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UNIVERSITY-INDUSTRY RELATIONS AND DEVELOPMENT OF ADVANCED TECHNOLOGY IN KOREA

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<Abstract>

A principal objective of this paper is to identify and examine some of the alternative research systems for stimulating technological development. Two proposals for major institutional framework for research and development have been presented. They reflect two different perspectives: one concerned with strengthening government-run research institute, which has been dominant force in Korean science and technology development, the other, concerned with establishing new relationships between universities and industries. There has been little public debate, up to now, over these proposals in Korean government and scientific community, but there has been continuing controversy over the issue of creating the necessary infrastructure for the development of science and technology. Three questions in particular will be examined. The first question concerns how scientific development is related with technological development. Interaction of science and technology may be the variable that is of central concern, but so far it has proved extremely difficult to conceptualize and operationalize. This issue is compounded greatly by such factors like innovation and manpower problems. The second question concerns identifying proper role of three subsystems (i.e. universities, industry, and government) in terms of their characteristics in the national research system. The third question concerns the way in which we can strengthen the country's science and technology potential by creating the necessary infrastructure for the development of advanced technology.

産學關係와 高等技術의 開發

김선호
행정학과

<요 약>

이 논문의 목적은 技術開發을 촉진하기 위한 硏究體制를 식별하고 검토하기 위하여 硏究開發의 제도적 틀로서 정부출연구기관을 강화하는 방안과 산학협동의 새로운 관계 정립을 모색하는 방안에 관하여 논의를 하였다. 특히 科學과 技術의 相互作用, 國家硏究體制의 세 下位體制인 대학, 산업, 정부의 역할, 그리고 고등기술의 개발을 위하여 필요한 下部構造를 창조함으로써 국가 과학기술의 潛在力을 강화할 수 있는 방법을 중심으로 고찰하였다.

1. STATEMENT OF THE POLICY ISSUE

The rapid success in Korean industry particularly up to the late-70s has been largely attributed to several major factors, as seen by many observers in Korean industry. Above all, a superior and abundant labor force was the most significant factor which enabled Korea to maintain a competitive position in the international market. However, the rising wage level in Korea, along with competition from other low wage countries of Asia in recent years, prompted Korea more resolutely to develop high-value-added products based on modern facilities and newest technologies.

The need for Korean industry to shift to "knowledge-intensive industries" means calling for phasing out smokestack industries and developing high-tech industries. That is, Korean government must help industries make shift to high technologies. For example, steelmakers are encouraged to move into new materials and alloys. Petrochemical companies are moving into biotechnology and new chemicals, and shipbuilding companies are developing robots and semiconductors.

One powerful reason for this shift to high technologies is the drying-up of technology flows from the West. Up to now, Korea's technological development has heavily relied on using foreign technology. It can be said that Korea's main goal is to catch up with western technology. Such a pattern, however, will not be allowed to continue.

In the past Americans were lax about selling technology to Korea. But, now, the United States is limiting technology transfers to Korea. Therefore, Korea needs to develop its own creative technologies to use as bargaining chips in exchange for western technologies and as a potential source of new revenues as worldwide protectionism threatens to reduce Korea's exports of goods and services.

Without any doubt advanced countries owe their high degree of industrial and economic development to dynamic technological changes. Achievements in science and technology pave the way for the development of new technologies, while technological progress leads to the exploration of new areas of science and technology. Thus science and technology move ahead at an accelerated pace in a close relationship, and the results of research and development clear the way for the establishment of new enterprises to produce new items with new know-how, a process which, spreading to all other industrial fields, improves the industrial structure.

People in a developing country, however, often wonder if investment in research and development might be wasteful since science and technology in a developing country are not directly linked to production. Economically, developing countries do not have the capacity to absorb the enormous investment write-offs required for such development while their small, weak industrial structures restrict the application of science and technology as well as its development. Also, university and government research centers are understaffed, equipment is outmoded, and facilities are substandard. Hence, it has been said that the development of technology within a developing country is, for all practical purpose, out of question, and many treated subject as though any such concept were simply an intellectual exercise.

Also, it is often asserted that any need for sophisticated technologies easily can be met through the transfer of technology from develped countries. However, a pressing need to possess indigenous sources of technological development in tune with national requirements is widely felt in the developing countries. The most important task facing developing countries in their pursuit of scientific and technological development is, then, to lay a foundation for such development and then to absorb the advances. Policy makers are interested in knowing how to arrange institutions for carrying out scientific activities.

A principal objective of this paper is to identify and examine some of the alternative research systems for stimulating technological development. Two proposals for major institutional framework for research and development have been presented. They reflect two different perspectives: one concerned with strengthening government-run research institute, which has been dominant force in Korean science and technology development, the other, concerned with establishing new relationships between universities and industries. There has been little public debate, up to now, over these proposals in Korean government and scientific community, but there has been continuing controversy over the issue of creating the necessary infrastructure for the development of science and technology.

Three questions in particular will be examined. The first question concerns how scientific development is related with technological development. Interaction of science and technology may be the variable that is of central concern, but so far it has proved extremely difficult to conceptualize and operationalize. This issue is compounded greatly by such factors like innovation and manpower problems. The second question concerns identifying proper role of three subsystems (i.e. universities, industry, and government) in terms of their characteristics in the national research system. The third question concerns the way in which we can strengthen the country's science and technology potential by creating the necessary infrastructure for the development of advanced technology.

2. BACKGROUND AND PROBLEMS

2.1. History of Korean Science and Technology Policy

With increased recognition of the importance of science and technology in national development, many countries are striving to develop science and technology under nation-wide programs and to carry out such programs. The R & D enterprise in the modern nation-state is an essential component of economic growth, international competitiveness, productivity, and employment(Miller and Pickarz, 1982) because scientific knowledge can be deliberately exploited to obtain desired technological improvements and, in turn, achieve specific private and public objectives (Spiegel-Rosing and Price, 1977).

Korea made remarkable achievements in laying a foundation for the development of science and technology in the 1960s, but to accelerate technological innovations in the 1970s and 1980s. R & D expenditures have been rising rapidly in recent years in both absolute terms and relative to the size of the economy. Rising from $224 million in 1977 to $3,381 million in 1989, total Korean R & D expenditures reached nearly 1.92 percent level of GNP in 1989 from 0.6 percent in 1977. The rapidly increasing trend in R & D is indicated also by the trend in research personnel involved in R & D. The total number of researchers increased from about 13,000 in 1977 to more than 66,220 in 1989.

In 1967, Korea inaugurated the Ministry of Science and Technology (MOST) as the central government agency responsible for the administration of science and technology. At the same time, Korea made the development of science and technology an integral part of its national development policy. Before the inauguration of the Ministry, the advisory function for the President regarding the science and technology had been performed by the Economic and Scientific Council, while the Economic Planning Board was in charge of part of science and technology administration. The inauguration of Ministry of Science and Technology, however, enabled the country to push science and technology development in consonance with the economic development plan. On this basis, the nation embarked on building up an infrastructure for science and technology during the 1960s.

As for the formulation of science and technology policy, MOST draws up draft policy reflecting the wide-ranging options of those in economic and scientific fields, and these draft policies are confirmed pending evaluation and review by various science and technology-related committee, as well as consultations among relevant government ministries. Especially, important policies and plans are determined after review by the National Council for Science and Technology, which is the top national council responsible for the evaluation of science and technology. The Council was established in 1973 to promote the development of science and technology with all government agencies participating. Regarding the execution of science and technology policy, relevant ministries formulate annual plans and implement them under a long-term design in accordance with the Science and Technology Promotion law which was enacted in 1972; this law regulates the basic government measures for the overall development of science and technology in the country. However, this law was mainly aimed at providing business firms with financial and tax privileges to induce technological development.

2.2. Goals and Objectives

One of the basic missions of the Ministry of Science and Technology is to develop sound research system. Major goals in Korean science and technology policy are: 1) development and maintenance of manpower of a quality and quantity to meet national science and technology needs, 2) establishment of an implementing structure to insure that public and private institutions, programs and policies will exist to support the essential role of science and technology in the life of nation, 3) broad development of industrial technology with special attention to the strategic high technology industries, 4) establishment of a climate of public understanding, participation and commitment in support of science and technology.

2.3. Problem Situation

Most of these goals and objectives represent fundamentals in the sense that they represent bases established to support the total development of science and technology. Many of these objectives are now in the process of being achieved with the desire to catch the industrial development of Japan (choi, 1975). However, restricted resources, manpower and financial means limit the scope of science and technology activities and the degree of specialization which could be brought to bear on national problems. As a result, activities has been limited with short-term and immediate problems, while the more diverse and long-term prospects, which are also inherently more risky, have not received much attention.

In the manufacturing industry, the R & D effort is still too small to cope with the needs of government and industry. This is definitely the weakest area where the largest effort is required in the years to come in order to bring the existing manufacturing industry up to full international competitiveness and productivity, and to develop new advanced technologies. This situation within industry is largely due to the low levels of government funding and manpower, the insufficient contribution of the private sector to R & D spending, and inappropriate infrastructure for the development of science and technology. Also, Korea's R & D effort is confined to a handful of research teams, often working in isolation and with scant material resource and endeavoring to achieve results in a society where scientific and technical research is rare activity, far removed from the everyday concerns of the population and hence little known, little appreciated and little understood as to its constraints. The correction of this situation is one of the principal issues of science and technology policy in Korea.

At the heart of Korean science and technology policy are its research and development programs, which are designed to give Korean industry a competitive edge internationally. It needs to develop a wide variety of leading-edge technologies, including supercomputers, new semiconductors, jet engines, biotechnology, optoelectronics, new alloys, biochips, communication satellites, robots, and solar energy. This was based on underlying premises that high technology development produces economic advantage across a broad front going well beyond the specific high technology sector in question (Nelson, 1984). Because of their long planning horizon, capital intensiveness, a high R & D content, and focus on basic research, these programs can be viewed by industry leaders as the main engines for Korea's economic growth in the twenty-first century. To achieve technological superiority in these fields, it needs to understand the underlying rationale for high technology development.

3. SCIENCE AND TECHNOLOGY INTERACTION

The rapid growth of technology during the last century was closely associated with the process of industrialization which was initiated by technological advancement. At that time the links between science and technology were very tenuous. Most of inventions, therefore, were the products of ingenuous intuition rather than the result of extensive scientific studies. This practice has been changed completely in our century now that the time interval between a discovery and its application has become shorter.

Thirty-five years elapsed after Faraday's discovery of the induction law before Siemens invented the generator which transforms mechanical power into electricity. There were only three years between Hahn's discovery of Uranium fission and Ferimi's first reactor experiments which proved the feasibility of releasing nuclear energy for technical purposes. These examples demonstrate in a very impressive way the remarkable narrowing of the time interval between a scientific discovery and its application. Indeed, there is ample reason to suppose that this interval will become shorter and shorter the more science and technology progress and the closer their interaction.

There is no doubt that technology still continues to advance along its traditional lines and that trial and error method remains an essential tool in its progress. On the whole, however, science is nowadays the main promoter of technology and consequently the cause of its rapid expansion. Also, advances in instrumentation and experimental techniques have been of major importance in enabling radical innovation in science and technology (Price, 1984). The case of semiconductor suggests that the relation between science and technology is symbiotic (Gibbons and Johnson, 1982) rather than technology is applied science. The important problem is not concerned with choosing, rather academically, a suitable starting point from which the transistor can be seen as the logical development, but rather the mechanism where by new concepts diffuse into existing practice and stimulate not only technology but science itself.

As a result of this tremendous acceleration in human activities, more attention is paid nowadays to the scientist who causes the changes in the environment rather than to the engineer who simply transforms new scientific ideas into technical hardware. Also, since modern science and technology are so tightly interwoven with one another, it is not nowadays possible to make clear distinction between the fields which are of interest to the scientist and those which are of interest to the engineer. In a great many cases, therefore, an engineer may be considered a scientist, and vice versa.

4. TECHNOLOGICAL ADVANCE AND NEED FOR DIRECTED BASIC RESEARCH

There are no recipes for the successful development of advanced technology in industry. However, it is important to recognize the essential uncertainties which surround the question - where should R & D resources be allocated - in an industry where technology is advancing rapidly. There are generally a wide number of ways in which the existing technology can be improved. It is uncertain which of the objectives most worthwhile pursuing, and which of the approaches will prove most successful. Also, a key characteristic of the R & D environment is differences of opinion and vision. The fact that different people look at a problem in different ways and see different things about it means that there is inevitable disagreement about what is the best course to take. The uncertainty that characterizes technological advance in high technology industries warns against premature unhedged commitments to particular expensive projects. The divergence of opinion suggest that a degree of pluralism, of competition among those who place their bets on different ideas, is an important aspect of technological advance.

In the case of the developing countries, the possibility may be considered of confining themselves, in the early stages, to the application of technique that already have been tried out in the industrialized countries and to the dissemination of the scientific knowledge they have acquired. However, this strategy does not work nowadays, for the following reasons. First, the technicians responsible for disseminating modern techniques are unable to acquire and maintain necessary level of competence without direct contact with the research workers in applied science who devise the new techniques. Second, it is also obvious that an applied science cannot be effective unless the research workers are in personal daily contact with the most advanced ideas in the basic science on which it rests. For these two reasons, adequate allowance for pure science should be made in plans and projects.

Long-range, undirected, fundamental research is a search for new knowledge, with little consideration of its ultimate significance and impact. It has a very long, 10 to 50 years, time horizon. Some of it will eventually have utility to industry. Its objectives are to add to "truth and knowledge" and to train people. It is best left to the universities.

Directed basic research, in contrast, is original scientific or technical work that advance knowledge in relevant scientific and engineering fields, or that creates useful concepts that can be subsequently developed into commercial materials, processes, or products and, thus, make contribution to the company's profitability sometime in the foreseeable future. It may not respond directly to a specific problem or need, but it is selected and directed into those fields where advances will have a major impact on new technologies.

Directed basic research is best conducted in industry, whose function is to create wealth. It involves conscious access to the truth-seekers at the universities; it is beneficial if the people circulate between industry and universities. In the development of radical departure from existing technology, university research is significant, because firms' internal R & D units tend to improve currently used technology incrementally (Phillips, 1980).

Many innovations depend on basic research aimed at understanding phenomena (Healey, 1978; Fernelius and Waldo, 1980). Properly selected and executed directed basic research gives a company the earliest knowledge of, and opportunity to minimize, the uncertainty introduced by advances in basic science; it gives greatest time to adjust to them and minimize losses; it provides an opportunity to create a strong and favorable competitive position. The key is selecting the right field of research, guiding the research through the communication mechanisms between industrial scientists and acadimic scientists.

5. THE ROLE OF GOVERNMENT

It is obvious that government should play a positive role in promoting research and development activities. But government must avoid the temptation to promote direct government involvement in targeting "winners and losers" in industry. The U.S. experience in government assistance to some companies, for example, should illustrate the fallacy of that approach. The history of government handouts indicates that the money is often given to the industries and regions who are best represented in political arena rather than on the basis of merit.

The proper role for government is to target the process by which they are developed - the process of innovation. A study (Allen et al., 1978) found that government regulatory restraints were frequently associated with successful innovation. In this sense, Korean government should focus on creating an environment in which high technology, innovation, new ideas and new companies are flourish. Making sure that such an environment exists is the best way to help Korea develop its technological foundation.

It is believed that there are four conditions needed for an environment that promotes technological innovation; a) A strong commitment to basic research, deepening and broadening our understanding of the fundamental processes that will form the basis for industries and products in the future; b) Incentives for investors and innovators to provide the capital and take personal risks associated with the development of new companies and products; c) A strong educational capability, particularly in the sciences, that assures an ample quantity of trained technical and management personnel and a broad base of technically literate citizens who an deal with the challenges of a high technology world.

A proper science and technology policy is one that focuses on these prerequisites for innovation. It consists of specific legislative and regulatory initiatives that foster these conditions and avoids government actions that would weaken them. It is clear that efforts to strengthen the country's science and technology potential should henceforth focus on creating the necessary infrastructure for the development of science and technology.

6. ALTERNATIVES

What kind of alternatives can one see for government action in creating the necessary institutional framework for advanced research and development? Three alternatives which have been discussed in Korea are as follows.

6.1. Descriptions of Alternatives

6.1.1. Strengthening Government-Run Research Institute

The arguments pleading for strengthening the current government-run research institutes concerns optimal mechanisms for research funding, by focusing on a particular area of both industrial and national importance based on the belief that the miracles of science do not come from the many - but from the very few. Realizing the need of specialized elite research organizations condusive to the development of technology, the MOST created several research organizations. As a representative example, the Korea Institute of Science and Technology (KIST) was founded in February, 1966 as a research organization for the tactical development of industrial technology. KIST was organized to fulfill a mediatory role in technological development and attracted the attention of technological and scientific circles for its revolutionary management and research system. It had tremendous success in attracting outstanding Korean scientists active abroad into the organization. Although these organizations produced the vast amount of technology, the amount that has been actually spun off to private industry is only a trickle. Among the reasons for this is one that I believe could be corrected by better cooperation between government-run research institutes and private industries.

6.1.2. Promoting University Research

Korean universities, whether private or public, are in principle, independent institutions in their pursuit of knowledge. But none of them are financially independent. Researchers in universities have had to rely on the traditional sources, namely the university budget, whose resources have necessarily to be spread very thinly, plus the occasional grant from national authorities or international agencies. Nonetheless, there remain a surprising number of individuals within the university who are prepared to engage in research.

It is significant that the Ministry of Science and Technology's long term plan on research and development did not deal with the question of university research. Yet the university represents almost one third of the total research capability of the nation. For the present, and in spite of a few exceptions where personal initiatives have led to the development of links with the applied research community, it remains largely unconnected to other parts of the national scientific and technological system: unconnected to education, since the involvement of students in research remains exceptional; unconnected to potential sponsors because in many areas the facilities required for scientific work of industrial concern are located elsewhere; unconnected to government applied research initiatives because each community has tended to remain relatively isolated from other scientists and engineers.

Many academic scientists feel that fundamental research should be more actively encouraged because it is considered to be a natural activity at a university, and because it is thought that its development would enhance the quality of science and overall intellectual climate, create new bonds between scientists and engineers, provide a basis for more intense contacts abroad.

Research grants to universities, where the majority of the basic research can be done, permit the training of thousands of graduate students. This new talent will be responsible for maintaining the research system in coming years. Strong support for basic science research permits Korean scientists and engineers to challenge intellectual frontiers in the most important fields of science and technology. That provided the new knowledge that drives our economic growth, improves our quality of life, and underlies our national defense.

In considering possible means of increasing the contributions of universities to accelerating technological progress in industries, the most promising possibilities may well involve altering conceptions of their role in such efforts. Many universities have a limited research purview which has been reinforced by a tendency to devalue contributions by faculty members that can be characterized as applied.

6.1.3. Tying University and Industry

Just as the universities benefits from government support, the same holds true for its ties to industry. Ties between industry and the university take three basic forms - philanthropic support, individual support, research partnerships. Philanthropic support is the donation of funds or equipment to a university or its research laboratory. Industry also provides support to a specified individuals within the university, generally through a consultantship and grant, which is usually awarded to faculty members working on research that advances the frontiers of a particular technical discipline of interest to the corporation.

Also, well-chosen basic research projects can stimulate productive partnership between scientists and engineers in all sectors of society- partnerships that are increasingly vital to development of new technologies that will keep Korean industry competitive with foreign industries. Partnerships account for almost 50 percent of industry-supported research at university in U.S. (NSB, 1982). These partnership arrangements usually call for joint planning and implementation of research programs as well as a sharing of financial rewards. The funds are provided by the corporation, the scientists by the university. Such ties can also reduce the risk that the university will become isolated or out of touch with the needs of the world because it is useful for exposing scientists to new and challenging problems that they rarely encounter in academia.

While corporate support broadens the financial base of the university, universities that rely heavily on government resources for their research activities are susceptible to having strings attached to such support, and could suffer a real crisis if government funds ceased to flow because of a shift in priorities. Therefore, the university-industry connection is really in a context that includes government regulation, financial and market components.

As long as sufficient long-term core resources are available for well chosen fundamental research, there are many advantages and an important positive stimulus for the fundamental work, if the university is also performing applied research and consultancy and collaborating with a variety of external agencies and institutions in joint research activities and in the provision of some scientific and technical service. If we look at the American example, the success of high tech industries is tied directly to the mission of research universities in the United States - namely, the discovery and dissemination of knowledge through teaching, research, and public service (Geiger, 1986).

6.2. Assessment of Alternatives in terms of Goals and Objectives

Alternatives for developing necessary institutional arrangements for advanced technology development differ in there value preferences and the degree to which goals and objectives of national science policy can be accomplished. We can gain some appreciation of requirements and effects of different alternatives by comparing in terms of inferred criteria from the national science policy goals and objectives.

The core estimates for the three alternatives are enumerated in the following table.

alternatives / criteria	government-run research institute	university research	tying university and industry
manpower development	low	moderate	high
directedness of research	high	low	moderate
attractiveness for scientists abroad	low	moderate	high
research capacity (manpower)	low	high	high
equipment availability	high	low	moderate
research network	moderate	low	high
government financial Obligations	high	high	moderate

6.3. Recommendation

Considering above-mentioned criteria, it is highly recommended for Korean government to take the alternative of tying university and industry. It has been argued that a close relationship between industry, universities and government can be an important spur to technological innovation (Dietrich and Sen, 1981; Fowler, 1984; Cotton, 1985). The presence of well-established networks of research scientists, drawn from industry as well as academia, provides one important base for government research support. A coordinated development of the industry research institutions and university research laboratories constituting the elements of the national research network is necessary, because the activities of these establishments are interrelated by virtue of their subject matter and by their common interest in contributing towards the development of advanced technologies. Achievements of experimental development have become dependent on the results of applied research, which in turn rest on those of fundamental research. It is therefore clear that the evolution of the different types of research (from fundamental to developmental) cannot normally be entirely disconnected.

Traditions for direct cooperation between academic institutions and industry in research on the basis of contracted projects were much less developed in Korea than those existing in the United States. The loss of quantity and quality with the braindrain to the U.S., the absence of a framework for efficiently using government funded R & D in the existing academic institutions or in industry also contributed to the isolation of universities and industries. From an industrial and university points of view, it has been considered a great waste of resources that the bulk of government funded research was not placed in universities or in industry, rather, it was taken care of by government-run-research institutes. In the United States, it has been witnessed that some of the more successful innovations have come about by a close cooperation between science based industrial companies and university departments.

7. PROPOSED POLICY AND ITS IMPLEMENTATIONS

According to Barker (1985), there are two assumptions on which university-industry collaborations are based. The first is that universities are doing a lot of research that may have value to corporations, and the second is that universities are willing to change their directions in response to industry needs. The problem then is to form a liaison between universities and industries. The necessary condition for the sound relations is that the interests of the two party should be satisfied. One of the organizational problems needs to be mentioned. Universities generally emphasizes unstructured research, with the advancement of knowledge and its wide dissemination as key goals. This differs from the primary efforts of industrial research organizations, which focus on developing product, creating a strong patent position, and reaping the benefits of research through successful commercialization. Disseminating information to wider scientific community is encouraged but with restrictions. Thus, a compromise on these divergent interests must be reached if a university and industry are to collaborate in R & D. Also, the university should have comprehensive programs in the fields that the corporation has targeted. A corporation also must build the university link as an integral part of its R & D structure. It must change their perceptions of scientific community. Universities need to be willing to get involved in research that industry really needs - just as industry must become aware of, and willing to use, the research that universities already are doing.

Also, it must be ensured that there is an adequate supply of trained technical people. The scarcity of trained technical people will put us at a severe competitive disadvantage in the technology development. The basic constraint on providing sufficient technical education is a lack of money. The cost of educating technical people, particularly engineers, is very high, and it is difficult to attract enough qualified Korean scientists from abroad because working in foreign academic environment is so attractive. Private industry and government has an important role to play in providing funding for increased technical education programs. By offering tax credits for corporate contributions to colleges and universities for teaching activities, as well as research, we can encourage private sector support to increase the capacity of our technical education facilities without requiring a bureaucracy to carry it out.

IMLEMENTATION # 1.

It is necessary to establish centers that provide for working relations between students and faculty, the hand, and industry engineers and scientists, on the other. It should emphasize the synthesis of engineering knowledge and to integrate different disciplines in order to bring together the requisite knowledge, methodologies, and tools to solve issues important to engineering practitioners. They should be located at academic research institutions in order to promote strong links between research and education. In engineering, the role of private industry has become invaluable in supporting research and providing state-of-the-art equipment.

IMPLEMENTATION # 2.

Korea needs to encourage specialized agents who can mediate between producers and users of technology. The importance of specialized agents as a link between knowledge producers and users is significant. One advantage of specialized agents is that they have an incentive to speed diffusion, unlike competing enterprises which may wish to control it. Creation of technology consulting firms is necessary, because these can draw on expertise from several research institutes, universities and industries. This is an important step in expanding specialized agents for technological development.

IMPLEMENTATION # 3.

The interchange of university and industrial staff members must also explored. The possible case will be that of a professor being hired by the industry either during a summer or while on a sabbatical leave of one or two semesters to work on a problem of mutual interest. Such an interaction is particularly beneficial for young faculty. Such activities contribute much to their teaching competence by giving them valuable industrial experience.

IMPLEMENTATION # 4.

Since the university is the only major center for fundamental research, it is essential that a substantial part of the total funds should be available for the university to build up long-term research activity through adequate funding mechanisms. Research funding usually come under two separate heads: institutional and contractual financing. In Korea, the level of institutional financing is set by parliament, and every institution receive funds according to the annual budget decisions. This pattern is similar to European and Japanese governments that support research through general, formulas based operating funds (NSF, 1986). Contractual financing by government agencies in necessary to fund new projects proposed by the research community and maintain the pressure of user demand on ongoing research. This type of funding is much less developed in Korea than in other counties. Contracting agencies may have either a definite technological goal or a scientific one. In Korea, the National Foundation for Scientific Research has been as one of the possible bases from which to develop such funding.

8. CONCLUSIONS

Korea's capacity for technological advancement is commonly perceived in terms of industrial sectors - microelectronics, steel and new materials, automobiles, and, more recently, biotechnology, telecommunication, and computers. Actual practices of Korean research and development activity has been to imitate those foreign technological artifacts. However, this list is, in fact, a transitory one - changing over time. A new list may supersede this one in a decade. The nation's innovative capacity should not be thought of only in terms of specific products; it should be understood as the continuous capability, widely diffused throughout the society, to produce and put to use pioneering science and technological resources. In other words, the essential national resource is the capacity for technological innovation - the ability to continuously discover, refine and produce frontier technologies and to use those technologies throughout the industrial, agricultural, and military enterprises.

Recent conflicts between Korean and U.S governments over patents portend increasingly serious problems. Realistic efforts to deal with these problems must begin by recognizing need to interactions between industry and university. Resulting increased cooperation in identifying the factors contributing further technological advances, and in probing newly emerging needs might well bring about a mutual reinforcement that would benefit both as well as the Korean economy.

REFERENCES

Allen, T. J, et al. (1978). "Government Influence on the Process of Innovation in Europe and Japan," *Research Policy*, 7(2), pp. 124-149.

Averch, H. A. (1987). "Measuring the Cost-Efficiency of Basic Research Investment: Input-Output Approaches," *Journal of Policy Analysis and Management*, 6(3), pp. 342-361.

Barker, R. (1985). "Bringing Science into Industry from University," *Research Management*, November-December, pp. 22-24.

Brooks, H. (1968). The Government of Science, Cambridge, MA: The MIT Press.

Choi, H. (1975). "Adapting Technology-the Korean Case," in V. Rabinowitch, (ed.), *Views of Science, Technology and Development*, New York: Pergamon Press.

Colton, R. M. (1985). "Status Report on the NSF, University/Industry Cooperative Research Centers," *Research Management*, November-December, pp. 25-31.

Dietrich, J. J., & R. K. Sen (1981). "Making Industry-University-Government Collaboration Work," *Research Management*, September, pp. 23-25.

Fernelius, W. C., & W. H. Waldo (1980). "Role of Basic Research in Industrial Innovation," *Research Management*, July, pp. 36-40.

Fowler, D. R. (1984). "University-Industry Research Relationships," *Research Management*, January-February, pp. 35-41.

Geiger, R. (1986). *To Advance Knowledge: Growth of American Research Universities*, Oxford, England: Oxford University Press.

Healey, F. H. (1978). "Industry's Needs for Basic Research," *Research Management*, November, pp. 12-16.

Miller, H. M. & R. R. Piekarz (1982). *Technology, international economics, and public policy*, Boulder, Colorado: Westview.

NSB, National Science Foundation (1982). *University-Industry Research Relationships*, Washington, D.C.: U.S. Government Printing Office.

NSF Discussion Paper (1986). "Research Policies and Strategies of Five Industrial Nations, and Implications for the United States," *Science & Tehnology Studies*, 14(1), pp. 24-30.

Nelson, R. R. (1984). *High Technology Policies: A Five Nation Comparison*, Washington, D.C.: American Enterprise Institute Studies in Economic Policy.

Phillips, A. (1980). "Organizational Factors in Research and Development and Technological Change: Market Failure Considerations," in D. Sahal (ed.), *Research, Development and Technological Innovation*, Lexington, Mass.: Lexington Books.

Price, D. d. (1984). "The Science/Technology Relationship, the Craft of Experimental Science, and Policy for the Improvement of High Technology Innovation," *Research Policy*, 13, pp. 3-20.

Spiegel-Rosing, I. & d. S. Price (1977). *Science, Technology and Society: A Cross-Disciplinary Perspective*, Beverly Hills, California: Sage.