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CONTENTS

PREFACE

With in its study programme, the Regional and Country Studies Branch of UNIDO carries out country level research on policies and strategies pertaining to the progressive development of the industrial sector in developing countries in present rapidly changing international environment.

In the context of the Expert Group Meeting on Policies and Strategies for Small-scale Industry Development held in Seoul in September 1985,[1/] the experience of the Republic of Korea was reviewed, inter alia, of strategies and measures related to the commercialization of R and D results, with particular reference to the small and medium industry sector. The presentation on the subject, made by Dr. Young-Ok Ahn, President of the Korea Technology Advancement Corporation (K-TAC), arose great interest at the Meeting and it was decided that a more detailed review and assessment of this expereince be prepared as a follow up research study.

In the study which is herewith issued, special attention has been given to the experiences of the activities of the several technology commercialization companies which have been established recently in the country. In particular, the development of the Korea Technology Advancement Corporation (K-TAC) is reviewed and a rumber of commercialization case experiences are analysed.

The study has been prepared by staff of the Regional and Country Studies Branch on the basis of a research paper prepared by Dr. Young-Ok Ahn, as UNIDO consultant.

1/ UNIDO/ESCAP Ad Hoc Expert Group Meeting on Policies and Strategies for Small-scale Industry Development in the Asian and Pacific Region, 17-20 September 1985, Seoul, Republic of Korea. Report issued under symbol UNIDO/IS.617.

1. INTRODUCTION

For private industries, a natural goal of research and development is commercialization. The goal is highly motivated by the potential for profit generation. In its pursuit of profit, the commercial company may undertake some basic research and may also sponsor researches by the academic community, but the basic driving force of the private industries is profit through the ultimate commercialization of research ideas. Unlike industry, the issue of commercialization is not necessarily of key importance for a national research institute or for the universities.

For developing countries, the research and development activities need to be closely linked to the promotion of industry and also to the task of effecting so called leap-frogging of the industrial capability. Research activities in national institutes sometimes therefore can become a guide for small and medium industry (SMI) sector which are faced with the task of starting industrial R and D from scratch for the first time.

A national research plan may also become a central basis for the national science and technology policy. Industries can gradually become participants in such a plan and may eventually surpass the national laboratories in some areas where the industries are better suited to bring about effective R and D results.

This paper attempts to describe how the science and technology policy of the Republic of Korea gave impetus to the nation's first contract research organization, and how the idea of doing commercializable research was imbedded in this operational mode from the beginning. The paper will also describe the establishment of a company whose major purpose is to create industrial companies, mostly SMIs, based on the technologies generated within the national research laboratories.

Most developing countries' national science and technology institutes have weak links either with the industry or with the Government organs in charge of economic development. In fact, most developing countries have a weak policy foundation for scientific and technology development and concomitant development strategies.

Many policy makers tend to advocate the idea of academic excellence and hope for the research results to be disseminated. In reality, institutes under government control are often asked to do too many things, such as testing, standardization and "research", all at the same time. Consequently, the institutes perform university-like "research" rather than research directed to industrial development. Often the institutes find it difficult to communicate with the industry and government effectively.

This lack of strong institutional organization and the inadequacy of research and development systems may prompt policy-makers and industrialists to rely heavily on imported technology. In the early phase of industrialization, when the Government does not exert an adequate control mechanism to co-ordinate the proper influx of foreign technology, it can easily occur that either obsolete technology is acquired or intermediate level know-how which is excessively valued.

National research institutes can play a major role in assessing the technology requirements and in judging whether the specific technology to be imported is reasonable in terms of technology content and price. Once the content of technology is mastered, the industrialist can negotiate the purchase of technology effectively. The savings attained through this effective negotiation quite often compensates for the research cost spent earlier.

To do all the above, however, the national research institutes must establish credibility with the Government and industry. If a successful commercialization is to be achieved, the national institutes and SMI laboratories should have top management people with significant industrial experience.

The development of science and technology potential, of course, is intimately tied to the economic development level of the country. In fact, science and technology can often stimulate the economic development and vice versa. In the case of the Republic of Korea, the First Five-year Economic Development Plan (1962-1966) centered on the construction of essential industries such as power, cement and fertilizer. Light industries such as textiles and plywood evolved through the initiatives of the private industries. In these years of "import substitution" the key issue was the availability of funds rather than technology since the technology required was generally available. The nation as a whole did not worry about technology development and international competitiveness. The plan largely succeeded and people were encouraged by its progress.

The Second Five-year Plan (1967-1971) continued this momentum, but added such important industries as petrochemicals and steel in its development plan. These indutries are highly capital intensive, but the acquisition of proper technologies were not too difficult. It was in this period that the government decided to establish the Ministry of Science and Technology (MOST) to supervise the co-ordination of the plan for technological self-reliance. Concurrently, a new "industrial" research institute called Korea Institute of Science and Technology (KIST) was formed through a special legislation. A start was made to innovate, "re-invent" and effectively absorb technologies needed for the national development. A small core of key people were recruited from overseas to staff the institute. The requirement was such that these key people preferrably had doctor's degree with minimum of five years' industrial experience. The emphasis of applied commercializable research therefore was built in from the beginning. The establishment of KIST, therefore, was the first manifestation of the will of the Government to conduct research directly tied to the Government's overall industrialization policy.

The Third Five-Year Plan (1972-1976) pursued similar goals of developing heavy industries with more attention to the international competitiveness. The experience in the developed nations was carefully studied to ascertain that the large capital expenditures were truly justified. Industries that require large number of skilled technicians, such as shipbuilding and automotive industries, were given high priority. With the Third-Five Year Plan, the Republic of Korea in a way made an all-out effort to enter the international market through a concerted, export-oriented economic policy.

During this time, MOST passed the 1972 Law for the Promotion of Industrial Technology Development to provide fiscal and financial incentives

to private industries for technology development. Somewhat prematurely, the Government also agreed to pass the Assistance Law for the Establishment of Special Research Organizations in 1973 which provided legal, financial and fiscal incentives to establish new institutes in shipbuilding, electronics, telecommunications, petrochemical, mechanical and materials engineering, and energy related areas. During this period, defence related institutes were also established. These events had a devasting effect on KIST since many key people had to leave KIST to start these new institutes thereby weakening the gathered momentum and also diluting the strength of multidisciplinary nature of KIST. In this case, the policy makers of the Government did not fully recognize the importance of sustained continuity of an R and D organization. Indeed, policy makers in developing countries often press for immediate results instead of providing enough time for the learning process to mature.

Before the depletion of staff, however, took place KIST had undertaken numerous projects under contract with the industry. The percentage of the industrial contract research, had been maintained at about 50 per cent level. The remainder of KIST's work was divided between Government sponsored research which was available to the public, and in-house research funded through the interests accrued from the endowment fund. The latter fund was used mostly as seed money to test out earlier ideas of KIST researchers. Over the years, therefore the results of this work began to accumulate within the institute, and KIST decided to establish a wholly owned "research commercialization company" called Korea Technology Advancement Corporation (K-TAC). A description of this company is given later in this chapter.

The years 1972 - 1976 were the most productive years for KIST. The morale was high and every staff was totally absorbed and dedicated in undertaking applied research in earnest, perhaps for the first time in the Republic of Korea. All efforts were directed to interact with the industry. Industry was quite receptive and began to see the possibility of acquiring technologies through other means than straight technology import.

Although many of the research topics were of "re-invention" type, tremendous burdens were placed on the project leaders to make certain that the research results were converted smoothly into commercial operation. Projects with uncertainties were sponsored through either the in-house research fund or the government fund.

The Third Five-Year Plan was followed by the Fourth and the Fifth which is still in progress. In these periods, the Republic of Korea continued to achieve economic growth and industries began to diversify. The quality of products began to improve in order to meet international competition. It is in these periods that electronics and related telecommunication industries began to take roots. Having the required raw materials through the petrochemical industries and coke oven gas of the steel industry, the country also began to produce agricultural chemicals and pharmaceuticals in significant quantities. Momentum for a special chemicals industry had begun and KIST played a key role in making this happen. Currently, the Republic of Korea like other developing countries is under pressure to recognize intellectual property rights of developed nations. With the realization that it may eventually be adopted, some researchers are now conducting research to discover new patentable active compounds.

In retrospect, the Republic of Korea within the span of two decades succeeded in creating an environment where the need for applied research is

recognized. More importantly, within the last five years, the country's industries also have established over 250 research laboratories. Some are competent and some are just at their beginning. But these industrial laboratories are giving healthy competition to KIST which merged with the Korea Advanced Institute of Science (KAIS) to become KAIST in 1980. The university is also slowly developing a larger volume of basic research. In light of these new developments, KAIST would continue its efforts to lead the nation by performing more long term relevant research. KAIST will try to solve problems for the various industrial subsectors as a whole. Problems relating to the heat treatment of precision moulds and applied research on computer integrated manufacturing, CIM, are good examples.

In these changing times, K-TAC's role also is changing and K-TAC will attempt to bring in the relevant technology to the country through licensing and joint ventures if justified. The main effort of K-TAC, however, remains to be the intelligent commercialization of R and D results coming out of national laboratories.

2. R AND D IN THE REPUBLIC OF KOREA

(a) Research institutes

Even before the Five-Year Science and Technology Development Plan went into motion, the Republic of Korea had seen noticeable growth in science in conjuction with its rapid pace of industrialization. Government expenditures of R and D increased from US $19.5 million in 1971 to US $165.5 million in 1980. Private investments in R and D rose even more drastically during the same period, going from US $9.1 million to US $155.2 million. Even when adjusted for inflation, R and D spending quadrupled during the 10-year period under review. R and D expenditures by industry rose from US $35.1 million in 1976 to US $122.7 million in 1980. Their share in sales increased from 0.39 per cent to 0.47 per cent during the same period. The proportion of Government investment budget, however, remained unchanged at about 2 per cent throughout the 1960s and the 1970s. The number of research organizations in industry increased from 107 in 1970 to 321 in 1980. The total number of researchers in Government, university and industrial R and D organizations rose from 5,628 in 1970 to 18,344 in 1980.

The foremost R and D institute in Korea is, of course, the Korea Advanced Institute of Science and Technology (KAIST), established (as KIST) in 1966 as a modern multi-disciplinary R and D centre, which covers a broad spectrum of applied research. In addition, it carries on a large-scale post graduate programme, annually producing fully one third of young scientists and engineers at M.S. and Ph.D. levels in science and technology. In more recent years, KAIST "spun off" a number of specialized research institutes somewhat prematurely. The idea, however, was to support the increasing sophistication and diversification of the country's industry. Thus, specialized R and D centres have been set up for shipbuilding, marine resources, electronics, telecommunications, energy, machinery and chemicals. More specifically, the Daeduck Science Town was established near Taejon, some 150 km south of Seoul, in the late 1970s to accommodate most of these newly established institutes plus many central research institutes of private firms.

Along with the Government-supported institutes, private companies were also encouraged to establish their own R and D institutes in order to meet the ever-increasing international competition and to be able to participate in the technology-intensive heavy and chemical industries. The Government promoted the establishing of R and D institutes through tax incentives and financial support. Thus, the total number of private research institutes reached 152 by the end of 1984.

Private research institutes, 1981-84

	1981	1982	1983	1984
Institute	53	83	112	152
Researchers	2,100	3,096	3,801	7,700

The Technology Development Promotion Law, enacted in 1967, provides a framework for various incentives to promote the development and upgrading of industries' technological capabilities. These incentives are aimed at reducing the cost of foreign technology imports and of industries' in-house R and D work by allowing: reduced tariffs on the import of R and D equipment; deduction of annual non-capital R and D and engineering expenditures from taxable income; accelerated depreciation on industrial R and D facilities; and a tax credit for investment in facilities for R and D and engineering work or commercialization of local R and D results. Furthermore, the law permits a company to set aside as "technology development reserve funds" up to 20 per cent of profit before tax in any one year for use in its R and D in the following two years. The Korea Scientific and Engineering Foundation, established in 1977, provides funds for strengthening basic and applied Research. In 1981, the Korea Technology Development Corporation was founded to provide venture capital needed to promote the formation of technology-based enterprises.

Government-supported R and D institutes

Institute	Date of establishment	Functions
Korea Advanced Institute of Science and Technology (KAIST)	5 January 1981 (KIST 1966, KAIS 1971)	Research and development of national projects
Korea Advanced Energy Research Institute (KAERI)	15 January 1981	Atomic energy research and atomic safety regulation
Korea Standards Reserach Institute (KSRI)	14 December 1975	Establishment of national standards
Korea Institute of Machinery and Materials (KIMM)	5 January 1975	Development of technology pertaining to machinery, metals and shipbuilding
Korea Institute of Energy and Resources (KIER)	17 January 1981	Development of technology of resources and energy exploitatoin
Korea Research Institute of Chemical Technology (KRICT)	2 September 1976	Research and experiment in chemistry
Korea Institute of Electronics Technology (KIET)	30 December 1976	Development of technology pertaining to semiconductor and computer industry
Korea Electronics and Telecommunications Research Institute (KETRI)	20 January 1981	Development of technology related to electrotechnology and telecommunications
Korea Ginseng and Tobacco Research Institute	9 January 1981	Research pertaining to ginseng and tobacco

In the course of the industrialization efforts during the 1960s and 1970s, R and D activities and technical improvements were the major tools in bridging the technical gap. Recently, however, successive technical innovations in advanced countries and interdisciplinary characteristics of large-scale R and D programmes have shown that a more systematic approach, a more advanced technology, and a higher level of technical information are required for the success of these programmes.

To cope with these needs, MOST initiated the national research and development projects in 1982 in which industry, research institutes and the Government jointly carry out specified research projects by creating co-operative efforts in each field. Projects in this category are large-scale R and D projects, which should be given the highest priority for the long-run economic and social development, and which cannot be implemented by industry alone. Knowledge-intensive and resource-saving technologies which also enhance the comparative advantage in international competiveness are highly recommended.

In 1984, 255 research projects of 134 industrial firms were selected as national R and D projects and funds equivalent to about US $26 million were provided as grants by the Government.

The major fields of highest priority are:

- such industrial technology as that used for semi-conductors, computers, research and development leading to assistance in machine industries;
- research and development to ensure safety in nuclear power plants;
- social welfare technologies, such as transportation and communication, pollution control and food safety.

Status of national R and D projects

Classification	1982	1983	1984
R and D expenditures (US $million)	21.9	42.2	36.5
Government	15.6	25.9	25.9
industry	6.3	16.3	10.6
No. of participating firms	86	131	134
No. of researchers	2,263	3,232	3,252
No. of projects	125	182	255

(b) Financial support

At present, the country has four venture-capital companies, in addition to the traditional commercial banks, to support the commercialization of technology.

The Koera Technology Advancement Corporation (K-TAC) has invested in the commercialization of R and D results from national research institutes. The Korea Technology Development Corporation (KTDC) plays the central role of financial support for the development of new technologies, products and processes, and for the improvement of conventional ones. The financial sources consist of investment by the Government and industries, issuance of debentures, and World Bank loans.

Domestic venture capital companies (as of the end of 1984)

Institution	Year of establishment	Shareholders	Capital (US $ million)	Type of support	Financial support (US $ mil.)
K-TAC	1974	KAIST, KIMM	1.5	Investment	1.6
KTDC	1981	Government, banks, industries	26.8	Investment, conditional loan, conventional loan	158.9
KDIC	1982	Short-term financing companies	8.8	Investment	6.1
KTFC	1984	Korea Development Bank	11.8	Investment, conditional loan, conventional loan	3.6

The conditional loan is a type of financial instrument that allows profit and risk sharing with project sponsors. This loan system will normally be repayed through royalty payments against sales revenues if the project is successful, including a reasonable return on the loan. If the project does not result in sales revenues, a portion of the principal (less than 30 per cent), will be recovered from the project sponsor. Royalties are paid within 15 years according to the project and the product life cycle.

The country's commercial banks also have a financial support system for starting a business. They review the project according to the age and experience of the businessman and the content of the project. The Government is also solving related problems and difficulties arising from starting up a business by eliminating complex procedures and documentation.

(c) Tax support

The Republic of Korea has various tax support systems for the R and D stage: reserve fund system in R and D, exemption of technology and human development expenses from taxes, exemption from local tax for private research facilities, and reduction of tariff rates for R and D equipment.

First, under the current Technology Development Promotion Law, expenses for the development of technology such as R and D spending for the development of new products and processes, research spending for the digestion and improvement of imported technology, technical information acquisition costs, technical expenses, research equipment acquisition costs, sponsored research costs, expenses for petitioning and commercializing industrial property rights, etc. are recognized as untaxable losses in income accounting.

As a result, industries can reserve funds for investment in research and development, and under the system of technology development reserve funds industries need not pay taxes on funds reserved for the development of new products and processes. The ceiling on reserve funds under the system is 20 per cent of the total income before tax (or one per cent of the total sales) for the period in which the income (or profit) is made of the taxation period of such income. Should industries desire to reserve funds for research and development investment under the system, they are required to fill in the appropriate application form and submit it to the Ministry of Science and Technology (MOST). The reserve funds made under the system must be invested in research and development within four years after the end of the above mentioned taxation period.

Second, when industries establish their own laboratories, 8 per cent of the acquisition cost of the facilities (10 per cent if the facilities are procured in the country) is exempted from corporate taxes and income taxes. In addition, untaxable special depreciation reserves are recognized just one time for up to 90 per cent of the acquisition costs of testing and analysis facilities for use in technology development. Moreover, industries building research facilities and acquiring test equipment can get, with priority, long-term low interest loans for such use.

Expenses for the application or commercialization of research results are also untaxable. For instance, up to 6 per cent of the acquisition costs of facilities directly used in commercialization of new ideas (10 per cent, should the facilities have been procured within the country) is exempted from corporate taxes and income taxes; Such an untaxable scope of the cost is applicable when patented new ideas of research results of the national research institutes are commercialized for the first time, provided such commercialization is recognized by the Minister of Science and Technology in consultation with the Minister of Finance.

Favours are also given for the application of Government-sponsored research results on a commercial basis. Some Government-sponsored research projects have resulted in industrial property rights, and among such rights are those which can be applicable on a commercial basis. For such rights, the license is granted free of charge wholly or partially to the institute which developed them or those who jointly invested with the Government in the research. Such favours regarding industrial property rights are designed to encourage industries to promote research and development activities through increased investment in the development of new products and processes.

(d) Market protection

The application of research results on a commercial basis involve many risks. To reduce such risks, the import of similar technology should be restricted for a limited period of time, and marketing support should be provided. This would promote industries' will to develop technology.

In other words, there should be measures of protecting industries manufacturing new products developed locally so as to promote the commercialization of research results and new ideas. The new products here mean products derived from locally developed new technology or from research on modification and improvement of imported technology. The protective measures the Government has already taken for the commercialization of new ideas and research results include restrictions on the import of similar products and the local manufacture of such products by other industries for a fixed period so as to guarantee the return of investment in research and commercialization as well as an appropriate profitability of the new products. In addition, the measures provide special financial support for applications of new ideas on a commercial level.

3. FUNCTION OF KAIST IN COMMERCIALIZATION OF R AND D RESULTS

In January 1981 KAIST was established by merger of KIST (Korea Institute of Science and Technology) and KAIS (Korea Advanced Institute of Science). Before the merger, KIST had been in pivotal roles for development of industrial technology and transferring the results of research, while KAIS had been educating high-caliber scientific and technological manpower. Now, KAIST is both a multidisciplinary research centre and a graduate school for science and technology.

Primarily, the idea of unification came out of Government. Earlier, MOST had 16 different R and D institutes under its control, which were then reduced to 9 in November 1980. This happened because the Government judged that the R and D institutes were excessively subdivided and thus ineffective in collective R and D performance. The Government wanted a basic change in the structure of R and D institutions for the merits of scale and operational economy.

As is often the case in developing countries, the limitation of human resources presents a serious problem in the Republic of Korea. At KAIST, therefore, the scientists of different specializations perform both an educational role and research work so that their capability can be utilized to the maximum.

KAIST was set up as a centre for excellent scientists of different disciplines. From the beginning KAIST has tried to secure competent faculty and research staff mainly through recruitment of overseas Korean scientists and engineers. The number of Ph.D. degree holders amounted to 285 as of August 1985, of whom 135 are in the faculty and 150 are the research staff. The table below shows the total manpower of KAIST.

Total number of personnel at KAIST, 1985

Executive member	Faculty	Research staff	Technician, typist	Administration	Total
2	132	421	447	96	1,098

KAIST's research activities were started off with the establishment of KIST in 1966. Until 1981, KAIST (formerly KIST) was a unique R and D institute for the industry, with most of its R and D projects being sponsored by industry, large and small. Since 1981, research for development of "seed technology" for national strategic industries has been regarded as more important and thus the focus has been moved on to long-term national projects. These types of research projects are selected by MOST and are thought to have far reaching technological impacts and to be of a relatively long-term, large scale interdisciplinary nature. But the contract research for the industry continues to be an important aspect of KAIST activities.

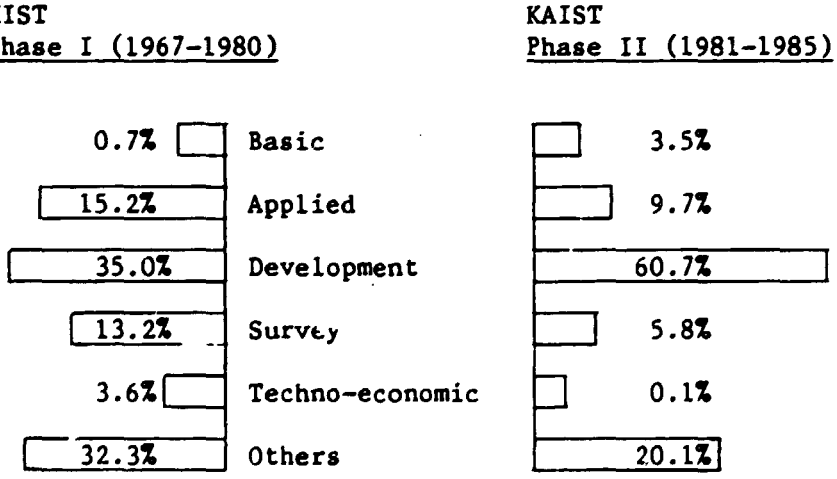
From the beginning, KAIST pursued flexibility in many aspects of management. Autonomy of research means that project leaders are given unhindered liberty in pursuance of approved project performance, subject only to general guiding principles and that the work is based on the principle of financial self-sufficiency for each fiscal unit. But it also requires flexibility of management. Several times, KAIST has reformed its organization for the purpose of timely response to social needs. This flexibiiity is well expressed in the establishments of such new research units as the Genetic Engineering Research Centre and the System Engineering Centre.

From the beginning of 1967 up to July 1985, KAIST has contracted about 4,000 research projects in total proceeds of about 96.4 billion Won (approximately $120 million), 2,333 of which represent applied and development projects while the rest are in the categories of basic research, survey research, techno-economic study, computer programmes etc. The table below shows the status of total research volume and number of projects from 1967 to July 1985. The statistics are divided into two periods: Phase I covers the KIST period until 1980, and Phase II the KAIST period up to present.

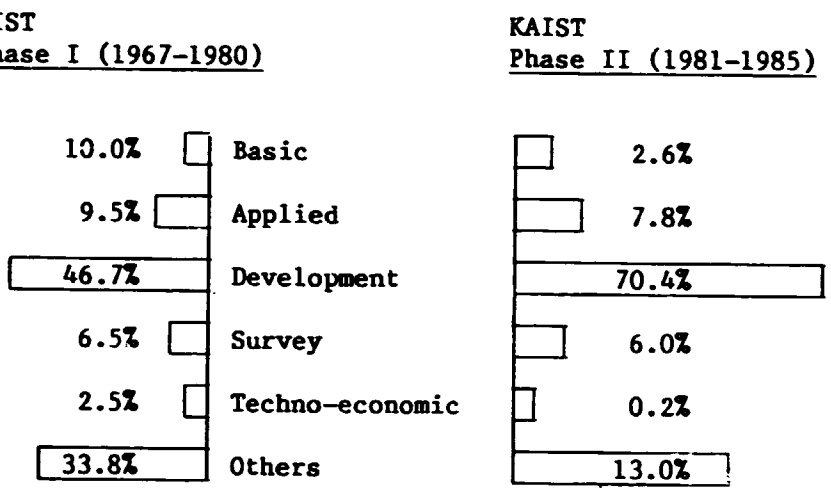
Status of research contracts from 1967 to July 1985 at KAIST

Research types	Phase I (KIST)		Phase II (KAIST)		Total	
	Amount	Number of projects	Amount	Number of projects	Amount	Number of projects
Basic	507	19	1,219	52	1,726	71
Applied	4,666	392	3,738	143	8,404	535
Develpoment	22,839	902	33,413	896	56,252	1,798
Survey	3,206	339	2,832	85	6,038	424
Techno-economic	1,188	92	75	2	1,263	94
Others	16,546	831	6,209	297	22,755	1,128
Total	48,952	2,575	47,486	1,475	96,438	4,050

Comparison (%) of number of projects between Phase I (KIST) and Phase II (KAIST)



Comparison (%) of research expenditures between Phase I (KIST) and Phase II (KAIST)



(a) Major criteria for project selection

KAIST takes into account various aspects for project selection as listed below. These aspects can be changed by the nature, project types, fund sources, and sponsorship of the project. Different weights may be given by the sponsors to each aspect, for example, national projects may receive higher weights on technological, economic and environmental aspects, while in industry-sponsored projects more attention would be paid to market and commercialization potential.

(i) Technology aspects:
- Technical sophistication of the project
- Technical information
- Design complexity
- Impacts to the other technology or industries
- Overlapping with the other research project

(ii) Market aspects:
- Marketability and its commercialization potential
- Product life cycle
- Competitiveness
- Needs of the users.

(iii) Organizational aspects:
- Postitive support and interest of top management (clients)
- Project leaders position in the hierarchy
- Project team capability
- Relationship with competitive product
- Communication channel.

(iv) Budget and time aspects:
- Total cost
- Overhead rate
- Length of project time
- Financial ability
- Contributions of KAIST
- Development capability
- Availability of technology import.

From 1984 KTDC asked to assess and select technology for the Industrial Technology Development Support Programme by MOST under the auspices of the national R and D programme. The programme is partially funded by the Government to promote co-operative research between public research institutes and industrial firms. KTDC evaluates technical merits and financial considerations and makes recommendations as to potential efficacy of research contracts between Government authorities and applicants from industry. In this case, KTDC takes four dimensions into consideration for the selection of projects.

(i) Fitness to national policy
- Technological improvement:
  Know-how accumulation (know-how acquisition)
  Technical dissemination

- National production increase
  GNP contribution rate
  Productivity increase

- Foreign exchange acquisitions
  Export increase
  Import substitution

(ii) Technological feasibility
- Technical novelty
  Creativity
  Innovativeness
  Degree of development

- Economical feasibility
  Value added
  Comparative priority

- Technical commercialization
  Technical development trend
  Quality competitiveness
  Price competition

- Degree of technology
  Constraints
  Timing

(iii) Environmental aspects
- Governmental policy
- Technology import
- Awareness of R and D (clients)
- Availability of technical information
- Involvement of industry

(iv) Economic aspects
- Impacts on import substitution
- Effects of export increase
- Utilization of internal resources
- Energy conservation.

The final decision to adopt the project is given by the review committees of MOST which divides the R and D proposals according to the following five fields.

- Basic science
- Mechanical and material science
- Electrical and electronical engineering
- Chemistry and chemical engireering
- Energy and natural resources.

Some of the criteria used at this stage are:

(i) Fitness to the national R and D strategies

- High technology in strategic fields
- Long-term and risky project but core industry technology

(ii) National economy aspects

- Impacts on GNP
- Export contribution/import substitution
- Capital-intensive project
- Job creation
- Value added

(iii) Technology aspects

- Creativeness
- Competition with existing technology
- Marketability

(iv) Commercialization

- Development capability
  - Manpower
  - Willingness
  - Organizing power
- Marketing
  - World market demand
  - Domestic demand
  - Market share
- Research resources support
  - Easiness of research equipment import
  - Technology transfer
  - Funding
- Product commercialization
  - Industrial environment
  - Stability
  - Growth rate.

(b) Commercialization at KAIST

With the growing impact of technology on industrial development and the growing prominence of R and D in the economic growth, considerable attention

has been directed to effective R and D management; e.g. project selection, organization, planning, budgeting, and especially the utilization of research results. At the commercialization stage of R and D results, not only the degree on technology itself is very decisive, but also the implications of technology with corporate business strategy, planning and control are often critical. The commercialization of R and D projects is influenced not only by technology itself but by market demand, environmental elements involving government support and technology transfer, management of creativity, and others. Recently, 4,050 projects of KAIST were reviewed and classified by research types: (1) Basic research, (2) Applied research, (3) Development research, (4) Survey, (5) Techno-economic study, and (6) Others (computer programming, technical service extension, and computer usage contract, etc.).

Of the total projects, 2,333 applied and development projects were further reviewed and classified into three categories: (1) Product development (P), (2) Process development (T), and (3) Others. The results of classification are shown in following table:

Commercial success or failure projects by product and process development
Unit: Number of projects

	Successful	Failed	Unused	Others	Total
Product	242	60	752	142	1,196
Process	89	3	307	46	445
Others	179	4	419	90	692
Total	510	67	1,478	278	2,333
Percentage	21.9	2.9	63.3	11.9	100.0

Reasons for success or failure of commercialization can also be analysed by considerating following five factors.

- Technology-push
- Demand-pull
- Environments
  - Government support
  - Technology transfer
- Management
- Others

The results of this analysis are shown in following table.

Factors for commercial success or failure
Unit: Number of projects

Factors	Product S/F	Process S/F	Others S/F	Total S/F
Technology-push	47/31	15/3	27/3	89/37
Demand-pull	177/18	66/0	66/0	309/18
Environment	0/3	-	-	0/3
Government support	12/7	6/0	51/0	69/7
Technology transfer	1/1	1/1	-	2/2
Management	1/0	-	31/1	32/1
Others	4/0	1/0	4/0	9/0
Total	242/60	89/3	179/4	510/67

More specifically, some tities of projects carried out are listed below. It is easy to see that many of the projects were undertaken by small and medium industries.

Technology	Main factors for success/failure
High nutrition-low cost foods for infant and growing children	Demand-pull/successful
Fish pickle powder	Demand-pull/failed
Development of ginseng beverage	Demand-pull/successful
Synthesis of sorbitol	Demand-pull/unused
Shampoo for dandruff control	Technology-push/failed
Development of synthetic method for Trimethoprim	Technology-push/successful
Development of synthetic method for Alpha Tocopherol (Vitamine E)	Technology-push/successful
Black and white film	Technology-push/successful
Cellulose sponge	Demand-pull/failed
Copper-clad laminates for PCB	Technology-push/successful
Flexible straw	Technology-push/successful
Flourocarbon technology	Technology-push/successful
Sealed Ni-Cd cell	Technology-push/failed
Seamless steel pipes, and stainless steel clad	Technology-push/successful
Black and white TV using hybrid IC	Environment/failed

Technology	Main factors for success/failure
Cordierite casket for tile production	Technology-push/successful
Rifmaycin SV	Technology-push/successful
Development of the hollow fiber dialyzer for artificial kidney	Technology-push/successful
NMR-CT (nuclear magnetic resonance-computerized tomography)	Technology-push/successful
Manufacturing technology or Fe-Cr-Co permanent magnet	Technology-push/successful
Synthesis of CFT (cefatoxime)	Technology-push/successful
Compound ultrasonic scanner	Technology-push/successful
Synthesis of vitabax	Technology-push/successful
Clinical enzyme	Technology-push/successful
Development of blended cement utilizing domestic blast furnace slags	Technology-push/successful
Synthesis of P-Hydroxylphenylglycine	Technology-push/successful
Polyester film manufacturing technology	Technology transfer/successful
Optical fibre	Technology transfer
SCP (single-cell protein)	Demand-pull/failed
High-strength and high-modulus aramid pulp	Technology-pull/on-going

4. TECHNOLOGY SUPPORT CENTRE FOR SMALL AND MEDIUM INDUSTRIES

The Technology Support Centre for Small and Medium Industries was established as the agent through whom technical assistance by government-supported research institutes could be provided to small and medium industries. The Centre is comprised of the Precision Machinery Technology Centre, the Foundry Technology Centre, the Technology Transfer Centre, the General Technical Service Section, and the Management Section for Administrative Services.

Precision Machinery Technology Centre

The Precision Machinery Technology Centre carries out R and D work on the analytic design of the NC machine, automatic programming and mechatronics.

Within the Centre, the Technical Services Group is chiefly engaged in the business of servicing the industries with the transfer of technical know-how and knowledge obtained in the process of the Centre's research, and with technical advice and spot solutions of manufacturing line problems of industrial enterprises, as well as with the introduction and application of advanced technology from abroad. It is also engaged in the business of assisting the small to medium-sized domestic machine industry by various means including organizing seminars and special courses for the field engineers.

Beginning in 1980, it has launched an "NC School" for promoting and establishing NC technology in the Republic of Korea.

Performance record of the Precision Machinery Technology Centre
Number of cases; () indicates number of participants

Item	1976	1977	1978	1979	1980	1981	Total
Research and development	4	9	8	3	7	4	35
Training and consulting							
Training		2 (115)	1 (80)		2 (46)	3 (143)	8 (384)
Individual visits	7	12	8	20	18	28	93
Seminar and lectures	2 (270)	5 (618)	4 (412)	8 (968)	1 (100)	9 (804)	29 (3,173)

Foundry Technology Centre

The Foundry Technology Centre is engaged in research work related to such fundamental concepts in foundry technology as melting onoculation, the casting plan and casting equipment. Other areas of study include the selection and utilization of moulding sand resources and moulding additives in the country, development of facilities for foundry pollution abatement, improvement of moulding line for increased productivity, production of precision casting,etc.

Lately, the Centre has examined the development of the lathe bed from high strength cast iron. In its studies, the Centre strives to improve lathe bed manufacturing techniques, as well as foundry technology relating to machine tool materials.

Research activities are diversified by studies of alloy casting and cast steel. Another area of investigation deals with the properties of natural sand and the utilization of silica sand in chemical bonding.

In addition, the Centre is engaged in technical consulting. An important part of the technical consulting services takes the form of refresher courses for foundry engineers. These mini-courses are designed to review basic knowledge as well as to introduce new advances in technology. Other forms of service are the collection and distribution of advanced technical information, and the testing of casting materials and foundry sands.

Technology Transfer Centre

The Technology Transfer Centre (TTC) assists the industry and Government by advising firms on the importation of technology, and by promoting international co-operation through the transfer of technology.

Performance record of the Foundry Technology Centre
Number of cases; () indicates number of participants

Item	1976	1977	1978	1979	1980	1981	Total
Research and Development	6	2	2	3	4	4	20
Training and consulting							
Training			3	2	2	1	8
			(152)	(219)	(182)	(100)	(653)
Individual visits	4	16	11	20	20	42	113
Seminar and lectures	4	2	1	3	3	5	18
	(306)	(216)	(50)	(220)	(320)	(231)	(1,343)
Tests and inspections							
Casting sands	50	20	5	378	72	86	611
Chemical analysis		25	6	282	200	243	756
Material testing				104	91	777	972
Raw materials		1		1	2		4
Casting failure tests				2	5		7
Technical consulting							
Facility improvements	1		10	15	10	12	48
Recommend experts	3	3	3	4	3	4	20
Raw material	2	1	2	2	5	5	22
Miscellaneous	1	2		5	15	12	35

To ensure the optimum conditions for technology importation, the Centre provides the interested parties with information of available technology, and acquaints them with pertinent Government regulations and procedures.

The Centre also advises industries as to the technology itself. It determines whether the desired foreign technology is appropriate for the industry's needs, thereby preventing the acquisition of low-level, outdated knowledge.

In order to quickly supply information on the relevant sources of technology to the country's industries, the Centre conducts an annual survey among the industries to ascertain what technology needs exist, and collects information about suppliers for processing into a data bank. Counterparts in Japan, the United States, and Europe facilitate a quick and effective matching of needs with available technology.

As advisor to the Government, the Centre regularly studies the problems regarding the import of technology, in order to aid the Government in taking the proper measures to support domestic industries' needs. Recently, the Centre has also reviewed the domestic technological information suitable for transfer to other developing countries.

Performance record of the Technology Transfer Centre
Number of cases; () indicates number of participants

Item	1976	1977	1978	1979	1980	1981	Total
Technology import (consulting)	96	133	136	128	104	178	775
Technology import (appraisal)	252	349	384	126	18	32	1,161
Technology import (seminar)	12	10	8	2	2	11	45
	(390)	(575)	(750)	(250)	(120)	(459)	(2,544)
Technology import (literature)		18,000	2,500	2,500	2,000	3,000	28,000
Overseas link establishment		1	2	2	2	4	11
Study reports	1	1	1	1	1	1	6
Magazine issues (quaterly)					4	4	8

The present linkages of TTC with overseas' organizations are as follows:

Asia — Asia Technology Co-operation Association (Japan), Japanese Chamber of Commerce, D.A. Japanese Branch.

America — Dr. Dvorkovitz and Associates, Association of Korean Scientists and Engineers in America.

Europe — TTD (Germany), PERA (Great Britain), Hepatex Ltd. (Switzerland), Scantech (Sweden), ICOMA (Federal Republic of Germany).

UN — UNIDO, APCTT/ESCAP, UNCTC.

Some significant contribution of TTC is the introduction of the Viking Ship Design Programme using a large scale computer which was sublicensed to the Korean shipbuilding industries. TTC also made the shell mould process of Japan available to 450 casting industries in Republic of Korea.

General Technical Service Section

The General Technical Service Section is responsible for the technological support of small and medium industries, and plays a central role between government-supported research institutes and other organizations concerned with assisting small and medium industries.

The main areas of technological support conducted by this Section include:

(i) Support service for the small and medium industries in areas designed as national R and D projects by the Ministry of Science and Technology:

- One-researcher-for-one-industrial firm style support service. (The technical support system's version of a "home doctor".)

- Development of common bottleneck technology in small and medium industries;

- Efforts to stimulate an open-door policy in the research laboratories of government-supported research institutes so that easy access can be established for eminent inventors and/or small and medium industries.

(ii) Extension of sponsored service. This would include promotion of co-operation or joint efforts for the management of and technological support for small and medium industries by the Small and Medium Industry Promotion Corporation and by other relevant organizations.

The "one-research for one industrial firm" programme links many of the KAIST researchers to industry of his choice, and this interaction quite often paves the way for large scale contract research.

The programme also includes slightly larger projects which are designed to tackle common bottleneck technology encountered by many small and medium industries. In 1982, for example, a KAIST team undertook a project to plan and design an electroplating industry complex near Seoul.

5. TECHNOLOGY COMMERCIALIZATION COMPANIES

KIST which began its R and D activities in 1968 had maintained a co-operative relationship with Battelle Memorial Institute (BMI), a well known contract research organization. BMI operates a research commercializing company called Scientific Advances Inc. (SAI) and a company called Battelle Development Corporation (BDC) which handles licensing and venture development. It was natural therefore for KIST to organize a similar activity and it accordingly established the Korea Technology Advancement Corporation (K-TAC) in 1974 to undertake similar tasks as those of SAI and BDC. K-TAC was run by a president on a part-time basis until 1982. The staff was small but drawn from the best people of KIST and outside.

Although K-TAC was wholly owned by KIST until 1982. K-TAC's stockholders at present are seven research institutes closely tied with MOST. The seven institutes represent chemistry and chemical engineering, machinery and metals, electronics and telecommunication, nuclear energy, standards, research and life sciences.

The purposes of K-TAC are:

(i) Commercialization of research results using know-how generated by various institutes. Other foreign and domestic technologies can also be utilized.

(ii) Marketing and sales of research results and their related industrial rights.

(iii) Sales of prototype equipment and by-products of research development work.

(iv) Sponsorship of additional R and D when required.

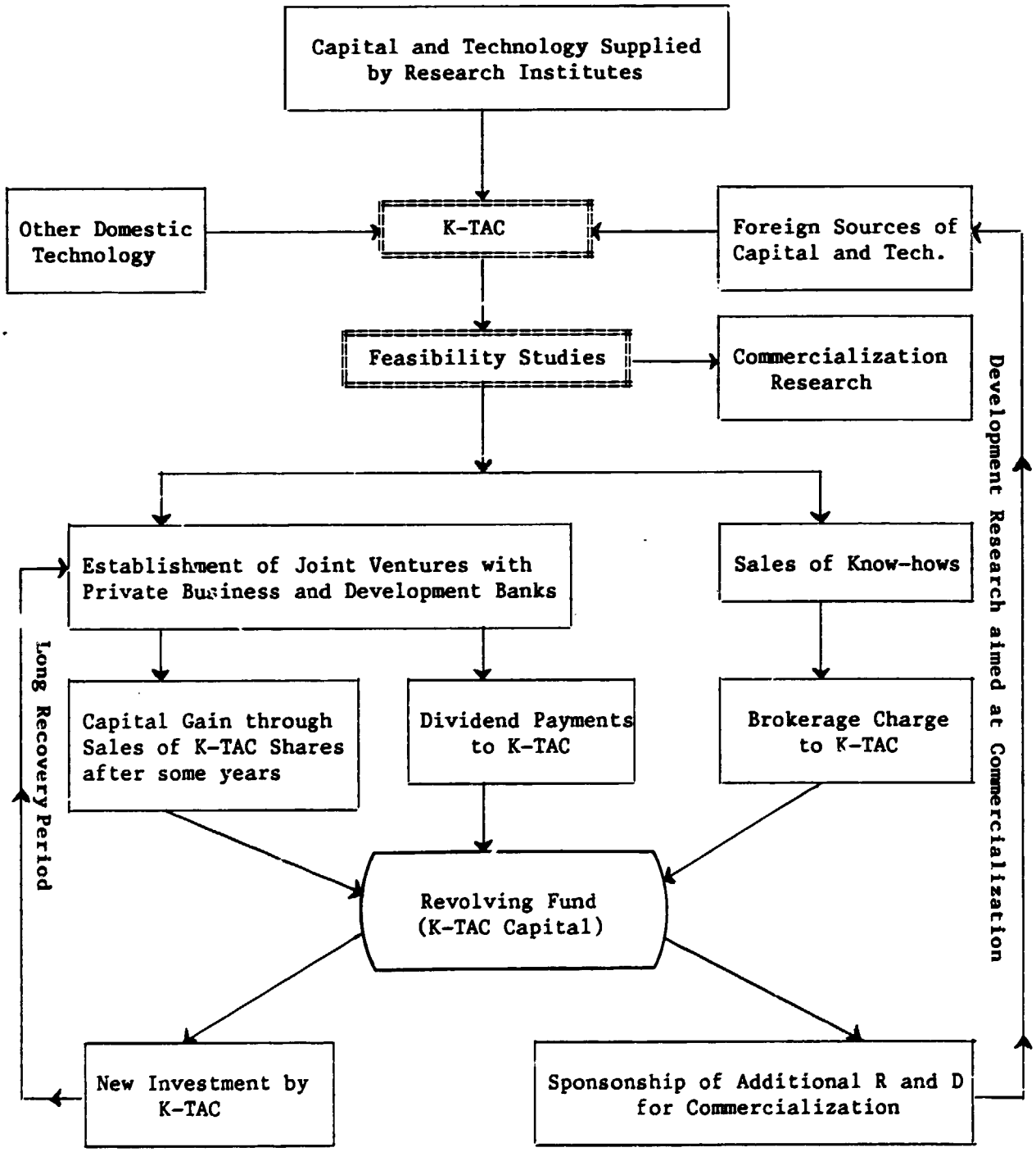
(v) Management assistance and market research.

Over the years, the company has maintained a group of specialists whose expertise is market and feasibility studies. Financially, the company operates with a revolving fund concept which is pictorially shown below.

It is important to note that the recovery period of initial investment averages around 5 years which is quite long. K-TAC's experiences so far show that the capital gain is approximately equal to the original investment, i.e. the value of the stock doubles in five years. Securing of sufficient revolving fund therefore is of paramount importance to operate this kind of company in a stable fashion over a long period of time.

Although K-TAC functions as a commercial corporation, it is also possible to establish such a unit either as a part of a research institute of a Government unit. However, it is believed that the present form of commercial operation gives largest freedom to the company.

The real difficulty, however, is in securing enough revolving fund as the company expands its activities. Certain amount of persuasion is necessary to obtain sympathetic attitude from the institute management and the Government, since this type of operation is quite foreign to academically oriented


Capital and Technology Supplied by Research Institutes
Other Domestic Technology
K-TAC
Foreign Sources of Capital and Tech.
Feasibility Studies
Commercialization Research
Establishment of Joint Ventures with Private Business and Development Banks
Sales of Know-hows
Capital Gain through Sales of K-TAC Shares after some years
Dividend Payments to K-TAC
Brokerage Charge to K-TAC
Revolving Fund (K-TAC Capital)
New Investment by K-TAC
Sponsonship of Additional R and D for Commercialization
Long Recovery Period
Development Research aimed at Commercialization

researchers. Gradually and steadily, however, the importance of K-TAC is being recognized as an important element in linking the research and industrial communities. MOST is also considering the idea of awarding the work of evaluating projects of imminent commercialization to K-TAC on a regular basis. If such work becomes a regular activity of K-TAC, K-TAC can also make a contribution in selecting projects with large commercialization potential.

Recently, in 1981, a financial institution called the Korea Technology Development Corporation (KTDC), began operating to provide R and D-related funding to the private industry. The initial idea to form the bank was born in 1977 when MOST applied for an World Bank loan to establish such an institution. KTDC was incorporated under the "KTDC Act" which paved the way for Government's equity investment and support. Currently the Government's share is about 23.5 per cent. The company, however, is largely controlled by the Federation of Korean Industries.

Records to date show that KTDC has made financial loans to R and D activities of the industry (52.3 per cent), loans for technology import (21 per cent), loans for equipment purchase (15.7 per cent) and loans for commercialization of R and D results (11 per cent). The difference between KTDC and K-TAC lies in the fact that KTDC is a banking institution whereas K-TAC is a research commercialization company. The two companies complement each other and co-operate in the creation of new companies.

The Korea Development Bank, in 1984, also created a financial corporation called the Korea Technology Finance Corporation (KTFC) whose function is nearly similar to that of KTDC except for the fact that it is wholly owned by the Korea Development Bank. K-TAC maintains a close working relationship with KTFC through joint financing new businesses.

Another recent entry is the Korea Development Investment Corporation (KDIC) which was established in 1982 through investments by 7 short-term loan companies. The mode of operation of this company probably comes closest to the style of venture-capital company. The company invests in R and D results, innovations and imported technology at the business formation stage primarily through purchases of stocks, convertible debentures and company bonds. The company normally purchases less than 50 per cent of the paid-in capital and does not particiate in its management. Within 6 years, the company sells its share to its original partners to realize capital gain. The pattern is quite similar to K-TAC except the fact that K-TAC participates in the new business development usually at the earlier phase, i.e. right after the end of R and D. K-TAC and KDIC have signed a letter of co-operation along with KTDC and KTFC.

6. FACTORS AFFECTING COMMERCIALIZATION OF R AND D RESULTS

There are numerous articles and books about the strategies employed for successful commercialization of research. Most of these, however, discuss the situation encountered in an industrial environment where a continuous feedback and contact with the real world markets are constantly maintained. The research projects from the beginning are launched with commercial application in mind. This chapter, however, will look at the situation of public research institutes where contacts with the outside world can become remote unless the institute makes an intentional and systematic effort to interact with the industry.

As explained earlier, KIST at its early stage of operation forced its researchers to interact with the industry by adopting the mode of contract research. Beginning 1981, however, MOST launched a matching fund system to advance the required R and D fund to the industry. Through this system, the industry was able to receive loans of up to 70 per cent of the project requirement which is payable within 5 years after the project becomes commercialized. The fund had a profound effect in linking public research institutes and the industry, since MOST would award the bulk of the fund to projects co-submitted by industries and research institutes under MOST co-ordination. The large potential for commercializtion therefore was built into the matching fund award system.

In addition to this, MOST also awards funds for national projects which are essentially long range in nature. These national projects are intended to solve problems that are common to some specific industry sectors, although the industry itself often is reluctant to solve them alone. The institutes also undertakes seed projects and in-house research that test early ideas of researchers. The results of the national research are available to the public whereas the in-house research list is available to K-TAC only. K-TAC regularly reviews these two areas for potential leads for new business development.

Once the initial review uncovers a potential area, the next stage is to conduct a prefeasibility study in which the market survey is the central issue.

This is often time consuming but most essential in deciding whether the project merits a more thorough feasibility study. Approximately one quarter of the projects survive this phase. This is followed by more detailed analysis where such items as initial capital investment and internal rate of return are estimated. Further attribution occurs and only about 10 per cent of the original number survive for further pursuit.

It is at about this stage that K-TAC begins an earnest search for a business partner who can take on the bulk of the work that remains ahead. It can either be a company or an entrepreneur. But the partner preferrably should have a manufacturing or sales experience. The identification of this competent partner probably is the most important factor in making the project a success.

Once the business partner is decided, K-TAC together with the partner reviews the feasibility in detail. At this stage, they also draft and sign such documents as joint venture agreement, technology licensing agreement and articles of incorporation of the new company. All details are examined

carefully including the method and valuation of the stock when K-TAC decides to sell its share to the partner in the future. If this is not clearly agreed, it is a certainty that this becomes a problem in the future when K-TAC decides to sell its shares. Financing of the project must also be discussed in detail. Normally, it is desirable for the new company to borrow only about half of the total investment required. In case K-TAC plans to consider research results as a part of equity participation, it is at this time that both partners should agree on the monetary value of the know-how or patents generated through the research.

Should K-TAC decides to do so, K-TAC can also invite development banks to take part in the venture. K-TAC's experience with the development banks has been very good as exemplified by the frequent participation of the Korea Long-term Bank, (KLB) (formerly Korea Development Finance Corporation) in K-TAC projects.

In the current age of technology revolution the survival and growth of the new venture depend heavily on the company's ability to absorb new technology. In all cases of K-TAC's success, KIST and later KAIST have continued to support the companies with second and third generation technologies to keep up with the technology advancement.

Important factors for successful commercializations according to the K-TAC experiences are:

- thorough and detailed feasibility study;
- selection of a competent business partner with strong entrepreneurial spirit;
- adequate financial resources; and
- continuous source of technology upgrading.

In some cases, the measures taken by the Government to protect the new venture can be considered. But this protection should be exercised in a limited manner only after careful deliberations.

7. COMMERCIALIZATION EXPERIENCES OF K-TAC

The first sale of technology and the first estbalishment of a commercial company by K-TAC were realized in 1976. Since then K-TAC has sold 15 technologies and started 12 new companies. The lump sum payment, initial payment and running royalties received by KAIST to date is estimated to be about 1.5 billion won. Total equity investments of 12 companies amounts to 8.45 billion won (K-TAC's portion 1.3 billion) and total sales by these companies are 34.6 billion won. New job creation of 813 people was realized. To support the above activities, K-TAC has sponsored 6.5 billion won worth of developmental research to pave the way for commercialization.

As mentioned earlier, K-TAC operates around a revolving fund concept. Therefore once an established company becomes a smoothly running business entity, K-TAC sells its share to its partner. To date, K-TAC has divested its shares of 4 such companies. Basic information on some companies created by K-TAC 1976-84 is given in the following table. In 1985, for instance, K-TAC has established a specialty gas company to serve the semiconductor industry. K-TAC is also in the process of launching a multipurpose specialty organic chemicals manufacturing plant.

In the early phase of K-TAC operation, the company chose to sell the technology to the industry. Good examples are fluorocarbon refrigerant and modacrylic tow manufacturing know-how, acquired through extensive pilot plant work at KIST. Contribution by K-TAC to KIST and KAIST through such sales of technologies is shown in the following table.

It can be seen that both the establishment of new companies and sales of know-how cover a wide range of fields since KIST/KAIST is a multidisciplinary research organization. The record indicates that K-TAC has sold about 50 per cent of the commercializable projects that were developed by KAIST. Usually the sales approach of K-TAC has better appeal to the business community since the proposal often includes prefeasibility analysis.

The sale of fluorocarbon refrigerant R-12 to the Korea Aluminum Company which was being managed by the Korea Development Bank took considerable skill on the part of K-TAC in order to persuade the Bank to make investment decision. The project succeded due to may factors that are indicated below and the Ulsan Chemical Company which produces the refrigerants is a prospering company today:

(i) Credibility of technical competence proven through relatively large pilot plant and the existence of world class fluorine expert consultant.

(ii) Availability of key plant personnel who had enough exposure to the handling of dangerous fluorine and confidence in the project.

(iii) The existence of the national mood to undertake new ventures to upgrade the industrial capability of the country which after all is the goal of national development banks.

The project success, however, also depended heavily on the following two factors:

Basic information on some companies created by K-TAC

Name	Namhae	Hanjung	Nonferrous powder	Jinheung	Yuhan	Optical fibre	Micro-research	Hanmi fine chem.
Date of establishment	1976	1977	1978	1978	1980	1982	1983	1984
Product	Ceramic saggar	Agri-chemicals	Nonferrous metal powder	Agri-chemicals	Antibiotic chem.	Optical fibre	Precision dies	Pharma intermed.
Source of technology	KIST	KIST	KIST	KIST	KIST	KAIST	Imported tech.	KAIST
Total capital in 100 million Won (K-TAC portion)	7(2)	14(1.5)	3(1)	10(1)	10(1.95)	6(1.2)	5(0.5)	3.5(1)
1984 sales (100 million Won)	54	177	13	44	35	9	7	5
Number of employees	2.37	199	37	105	80	33	41	42
Business partners	2 entre-preneurs and KLB	Korea Agrichemi-cals Co.	1 entre-preneur	Taehan Agrichemi-cal Co.	Yuhan Pharma KLB	Gold Star Co. Taehan Elec. Wire Co.	2 entre-preneurs KTDC, KLB	Hanmi Pharma Co.
1983 export (100 million Won)	15	13.6	-	24	21	-	4	-
Mo. of domestic competition	None	10	None	10	1	4	3	1
Market share (%)	100	25	70	12.5	45	-	5	30

(i) Eventual expansion of the market due to the growth of the country's economy.

(ii) Import ban of the refrigerant for a limited period of time (5 years).

The case of the modacrylic filament tow project which was undertaken for synthetic wig, carpet and other nonflammable textile application, however, was not as fortunate. By the time the industry bought the technology and when the company nearly completed the detail design of the plant, the wig market disappeared. The technology is still waiting to be commercialized. The artificial silk worm feed project is still under careful study although the technology was transferred in 1979. All the other know-hows are in active use at present.

The case of starting a ceramic saggar industry by establishing the Namhae Ceramics Co. is a success story. No government protection was given in this case. This is a typical case of import-substitution through domestic R and D. Not only was the technology developed at KIST internationally competitive but the management team headed by K-TAC staff truly devoted all their effort to make it a success. Distribution of Namhae shares were: K-TAC 40 per cent, KLB 20 per cent, Entrepreneur A 9 per cent and Entrepreneur B 31 per cent. The structure was such that the chief executive had great degree of freedom with K-TAC support since KLB as a banker normally remained neutral. This seemingly good structure, however, presented a serious problem when K-TAC wanted to sell its shares, and each entrepreneur wanted to control the company by buying the K-TAC and KLB shares. Through this experience, K-TAC has learned to let the business partners agree on the precise methodology in divesting K-TAC shares during the formation stage of the new company.

Technologies sold to industry by K-TAC
(Million Won)

	Year	Lump sum	Initial	Royalty/year
Fluorocarbon refrig. -12	1976	140	-	-
Cordierite saggar	1976	60	-	-
Modacrylic filament tow	1977	200	-	-
Vitavax growth chem.	1978	15	-	-
Vanilla flavor	1978	20	-	-
Mul-cord saggar	1978	40	-	-
Artificial silkwork feed	1979	200	-	-
High temp ceramic mat	1979		2	2%/13
Specialty metal wires	1979	-	30	1%/5
3-Formyl rifamycin SV	1980	-	100	1%/5
HMI	1980	-	2	3%/10
Optical fibre	1982	80	-	-
Fluorocarbon refrig-22	1982	90	-	-
AMBT specialty chem	1984	-	11	103 Won/5
Cefotaxime antibiotics	1984	-	10	2%/5

The case of the Korea Nonferrous Powder Co. is a lesson in not to start a company when the technology is not adequate and when the partner is inexperienced in business. Later, another entrepreneur with solid financial background had to step in to improve the company position. One of K-TAC's top management was sent at the request of the new management to run the company full time.

The case of the Yuhan Chemical Co. is a success, however. The technology was good and the partner was a leading pharmaceutical company in the Republic of Korea. The new company is requesting KAIST to come up with new technology so that they can expand.

One of the most interesting case studies of commericalization is that of the Korea Optical Fibre Co. venture. After the research project was undertaken at KAIST for a very long period of time, K-TAC was requested by KAIST to form a company with two of the leading industries in the country. Through this venture, local industries were able to demonstrate to the advanced nations that, in a certain limited way, a developing country can challenge the high technology sector. Although the venture had to be dissolved due to the formation of new joint ventures with A.T. and T. and Sumitomo, the first company was certainly catalytic in bringing in advanced technology to the country. K-TAC recovered its investment and the two business partners made unseen profits through tougher negotiations during the technology purchase.

Microresearch and the Hanmi Fine Chemicals' companies which have been recently organized are struggling through their first phase of company operation. But the outlook is good and there is confidence that both companies will do well in the long run.

Some factors for success and failures in K-TAC's experiences are listed below.

Success and failure factors of research-based new companies started by K-TAC

Successful cases

Namhae Ceramics Co.	Hanjung Fine Chemicals Co.
- Sustained K-TAC support	- Stable market
- Able management	- Continuous management and technical support by K-TAC and KAIST
- Good product quality	
- Stable market	- Will of business partner to expand the company
- Continuous technical support by KAIST	- Eventual possession of own R and D capability

Failure cases

Samwoo Specialty Wire Co.	Korea Optical Fibre Co.
- Inadequate technology	- Small market
- Small market	- Sudden appearance of multinational competition
- Lack of capability to add new items	- Dissolution of joint venture
- Government regulation to protect small businesses	

As K-TAC continues to create new companies in the future, it is certain that K-TAC's ability to select better projects to assure rapid stabilization will continue to grow.

8. CONCLUSIONS

The idea of commercializating R and D results of public organization is of an ongoing interest in every nation that spends public funds either through Government or other means of endowments. In the United States, for example, the NASA technology transfer programme, called "spin off", has been in operation since late 1960s. Recently, some industrial companies are making intentional efforts to commercialize technologies that exist at such well known laboratories like Los Alamos and Argonne.

In case of Japan, the efficient co-operation that exists between the national industrial research institutes and the industry is well known. In case of France, the role of Government legislation in creating the French Petroleum Institute (IFP) is also well publicized. Observing all these successes, the Republic of Korea is trying to find an optimum system through which the industry and the public research institutes can interact effectively. One such experiementation is the operation of K-TAC. It is by no means an easy task and K-TAC has gone through many trying experiences to grow this far.

Looking back at the experience of K-TAC, which is one of the many avenues for effective commercialization, the following elements seem to be most important in sustaining such an effort.

- Reasonably adequate capital to endure the long period of waiting required to realize capital gain through sale of shares.
- Establishment of a regular source of income through consultancy either to the industry or the Government.
- Existence of a reasonable source of technology generation with good chance of commercial success.
- Proper selection of an entrepreneur or a business partner who is willing to take chances with the new technology.
- Strong institutional assistance and co-operation through steady exercise of its will to make things happen.
- Existence of competent staff with good contacts both with the industry and the research community.

Whether the above requirements are relevant to other developing countries is difficult to judge. But it is quite likely that the lack of some of the elements will certainly deter the progress of similar undertakings. As is always the case, the best lessons are learned by doing. Organizations similar to K-TAC can be created. But unless some top management staff who are conversant and comfortable in dealing with industrial technology and indigenous business practice can be recruited, the undertaking can expect tremendous problems. Even if such people are recruited, it takes many years to provide the new organization the required expertise. It simply takes time and on-the-job training. If the R and D community decides to create a K-TAC-like organization, therefore, it is best to start one early even if the initial scope may be small.

An international organization such as UNIDO can formulate a programme to stimulate the R and D activities of public institutes of developing countries through a programme to create K-TAC-like organizations. Another tool to gain similar objective is to exchange techologies that are close to commercialiazation, for example, from KAIST to other similar institutes of developing countries.

At present, the Government of the Republic of Korea is putting major emphasis in the development of small and medium industries. Such endeavours focus on the improvement of the present status of SMI or the new creation of technology intensive enterprises. It is believed that a steady effort in both these directions is of crucial importance.

In the society of today, many business entities are formed and also go out of existence. But the records indicate that the bulk of new progress and employment generation are realized through the dynamics of small and medium industries. The creation of such industries from the technology side, as opposed to the market side, can and will be a very important element in the process of economic and social development.