# Public-Private R&D Collaboration in Korea

## A Cross-Sector Survey of Incentive Structures

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The issue of incentives in the transfer of knowledge during public-private R&D collaborations has significance on several levels, but the related literature is generally limited to studies of technology-leading nations. This paper approaches the topic of incentive structures and tests for their presence in Korea, with its steadily developing institutions supporting public-private R&D collaboration. A unique dataset is used based on responses of publicly funded cross-sector (public-private) R&D collaboration project leaders. Based on this largely descriptive study, it is clear that programs promoting cross-sector collaboration have been designed to compensate for variance in incentives among and between research sectors. This, however, does not preclude the possibility that complexities will arise in the future, especially with regard to intellectual property rights.

## Introduction

The amount of public funding allocated for R&D in Korea has dramatically increased over the last fifteen years. Within this distribution of research funds is a subset targeting collaboration, among which particular emphasis is placed upon research collaboration between public and private research entities. Historical trends, changes in the institutional environment, and standardized indicators of technology and innovation (patents and publications) in Korea verify the growing importance of public-private R&D collaboration.

This paper calls for an even closer look at the underlying mechanisms which facilitate successful research in a collaborative context. Given that innovation is found at the intersection of the firm, the university, the government research institute (GRI), and the customer (Powell et al. 1996), scrutiny of such mechanisms will help resolve how and why different research entities approach one another. In terms of Korea, a response to this issue has yet to be studied with hard data, which is surprising given the abundance of reports documenting its remarkable industrial and technological development.

Research partnerships are an innovation-based relationship pooling resources for shared R&D objectives (Hagedoorn et al. 2000). In this way, public-private R&D collaboration is a goal oriented effort to generate results while temporarily bridging differing incentive patterns. This process of coordinating incentives is not uniform across sectors. Powell et al. (1996) focus on four incentives for the upsurge in R&D collaboration from the private firm's perspective: risk sharing, obtaining access to new markets and technologies, speeding products to market, and pooling complementary skills. Public researchers also have much to benefit and are incentivized to engage the private research sector for funding, materials, technical services, industrial credibility, academic recognition, human resources, or to justify the social benefits of one's research (Joly and Mangematin 1996).

The presence and degree to which these incentives affect cross-sector research collaboration has ramifications for science and technology-driven policies and will be examined with regard to Korea. Sufficient understanding of these intangibles in the public-private research relationship allows the policymaker to direct resources with more efficiency. This discussion, thus, progresses beyond popularized calls for greater investments in R&D (Solow 1957), for increasing the rate at which new ideas are discovered (Romer 1990), or for fostering the ability to use such ideas (Jones 2002). Ultimately, the following questions are considered here: Are the method and characteristics of public-private R&D collaboration generating positive outcomes for all concerned parties? Are the goals of the research funding programs consistent with the orientation of the fund recipients? And is the distribution of research funds for such projects efficient?

To clarify the meaning of public-private R&D collaboration, the second section of this paper presents a typology of research types and sectors. The third section discusses the issue of government involvement in matters of public-private R&D collaboration. This is particularly relevant when accounting for the presence of micro-level incentive structures. Three sets of information are then presented with regard to the Korean case: details about Korea's public-private R&D collaboration-related institutions (fourth section), a description of the cases arising from such institutions (fifth section), and the description of a unique dataset of responses from recipients of public funding promoting cross-sector research collaboration (sixth section). These responses are based on both interviews with directors and project leaders of publicly-funded collaborations as well as closed-ended questionnaire responses, all of which is analyzed in the seventh section. The final section of this paper summarizes the findings of this paper and makes key policy recommendations with regard to future R&D collaboration of this nature.

## Typology

The definition of "public-private R&D collaboration" employed here follows closely from the classifications of R&D offered by the *Frascati Manual* (OECD 2002). The *Frascati Manual* also classifies sources of R&D, which are subsequently categorized here as "public R&D" or "private R&D." For the purposes of this discussion, and presented in Table 1, public R&D includes that originating from government research institutes (GRI) and institutions of higher education. GRI R&D is specifically that of all entities of government which furnish but do not sell to the community including (1) services, other than higher education, which cannot otherwise be conveniently and economically provided and (2) administration of the economic and social policy of the community. R&D of institutions of higher education includes that of all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. Private R&D is produced by firms, organizations, and institutions whose primary activity is the market production of goods and services for sale to the general public at an economically significant price.

Based on this typology, the definitions of public-private R&D collaboration are clearly not limited to one single structure, although the focus here is industry-GRI and industry-university collaboration.[1] Accompanying this focus is a series of somewhat strict, albeit realistic assumptions about the

[1] It should be noted that these two collaboration structures are not exclusive of one another. I.e., collaborative projects between the private sector and both types of public-sector research entities (GRI and university) are included under the classification "public-private R&D collaboration".

alignment between R&D types and sources. First, the source of basic research is public R&D, particularly university-based, but also GRI-based research. This is true in spite of the fact that the historical role of GRIs to engage in basic research, as Mansfield (1972) points out for the U.S. case, has been considerably modified and now includes applied research as a goal.

**Table 1.** Research types

| | |
|---|---|
| Basic research | 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. |
| Applied research | Original investigation undertaken in order to acquire new knowledge. It is directed primarily towards a specific practical aim or objective. |
| Developmental research[2] | Systematic work, drawing on knowledge gained from research and practical experience, that is directed to: (1) produce new materials, products and devices; (2) install new processes systems and services; or (3) improve substantially those already produced or installed. |

Source: OECD (2002).

Paralleling the tendency for basic research to be done in the public research sector is the assumption that applied and developmental research is done primarily in the private sector. Holmstrom (1989) points out that small firms engage in innovative projects, but that the high cost of managing such projects for large firms prompts a lower incidence. Yet, in countries which have dominating, large firms – such as Korea – the private research sector possesses the ability and incentive to conduct basic R&D independently of public research entities.

An examination of expenditures in R&D in Korea according to sector and purpose (Fig. 1) shows a clear correlation between the character of work by universities, GRIs, and private firms and expenditure per sector. There are clear parallels between sector and purpose throughout the 1995-2002 period along the lines described above. Further, the simultaneous increase in both private sector and applied research expenditures in 2002 is a result of private sector research projects composed of multiple research types. Basic research, on the other hand, closely mirrors the expenditures of the university, which tends to indicate that Korea's conglomerates do

[2] The *Frascati Manual* uses the term "experimental development" for this third classification of R&D.

not engage in basic R&D, or at least that it is principally done at the university and/or GRI.

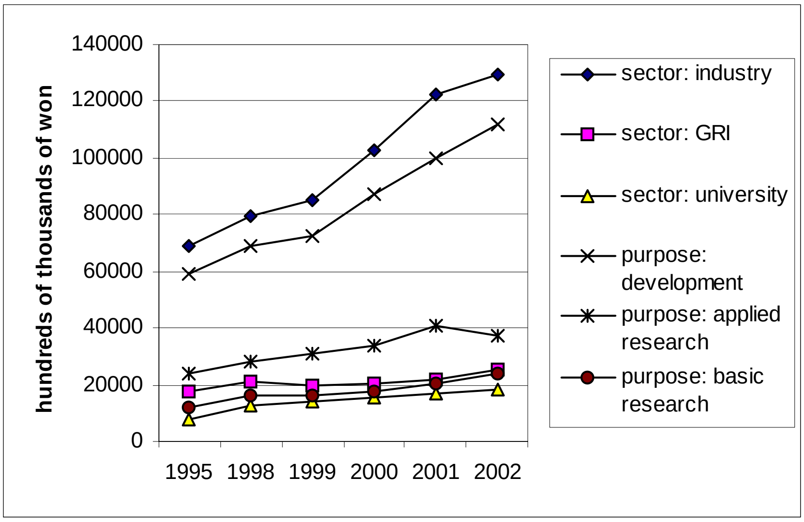


**Fig. 1.** Expenditure in R&D: sector and purpose
Source: ITEP (2004).

## Incentives & Government Involvement

At the heart of a discussion of public-private R&D collaboration is the question whether and to what degree it should be promoted through government involvement or left to develop through market mechanisms. The general consensus is that R&D collaboration is beneficial and should be supported. A full account of public-private R&D collaboration must also treat the complex issue of technology transfer, and the primary aim of this section is to present all sides of the literature in an abridged form. A secondary goal here is to situate the incentive structures of research entities within these arguments in an innovative way.

Support for government involvement begins here with David et al. (2000) and their documentation of the positive effects of government-led R&D upon private R&D at the aggregate level. A similar sentiment is presented in OECD (2004), which emphasizes the necessity for an interface between science and industry. Dasgupta and David (1994) contend that the government must intervene to maintain the efficient distribution of resources for basic and applied research, in spite of the fact that the reputation-based reward system at universities increases the stock of available knowledge. And Fagerberg (2003) adds a level of complexity to the issue of government involvement, pointing out that an increase in interactions between research entities has been found to correct those instances when government support results in tacit knowledge (routines and procedures), which are ultimately nontransferable.[3]

The role of the government in public-private R&D collaboration is complicated, however, when accounting for issues of technology transfer and diffusion. With regard to such technology transfer issues, Mowery et al. (2004) show how licensing and contract research disincentivizes research efforts. This point rests on the tension between a researcher's attempts to minimize transaction costs or to allow codified knowledge to be given rights as intellectual property. In Lenoir's (1998) analysis of the German case, for example, state investment in university research was found to lead to major growth in scientific knowledge and bolstered industry, but only in the presence of a legitimate intellectual property rights (IPR) regime, competitiveness, and positive relations between academia and industry.

This point about whether researchers decide to conduct R&D in-house or in collaboration with research entities is affected by the degree of government involvement and the nature of institutions related to IPRs. Based on this literature review, it is assumed that deficiencies in the IPR regime are partially offset with increased government involvement as a promoter of public-private R&D collaboration.

In light of this balance between policies calling for collaboration and those fostering technology transfer, it is the goal of this discussion to examine the degree and presence of incentives for cross-sector collaboration. Such incentives are an operative mechanism easily overlooked in the process of policy construction, in spite of warranted consideration. An examination begins with the assumption that strong incentive structures call for diminished government involvement. Similarly, strong disincentives for collaboration are correlated with concerns about technology transfer-related issues.

It is expected that an analysis of the relevant data will reveal that incentives are not uniform both in aggregate form or when divided by sector. Variance and imbalances between sectors can be satisfied by nuanced specifications in the funding program. In this way, such variance reflects the need for programs that are not one-size-fits-all. With consistent uniformity or strong incentives for public-private R&D collaboration, there would be little need for the government to incentivize cross-sector collabo-

[3] Fagerberg (2003) states that government support for the provision of knowledge may oversimplify the nature of knowledge, resulting in tacit knowledge.

ration. Along the same lines, strong disincentives prompt a call for examination of the technology transfer regime. The point here is that variance in the measures of different incentives necessitates multifaceted policy orientation.

Incentives have been found to have considerable benefit for R&D collaboration. Mowery (1998) states that they provide knowledge spillovers, accelerate commercialization, and facilitate the transfer of results from public to private sectors. Mowery (1995) also includes, among the advantages of collaboration in research, the ability of firms to lower costs, the ability to lower risks, the ability to reduce the disincentives in R&D with firms arising from appropriability problems for firms, the ability to reduce R&D investments of participating firms, and the ability to exploit the economies of scale in the R&D process. Teece (1986), on the other hand, emphasizes that the successful commercialization of an innovation requires that the know-how in question be utilized in conjunction with other capabilities or assets. Services such as marketing and after-sales support are almost always needed. The degree and presence of these incentives, in particular, will be scrutinized in the following pages.

## Institutional Review

A detailed outline of the development of institutions related to public-private R&D collaboration allows one to make viable policy prescriptions about the efficacy of public efforts to prompt collaboration between these two sectors. In Korea, public-private R&D collaboration began in the 1960s and 1970s, during which imitation was the source of rapid industrialization. This imitation, or “reverse engineering,” of existing foreign technologies required minimal investment in R&D for the production of simple products. Reverse engineering, however, rarely occurs in a vacuum and requires multi-level interactions between the firm and universities and public R&D institutes (Kim and Nelson 2000).

The Korea Institute of Science and Technology (KIST) was established in 1966 as Korea’s first GRI in response to the need for such multi-level interactions. Its purpose was to provide solutions for less complicated technological issues as well as to help internalize foreign technologies. As the industrial focus expanded and the demand for technical support increased in the 1970s, KIST was spun-off into various specialized institutes.[4]

[4] ETRI, the GRI of focus in the subsequent empirical analysis, is one of the principle spin-offs.

As private firms developed their in-house research capabilities, the need for GRIs diminished, and they were restructured in 1982 as part of the Ministry of Science and Technology's (MOST) National R&D Program. GRIs now complemented industry research by engaging in upstream tasks, thereby preventing the weakening of the science knowledge base and duplication of efforts. This project was the first indication that policy directives acknowledged the significance of moving beyond simple imitation or reverse engineering of foreign-based technologies.

To minimize duplication of research efforts and delineate R&D specializations between different ministries, from the mid-1980s, the Korean government began technology planning and evaluation for public R&D programs. This attempt to develop a long-term, strategic approach to R&D called for the participation of both the public and private research sectors. In this way, all research interests were reflected in public R&D programs, which ultimately led to the first concrete cases of publicly instigated public-private R&D collaboration (Chung 2001). Public-private R&D collaboration then took off from 1989, returning to the tradition of adopting foreign-based methods. These replications now come in the form of policy orientation rather than technology-based techniques. For example, the Small Business Innovation Research (SBIR) program and the Advanced Technology Program (ATP) in the U.S. have corresponding programs in Korea.[5]

The New Economic Five Year Plan of 1993 was the first set of policies clarifying the government's role in the transfer of technology from the public to the private research sectors (Choi and Lee 2000). The Plan aimed to facilitate collaboration among research entities from both sectors, and it was followed by the 1995 Support Act for Starting SMEs, which facilitated technology transfer specifically from the public to private sector. The financial crisis of 1997-98 prompted a marked shift in Korea's policy orientation to address some of these alignments, arising in the form of the 21st Century Frontier Technology R&D Program. With goals of raising the degree and number of researchers and reforming Korean universities, the effects upon public-private R&D collaboration will have continued significance.

[5] Korean counterparts for the SBIR program and the ATP are ITEP and CoE, respectively, both of which are detailed here.

## Cases

Competence-building institutions in Korea were designed to generate capabilities for which there was little initial demand. This was initially done through private-sector development and correctly anticipating the future needs of industry. Information exchanges between the public and private sector helped with this process (UNIDO 2005), resulting in a number of funding programs designed in part to continue such exchanges.

There are also methodological advantages to focusing on specific funding programs. Examination of public-private R&D collaboration at this level limits the potential for bias in the data. National reports have indicated that upwards of one-third of all R&D conducted in Korea was done in the context of cross-sector research consortia. It has been pointed out, however, that the overarching nature of particular projects provides a poor description for such consortia (Chung 2001). Describing research towards a single project goal as "independent but coordinated work" is not consistent with the typology of public-private R&D collaboration.

White papers, formal directives, and personal interviews with analysts at government agencies have led to the selection of several funding programs which call for public-private R&D collaboration as a stressed or necessary condition of receiving research funds. The Korea Science and Engineering Foundation's (KOSEF) Centers of Excellence Program (CoE) and Institute of Information Technology Assessment's (IITA) Information Technology Research Center (ITRC) Program provide funding to university-based researchers. GRI-based project leaders were selected from Korea's Electronics and Telecommunications Research Institute (ETRI). Representing private sector participants in public-private R&D collaboration are participants in the Mid-term Technology Development Program (ITEP, for short).[6]

Sources of government funds for public-private R&D collaboration include, but are not limited to, MOST, the Ministry of Commerce, Industry, and Energy (MOCIE), and the Ministry of Information and Communication (MIC). These three ministries are representative of much of the federal obligation for R&D, and the conditions of its provision are highly likely to affect the structure of public-private R&D collaboration. In the case of MOCIE and MIC, funds are provided for R&D on the condition that results are commercialized. MOST, with its stronger emphasis on basic research, orients its programs around long-term knowledge for eventual commercialization. And when funds are given to public institutes, it is not merely inferred, but stipulated that relations with industry should be fos-

[6] See Appendix for a list of abbreviated terms.

tered. The relations between the funding ministry and the research entity are illustrated in Fig. 2.

KOSEF outlined the policy orientation of the CoE over fifteen years ago, but the continuing emphasis is due in part to recent implementations, such as MIC's "839" policy, which is changing the focus of public research institutes from basic research to research that will enlarge the market for particular products. Applied and developmental research is the primary avenue, and public-private R&D collaboration has been identified as a necessary means.

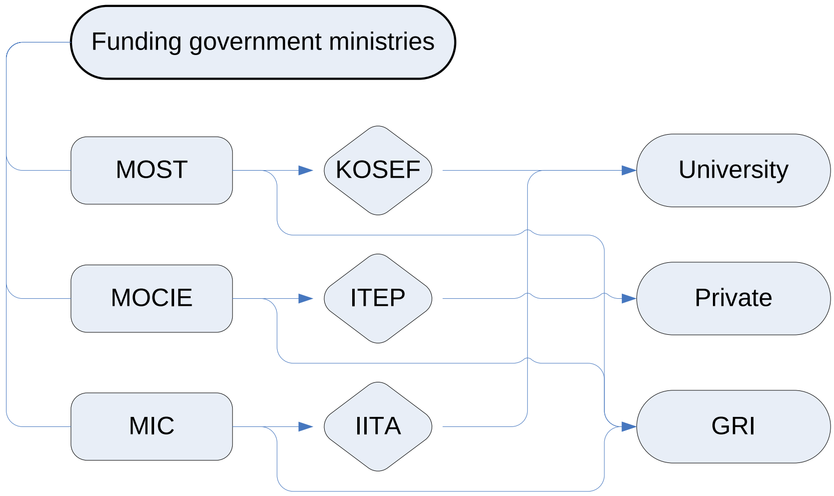


**Fig. 2.** Connections between ministries and research entities

Private investment in public-private R&D collaboration, on the other hand, may occur in one of two ways. A firm may invest in a project involving public researchers at some level, which is a condition of R&D of several ITEP R&D funding programs. Private support may also occur *ex post* as firms purchase final results which are based on close consultation throughout the R&D process. Depending on the case, R&D results may be patented by the university, the GRI, the private firm, or some combination of these public and private entities. In the case of university or GRI patent ownership, the rights to use such intellectual property may be licensed out to the company for a specific period of time.

## Data

There exist several datasets dealing with R&D consortia and partnerships. Management-based studies, such as those of Sakakibara (1997) and Mowery (1990, 1998), focus on cases of public sponsorship of private R&D consortia, but these largely exclude the precise influence of the public R&D entity. In addition, there is a complete absence of data with regard to the Korean case. Here, an attempt is made to address both of these deficiencies through survey research. Several examples of survey-based research are presently available, including that of Mansfield (1991), Klevorick et al. (1994), and Blumenthal (1986), who all attempt to make a qualitative analysis with parallels to this discussion. Also lending support to the survey method is the fact that, among the more than eighty studies of the ATP, eleven are based on survey methods (Ruegg and Feller 2003).

To minimize sample selection bias, respondents of this survey are limited to directors of research centers and managers of projects that have received public funds for research on the condition that cross-sector collaboration occurs. These programs have been highlighted in the previous section: KOSEF's CoE, IITA's ITRC Program, instances of public-private R&D collaboration occurring at ETRI, and ITEP's Mid-term Technology Development Program. The data and results are subdivided into qualitative and quantitative sections, both of which are based on the responses of project leaders and directors of public-private R&D collaborations.

The qualitative components of this study are based on 38 survey-based interviews held with 15 CoE directors and 23 ETRI directors. Interviews were standardized, but responses were open-ended in nature. The results of these interviews were fruitful, both in terms of direct findings as well as their contribution to the construction of a closed-ended questionnaire suitable for quantitative analysis. It should be apparent to the reader that the open-ended interviews were conducted only with public-sector research directors and project leaders, while the closed-ended questionnaire results include responses from both sectors. Confidentiality issues prevented interviews with ITEP participants, but the approval and distribution of the closed-ended questionnaires by ITEP managers helped ensure a relatively healthy response rate (see Table 2 for details).

The quantitative section of this study is based on a maximum of 125 questionnaire responses from research project leaders and research institute directors, all of whom are recipients of public research funds in one of the aforementioned programs. The overall response rate is 44 percent (see Table 2). In total, 1,742 public-private R&D collaborations have been supervised by this sample of research directors and project leaders, from

1997 to 2005 (987 and 755 projects for public and private sector respondents, respectively). The questionnaire was distributed and collected by the author, ministry-level officials, GRI-based directors, and government agency officials.

Questionnaire responses are structured on a seven-point Likert scale, with “1” and “7” representing the least and greatest values, respectively. Five different measures are used to assess perceived knowledge spillover and complementary assets. The five measures examine (1) the amount of general complementary knowledge transfer via collaboration (*getcomp1*), (2) the degree of specific complementary knowledge transfer via collaboration (*getcomp2*),[7] (3) the degree to which collaboration boosts the capabilities for typically other-sector research projects (*getcomp3*), (4) the degree to which collaboration boosts one’s capabilities to identify typically other-sector research projects (*getcomp4*), and (5) the degree to which collaboration provides valuable technical know-how (*getcomp5*).

**Table 2.** Questionnaire response rates

| | Sent | Received | Response rate |
|---|---|---|---|
| ETRI | 99 | 49 | 0.49 |
| CoE | 66 | 24 | 0.36 |
| ITRC | 43 | 27 | 0.63 |
| ITEP | 118 | 42 | 0.36 |
| Overall | | | 0.44 |

To confirm the degree and facilitation to which results are transferred from one sector to the other, three measures are introduced. The first considers the degree to which collaboration allows researchers to apply know-how to commercial projects (*collop*), which is the underlying goal for the programs calling for increased cross-sector research mentioned above. The second measure looks at the degree to which collaboration increases one’s infrastructure (*collinf*). The third measure considers the frequency of use of other sector’s know-how in particular projects (*usefultech*).

Before formally testing for the presence and degree of incentives based on the dataset described above, it is useful to examine related findings from the questionnaire. The quantitative data extends from 1997 to 2005 in

[7] The difference between *getcomp1* and *getcomp2* is not subtle. The former is based on the transfer of market knowledge (from the private to public sector) and basic R&D knowledge (from the public to private sector). The latter is based on the receipt of information about customer needs and trends (from the private to public sector) and cutting-edge technologies (from the public to private sector).

an attempt to control for variation during the economic crisis.[8] This time period presents some notable trends with regard to the 125 respondents under examination here, especially when comparing results by sector. For one, there may be implications for the basis of each sector's incentive structure. This is especially true when considering the numbers of patents and publications arising from public-private R&D collaboration. The standard assumption is that patents are more closely associated with private research efforts, while publications are emphasized by the public sector, especially universities.

The number of cross-sector projects from 1997 to 2005 exhibits a lag for the private sector (Fig. 3), but the 2005 datapoint shows that the two sectors are now nearly the same. This is also the case for the average number of patents (Fig. 4) and publications (Fig. 5) arising from public-private R&D collaboration. Patents exhibit only a slightly higher average for the private sector, especially since 2002. The difference in average number of publications is greater, albeit at a diminishing rate since 2002. What these convergences imply for incentives to collaborate is not entirely clear. At this point, claims can be made that public and private project goals are becoming increasingly correlated, in spite of clear differences in industrial affiliation (Fig. 6).

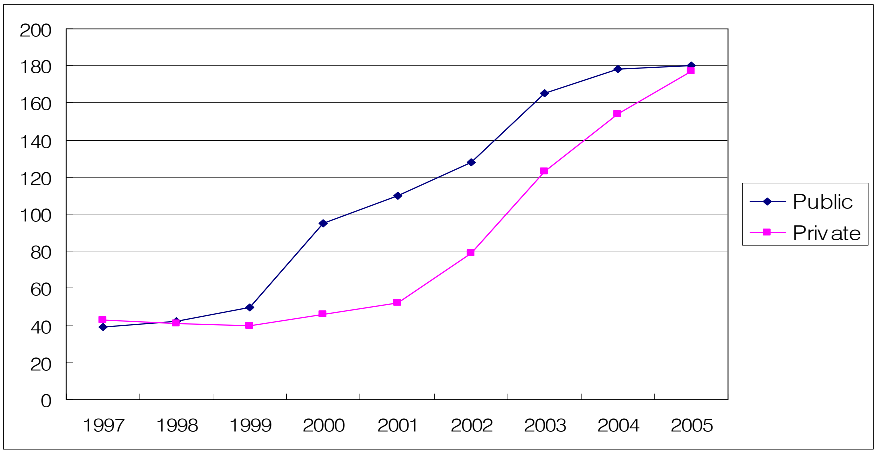


**Fig. 3.** Number of projects with other sector

[8] The eight incentive measures described above are not longitudinal in nature, however.

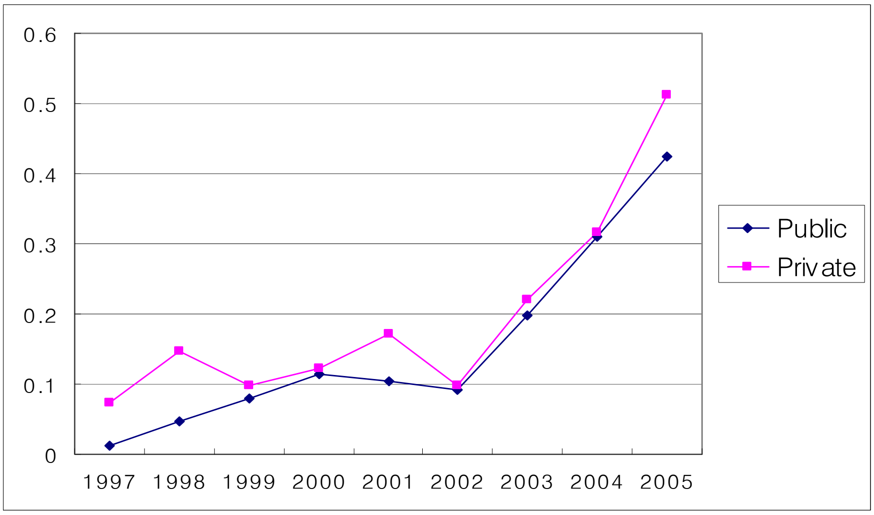


**Fig. 4.** Average number of patents arising from collaboration

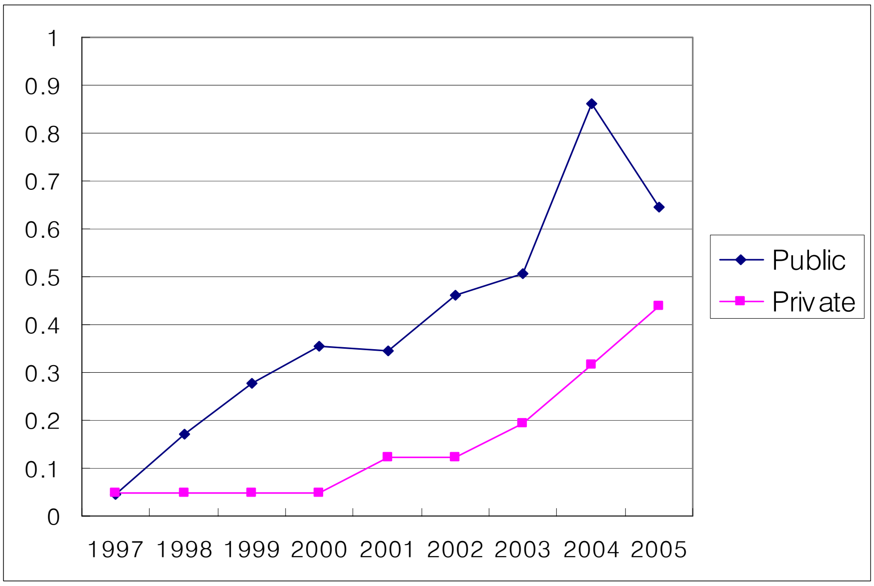


**Fig. 5.** Average number of publications originating from collaboration

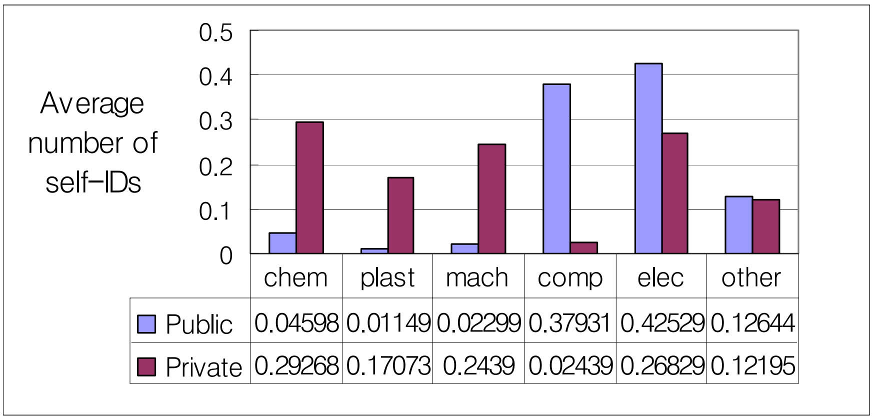


**Fig. 6.** Industrial affiliation by sector
Note: Abbreviations are as follows: "chem" - chemical manufacturing; "plast" - plastics and rubber products manufacturing; "mach" - machinery manufacturing; "comp" - for computer and electronic product manufacturing; "elec" - electrical equipment, appliance, and component manufacturing; "other" - all other sectors.

## Results

### Qualitative Results

A total of 38 interviews were held with public-sector research directors: 15 CoE directors and 23 ETRI directors. The results of these surveys are subdivided here into three sections. Again, it should be noted that these open-ended questionnaires are based solely on the responses of public research directors and project leaders.

Type of public-private R&D collaboration: The impetus for collaboration is primarily structured around improving the use of a particular technology and ultimately commercializing the results. To this end, industrial consortium and industrial researcher education programs have been established to promote the research contents of the public research institute. Technical advice on general or detailed issues may be provided to companies, which may or may not be incentivized with an honorarium or fee. As well, collaboration may provide private firms with the opportunity to use facilities which are not otherwise available.

In other instances, public-private R&D collaboration is based on developing new technology (machines or processes). The partnership is based on the supply of specific components by the private partner, which facilitate the research efforts of the public institute. The private partner, usually an SME in this case, is typically specialized in the manufacturing of such components and may also be accessed to generate specific components for the finished R&D result. Many research subjects stressed that the private firm was an invaluable source of components which would have been extremely difficult and costly for the public R&D institute to produce.

Public R&D directors also pointed to the effects of patenting institutions upon public-private R&D collaboration. In many cases, the private firm engages in collaboration with the sole purpose of patenting the R&D results. This conclusion is consistent with Fig. 4. Royalties from the privately-sponsored patent are returned to the public research institute. There are, however, complications regarding royalty policy which create a disincentive for private firms to become involved with public research institutes. At times this can lead to a stand-off of sorts following the completion of an R&D project. That is, no outcome is presented which has benefits outweighing the costs of losing rights to the intellectual property.

Project design: In 26 percent of the survey responses, projects are designed in the public sector while recognizing the demands of industry. Another 34 percent of the survey responses – all ETRI-based – showed that the projects are designed primarily at the public institute, but that the private firm may be involved in project design in varying degrees from the project's early stages.

Nuanced versions of these responses are rooted in the various forms of discussion which may result between partners. For example, basic ideas may be provided by the public research institute, which are then confirmed by the private firm. The line of communication may also be more mutual in nature as public institutes inform the private firm of their capabilities and discuss a proposal for the private firm's review. Conversely, the private firm may approach the public institute with a specific problem. This point, in tandem with the property rights issues mentioned above, indicates that a more concrete design process will minimize uncertainties about project goals and expectations. Avoiding uncertainties may not be possible and, indeed, such uncertainties seem to be inherent in public-private R&D collaboration.

Complementarity: Differences in particular knowledge between the public and private sectors is emphasized. Industry provides information about current application areas and estimates of technology demand, while public research takes a more long-term perspective of a particular technological development. The need for practical information from the private sector was viewed as essential for the generation of practical and commercializable results. Public researchers are responsible for the generation of core research results or prototypes, while private researchers facilitate the process toward commercialization.

## Quantitative Results

To supplement the above findings, formal estimates are presented here of the degree and presence of incentives for cross-sector collaboration. Such incentives are believed to be an operative mechanism in the balance of policies calling for collaboration and those fostering technology transfer. It is expected that incentives are not uniform in aggregate or across sectors. Uniformity of incentives or disincentives calls for, respectively, further investigation of state involvement or of the institutions of technology transfer.

Two areas of incentives are considered, in line with existing research on the issue of R&D collaboration. The first area of incentives – the degree to which collaboration provides knowledge spillovers and combines complementary assets – is studied with *getcomp1*, *getcomp2*, *getcomp3*, *getcomp4*, and *getcomp5*. The second area of incentives measures the degree to which results are transferred from one sector to the other, evidenced by *collop*, *collinf*, and *usefultech*.

An analysis of this array of incentive measures for public-private R&D collaboration will ensure that the tendency for uniformity is sufficiently tested. Taking up the issue of knowledge spillovers and complementary assets, Fig. 7 presents the aggregated responses for *getcomp1 – getcomp5*. A cursory look at the distribution of responses shows that uniformity is not present among these responses. The fifth measure (*getcomp5*) is weighted at the low end, the second and fourth measures (*getcomp2* and *getcomp4*) are weighted at the high end, while the third measure (*getcomp3*) is weighted even higher. The first measure (*getcomp1*) approximates the normal distribution.

Chi-square tests according to sector indicate that, for the second, third, and fourth measures (*getcomp2*, *getcomp3*, and *getcomp4*), the public sector exhibits a statistically significant, larger number of high scores than the private sector (see Fig. 8). As such, incentives surrounding the transfer of general complementary knowledge and valuable technical know-how are similar across sectors. The incentives to collaborate based on specific complementary knowledge transfer and the boosting of capabilities to conduct and identify typically other-sector research projects are not similar, however.

Turning now to incentives related to the transfer of results from one sector to the other, the disaggregated results are presented in Fig. 9. There is no statistically significant difference between incentives for each sector with regard to cross-sector collaboration’s effect upon the application of know-how to commercial projects (*collop*) or upon the increase of infrastructure (*collinf*). Chi-square tests according to sector, however, show that there is a strong difference between sectors in terms of the frequency of use of techniques or instrumentation developed by the other sector (*usefultech*). As was the case for the first group of incentives, there is nonuniformity both within and between sectors.

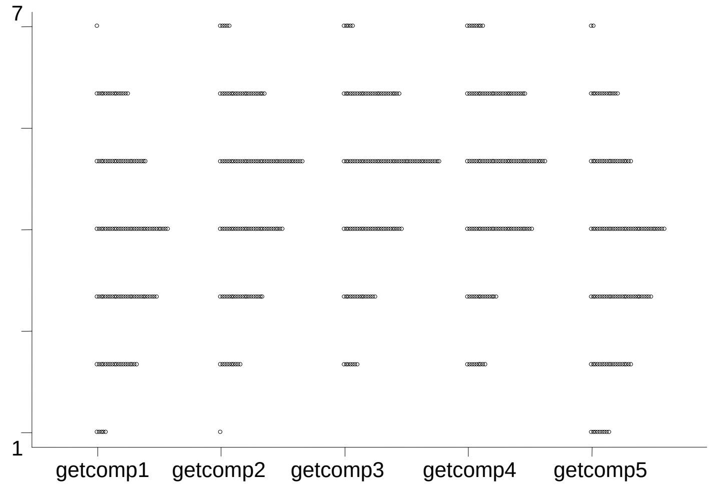


**Fig. 7.** Aggregate results for *getcomp1 – getcomp5*

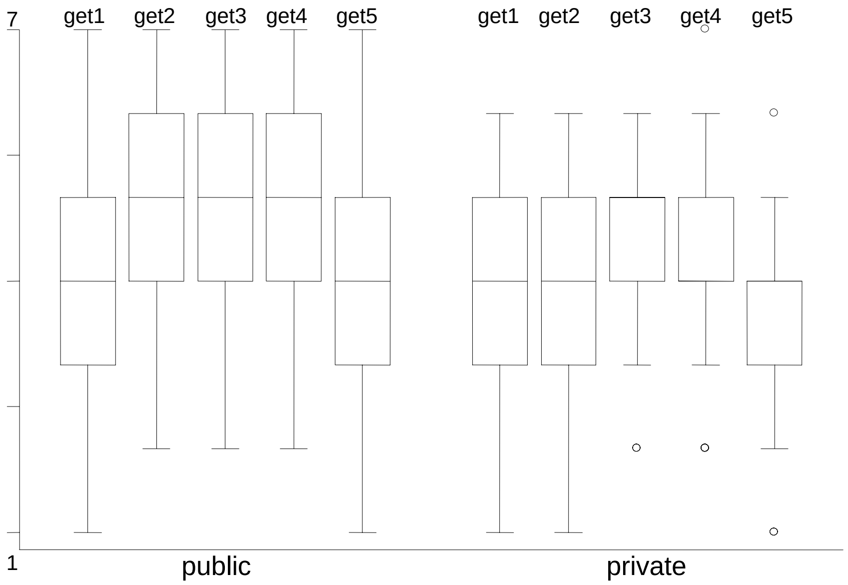


**Fig. 8.** Results for *getcomp1 – getcomp5* by sector
Note: Abbreviations are used ("get1" for getcomp1, "get2" for getcomp2, etc.).

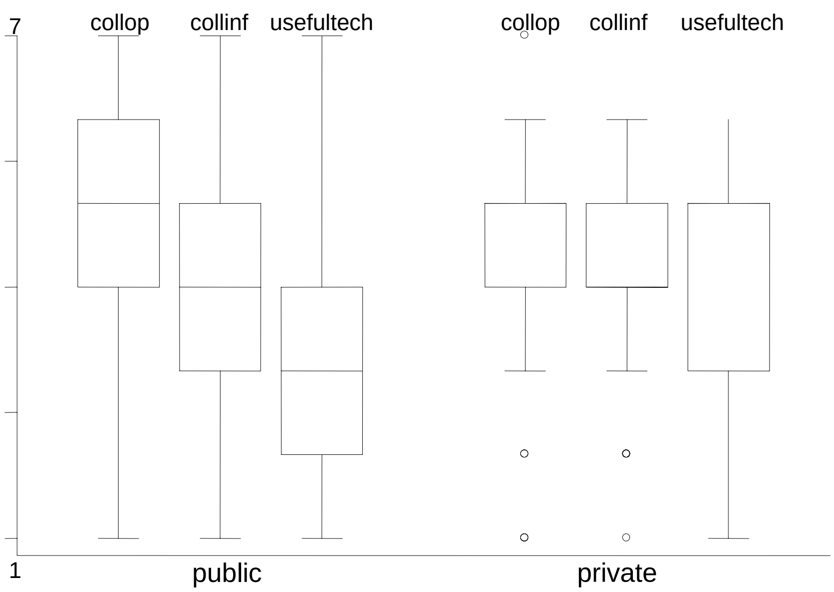


**Fig. 9.** Results for *collop*, *collinf*, and *usefultech* by sector

## Conclusion

This discussion has detailed public-private R&D collaboration in Korea from several perspectives, and an important policy-related claim has been offered and tested: Given that incentives for public-private R&D collaboration matter, is the Korean government misallocating resources? It has been found that programs calling for cross-sector research collaboration are sufficiently accounting for the incentives of public and private research entities. This conclusion is reflected for the most part in both the qualitative and quantitative results, which present a picture of broad R&D collaboration types, uncertainties about end results, and variance in incentive structures both within and across sectors.

To supplement this research question, a thorough review of Korea's institutional development with regard to cross-sector R&D collaboration is presented. This review indicates that Korea is continuing to move away from the precedent of duplication of foreign-based technologies. At the same time, the method of generating innovations in a cross-sector collaborative context strongly resembles programs like the U.S.'s ATP and SBIR Program. Modifications persist, though, such as the 21st Century Frontier Technology R&D Program, which was established following the 1997-98 financial crisis.

The unique dataset employed here, based on responses of contemporary participants in public-private R&D collaboration, illustrates that the public and the private sector may not be as ideologically distinct as was once thought. Average numbers of publications and patents arising from each sector seem to be converging over time. Before setting out on this research project, it was presumed that public-private R&D collaboration was not developed to the point where returns were consistent or predictable. In reality, this convergence in patents and publications indicates overall consistencies in the national R&D program. One can sense that the national innovation system of Korea will continue to capitalize on the joint capabilities of the public and private sectors.

Despite the fact that the results of this discussion are largely positive, the issue of government involvement is still not wholly resolved. Indeed, qualitative results show that there are complications to establishing intellectual property rights between collaborators beforehand. The inability for research entities to properly anticipate the ownership rights of public-private R&D collaboration results is not only a fault of the research project planners, but could also reflect a lax IPR regime. Of course, from a policy perspective, it might also illustrate the difficulties of creating a balance between one-size-fits-all programs and over-specified programs which exclude more abstract projects with potentially greater returns. Further investigation will undoubtedly serve to clarify these points.

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## Appendix: List of Abbreviations

| | |
|---|---|
| ATP | Advanced Technology Program |
| CoE | Centers of Excellence |
| ETRI | Electronics and Telecommunications Institute |
| GRI | Government research institute |
| IITA | Institute of Information Technology Assessment |
| IPR | Intellectual property rights |
| ITEP | Korea Institute of Industrial Technology Evaluation and Planning |
| ITRC | Information Technology Research Center |
| KIST | Korea Institute of Science and Technology |
| KOSEF | Korea Science and Engineering Foundation |
| MIC | Ministry of Information and Communication |
| MOCIE | Ministry of Commerce, Industry, and Energy |
| MOST | Ministry of Science and Technology |
| SBIR | Small Business Innovation Research |
| SME | Small and medium enterprise |