These environmental changes gave birth to such organizations as the Science and Technology Policy Institute (STEPI), Korea Academy of Industrial Technology (KAITECH), and Institute of Information Technology Assessment (IITA) which are responsible for the planning and evaluation of the Special R&D Program, Generic Technology Development Program, and National Telecommunications R&D Program, respectively. Those organizations have sought to develop quality methods and procedures to increase professionalism and fairness in the national R&D evaluation systems.

We explained in this paper how the entrusted organizations are functioning, and what efforts they have made to improve the evaluation systems. We pointed out that, despite the efforts of the government and relevant organizations, there is still much to do to realize effective national R&D evaluation systems. In the previous section, we identified two major problems, that is, the insufficient utilization of evaluation results and the lack of objectivity and credibility inherent in the national R&D evaluation systems, and suggested some guidelines for future improvements in terms of managerial and methodological perspectives.

Now, we want to discuss further the matters having implications for the policy makers. The cooperation among the ministries (MOST, MOCI, and MOC) and the entrusted organizations should be tightened. R&D has become more interdisciplinary and related to more governmental branches. Although the Presidential Advisory Council in Science and Technology provides related policies, daily coordination is to be made among the related ministries and organizations. This has not been satisfactorily achieved (Kim and Dahlman, 1992). Cooperation among the ministries seems to be especially critical for efficient use of the national resources. For instance, most of the R&D projects in telecommunications and information technology are funded by MOC, but MOST and MOCI are also funding R&D projects in the same area to some extent. Hence, to reject duplicated projects, to undertake cross-ministerial cooperative projects, and to transfer own know-hows to other ministries, interministerial coordination is indispensable. This linkage is also needed for the ministries to share the methods and experiences in the R&D project management and evaluation.

Tight vertical linkage between a ministry and the entrusted organization is important, but this linkage should not impinge on the autonomy of the entrusted organization. As a reminder of the rationale of establishing the entrusted organizations, division of roles is necessary. The government is to formulate national R&D policies, and the entrusted organizations are to conduct the professional tasks of managing and evaluating the national R&D programs.

One notable characteristic of the Korean evaluation system is that they use multiple sources of information in selecting and evaluating R&D projects. In terms of reviewers, researchers, and directors of research institutes to which the researchers belong (for self-appraisal), external experts from academia/research institutes/industries, program directors within the entrusted organizations, and expert committees located at the ministries are used. In terms of evaluation methods, semi-quantitative and qualitative methods are employed together. And, in terms of evaluation objects, reports submitted by researchers, site-visit opinions provided by program directors or secretaries, testing of results made by specialized testing organizations, presentations of research results given by project leaders, and opinions of representatives of the participating firms are considered. Combination of diverse information sources will more likely guarantee precise and objective evaluation. However, it requires a great deal of cost and manpower to collect, analyze, and integrate the various data, and to submit evaluation results timely for the political decision-making process. Thus, serious consideration should be made about budget allocation for the evaluation and about raising program managers and related staff members well equipped with appropriate knowledge and experience needed for their tasks.

In order to utilize the evaluation results for policy making and program improvement, the evaluation purposes and utilization plan must be settled at the design stage of evaluation, and consensus on program objectives has to be reached in advance among stakeholders. In addition, evaluation can contribute more to program improvement when it is used in a feedforward than a feedback perspective, hence, a shift of the perspectives and of the expectations on evaluation is to be made in policy-makers' minds.

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