SCIENCE AND TECHNOLOGY FOR INDUSTRIALIZATION

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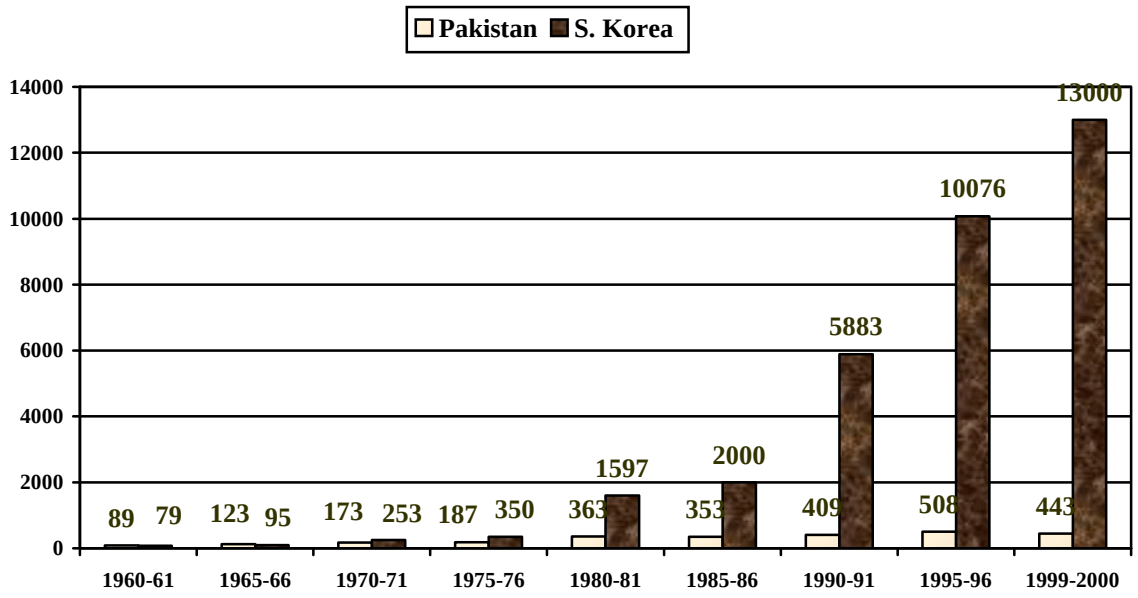
ABSTRACT

Technology considerations have been introduced in economic theory and there is no doubt in the minds of most policy makers that technological improvements are usually linked to economic growth and higher standards of living. Nowhere has this been more evident than in the economic miracles achieved by East Asian countries in the last three decades where high economic growth was accompanied by improved income distribution.

Developing indigenous S&T capabilities for industrialization is dependent on several factors which include historical and cultural traditions, political and economic stability, particularly attainment in science education, natural resources, the structure of firms, financial institutions, modes of technology transfer and market forces. An all-encompassing formula for countries to emulate does not exit, yet there are lessons to be learnt from the experiences of East Asian countries.

This article reviews the S&T policies followed by South Korea in the last five decades. The role of S&T policy in industrialization and its impact on the economy is discussed[1]. The comparison with Pakistan's S&T policy highlights its weakness as well as its non-integration with economic, industrial, educational and other policies related to the socio-economic development of the country.

South Korea has witnessed unprecedented economic growth in the last three decades. Figure-1 shows the comparison of the growth in per capita GNP for both Pakistan and South Korea during last four decades.



Source Pakistan: UNESCO, Statistical Year Book 1980, 1982, 1991 and Economic Survey of Pakistan
Source South Korea: Science & Technology Policy Institute (STEPI), South Korea

Figure - 1: Growth of Per Capita GNP (US$)

The GDP growth rate in Korea has been over 8 percent per annum. Being one of the poorest countries in the 1960s with per capita GNP of $ 79, Korea is fast catching up with the western industrialized economies with per capita GNP of $13,000 in the year 2000. Its economic growth has also accompanied better income distribution and improved quality of life for the majority of its people[2].

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By contrast, in Pakistan the ratio of people living below the poverty line has increased from 30 percent in 1971 to 47.8 percent in year 2000. In the last decade, the country has experienced continuous economic and social deterioration which is reflected in low average annual growth rate of GNP and a large segment of the population living in poverty[3].

HUMAN RESOURCE DEVELOPMENT

Several studies have shown that educational attainment has a positive impact on growth and contributes to reducing inequalities. Similarly many experts have argued that availability of a highly skilled labour force contributes towards productivity and enhancing the profitability of investment[4].

In 1964 Herbison and Myer[5], using data from developing countries, found South Korea, Taiwan and Yugoslavia with levels of educational achievements far above other countries. A knowledge base had been created earlier on. Government policies supporting broad based high quality education are frequently mentioned as common features behind economic growth of these economies. Certainly a broad knowledge base has become the cornerstone for building modern societies.

Table - 1: Shows the Comparison of Literacy Rate and Enrolments Between South Korea and Pakistan

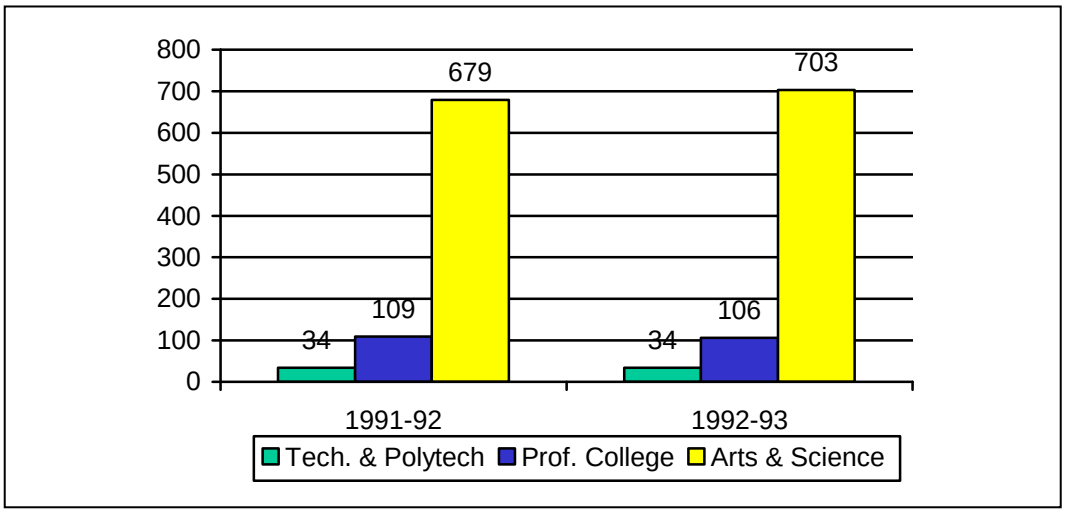
Age	Percentage of Enrolments by Age Group			
	1970	**1980**	**1990**	**1995**
Illiteracy Rate	10.6	0	0	0
Elementary School 6-11	100.7	102.9	100.9	98.7
Middle School 12-14	51.2	95.1	96.3	100.6
High School 15-17	28.1	63.5	86.8	89.9
Tertiary 18+	8.8	16.0	37.6	54.6

Age	Percentage of Enrolments by Age Group						
	1970	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**
Illiteracy Rate	NA	NA	72.1	68.5	64.5	60.6	56.7
Elementary School (5-9)	36	40	40	44	61	71	89.0
Middle School (10-12)	13	15	14	17	23	45.8	47.5
High School (13-16)						30.8	29.5
Tertiary (17-23)	2	2	NA	2	3	3	2.6*

Source: i) UNESCO Statistical Year Book 1999
ii) S&T Indicators of Pak (1999-2000)

Pakistan's literacy rate is exceedingly low and despite increase in the number of universities and other educational institutions, the quality of education has not shown much improvement. Expenditure on education has also been low as no government showed the requisite commitment towards educating the masses. The quality of education at all levels suffers due to shortage of qualified teachers. High drop out rates at primary level not only reflect the social/economic problems but low quality and lack of efficiency exhibited by the Pakistan educational system.

In most developed countries the enrolment-ratio in general technical education is 50:50 if not more in favour of technical education. In Pakistan the ratio is 9:1 (Figure-2). This is mainly because of the disregard of technical education towards the job market.



Source: (i) Economic Survey 1997-98 (ii) Pakistan Statistical Year Book-1995
(iii)Federal Bureau of Statistics, Pakistan

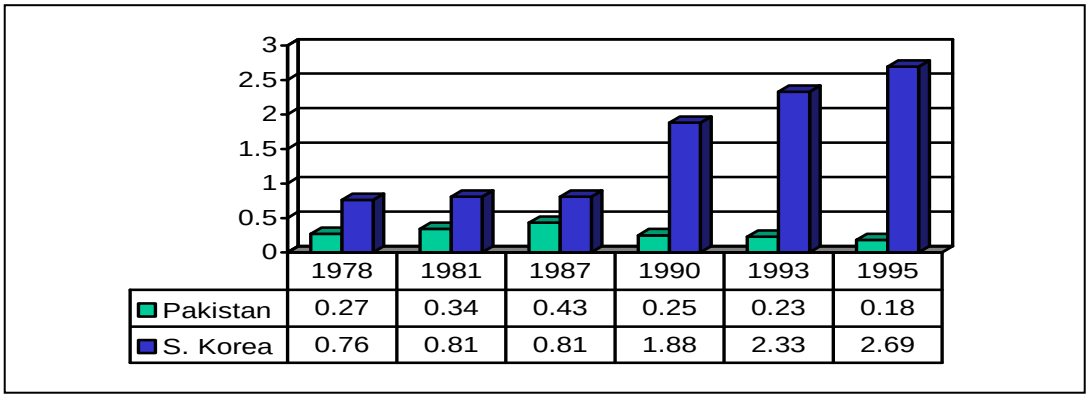
Figure - 2: Comparison of Enrolments

For example none of the technical colleges are providing training in production techniques. The other reasons for technical education not been able to attract a large number of students is the low prestige attached to the profession.

INVESTMENT IN RESEARCH AND DEVELOPMENT

Besides education and training of human resources, R&D activities are essential for building knowledge based economies. R&D conducted at academic institutions and industry are key to the accumulation of knowledge required to strengthen innovation. Expenditure on R&D is an important indicator which is equated to the economic development. More meaningful is R&D expenditure by the private sector or by industry.

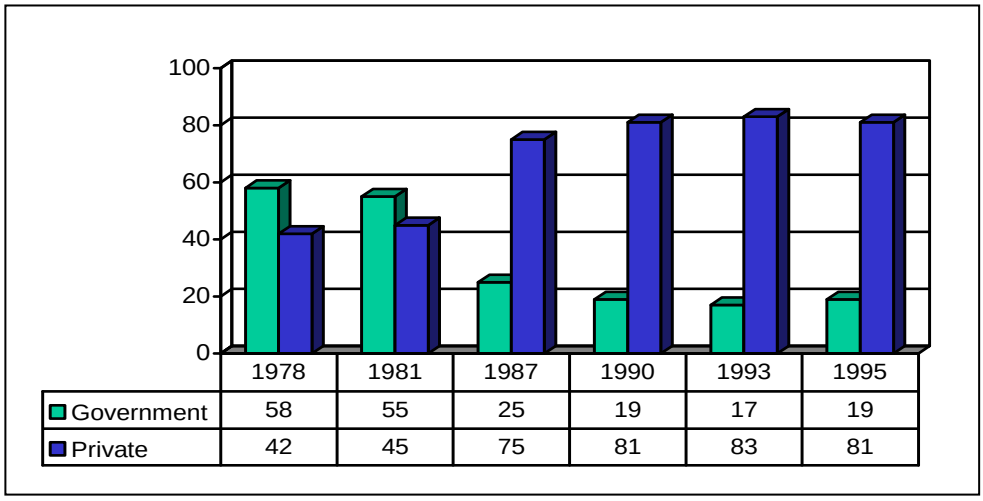
Figure 3-4 shows comparative investment in R&D for Pakistan and South Korea and also the growth of private investment in R&D in South Korea. The R&D expenditure of private firms increased from $3.36 billion in 1990 to $8 .95 billion in 1995 contributing almost 81 percent of total R&D expenditure. The number of private R&D organizations grew from one in 1970 to 2270 in 1995[6]. According to G. Cardoza, the investments in education and R&D not only have positive effect on knowledge accumulation (Scientific publications and industrial innovation patents etc.) but also seem to have a positive impact on employees' productivity.



	1978	1981	1987	1990	1993	1995
Pakistan	0.27	0.34	0.43	0.25	0.23	0.18
S. Korea	0.76	0.81	0.81	1.88	2.33	2.69

Source: i) PCST Publication, S&T Potential of R&D Organizations, 1990 ii) PCST Publication, S&T Indicators of Pakistan, 1999, iii) Science Policy Cell, MoST, December 1987, iv) MoST, Science and Technology Annals, (S. Korea) various years

Figure - 3: Comparison of R&D Expenditures as Percentage of GNP Pakistan & South Korea

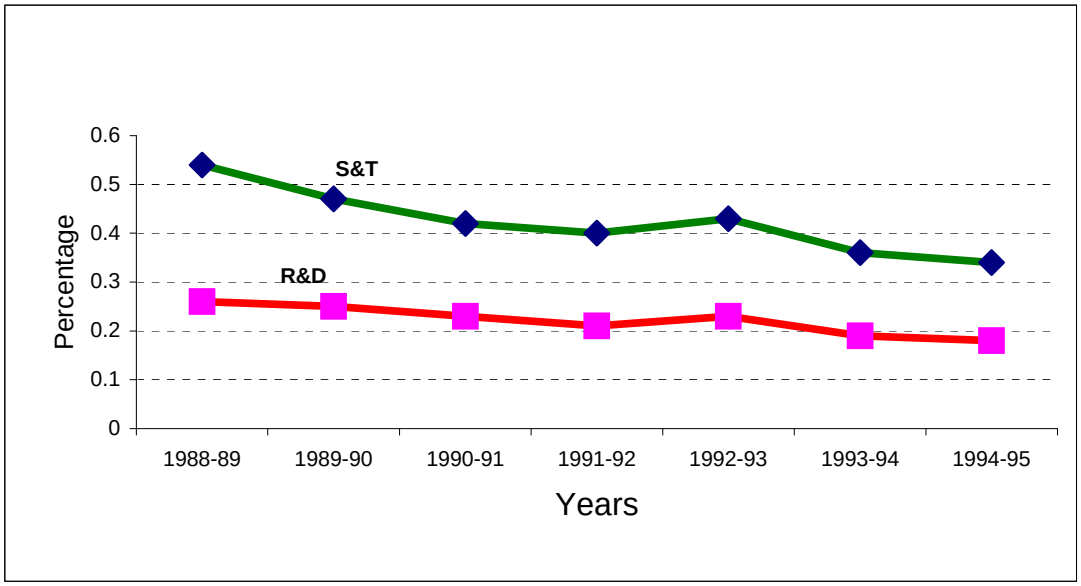


	1978	1981	1987	1990	1993	1995
Government	58	55	25	19	17	19
Private	42	45	75	81	83	81

Source: MoST, Science and Technology Annals (South Korea)

Figure - 4: Government Vs. Private R&D Expenditure (Billion won) **South Korea**

R&D expenditure in Pakistan stagnated for several years between 0.15 to 0.18 percent of GNP. (Figure-5) shows trends in R&D expenditure for the last 20 years. With considerable increase in the number of R&D organizations, the R&D budget mostly contributed by the public sector was distributed very thinly. The private sector contribution to R&D is not documented but there is enough evidence to assume that private sector is neither seeking help from public R&D organizations nor conducting in-house R&D activities[11].



Source: PCST Data, Pakistan Economic Survey 1996-97

Figure - 5: Public Sector (Non-Classified) S&T and R&D Budgets as Percent of GNP (1988-1995)

On the contrary, South Korean firms not only intensified in-house R&D from 1980 onwards, but also began globalizing their R&D activities and building strategic alliances.

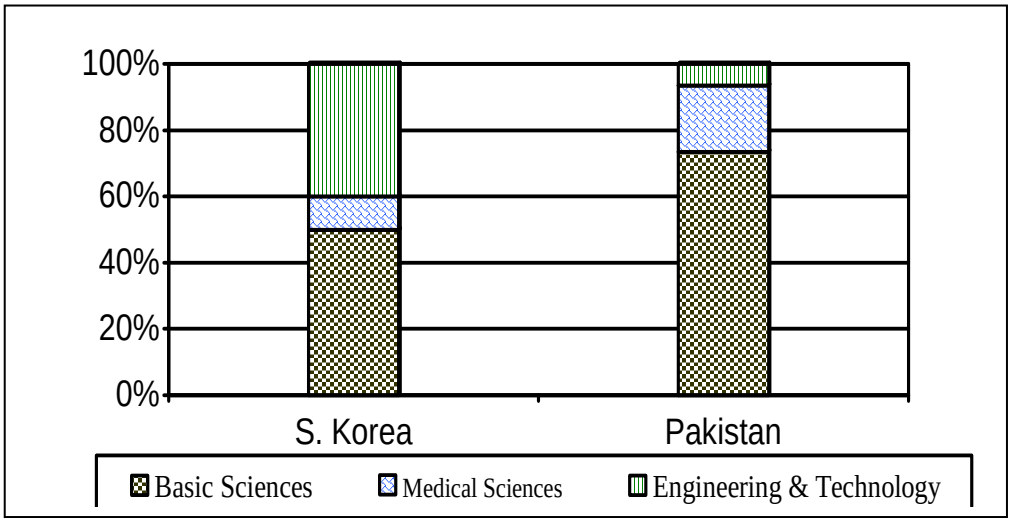
An example of reverse engineering and subsequent technological improvement in South Korea is the development of the microwave oven by SAMSUNG. In 1976, after Japanese and US firms refused to transfer technology, SAMSUNG organized a task force to collect information, evaluate technical possibilities and undertake reverse engineering in order to develop its own microwave oven. In addition, to gain access to the technology of the Magnetron tube used in microwave ovens, SAMSUNG acquired a US company facing financial difficulties. After two years of trial and error, SAMSUNG was not only able to reverse-engineer the microwave oven but also to become one of the world's largest exporters of this product.

To guarantee access to new knowledge and accelerate the rate of innovation, electronics firms adopted a mixed strategy which combined in-house R&D, strategic alliances, acquisition of high-tech firms, establishment of international R&D networks and development of their own engineering, design and organizational capabilities. The R&D networks included joint R&D projects with other local or foreign firms and R&D outposts in developed countries. These new collaborative arrangements represented an important step in the process of diversifying the sources of knowledge and expertise[8].

OUTPUT OF SCIENTIFIC RESEARCH

Research Publications

As can be seen from Figure-6 the greatest percentage of scientific papers published from Pakistan (1995) was in the field of basic and medical sciences. In South Korea (1993) there was a more balanced distribution of scientific publication between basic and applied sciences with a large proportion of publications in engineering and new technology fields (36%).



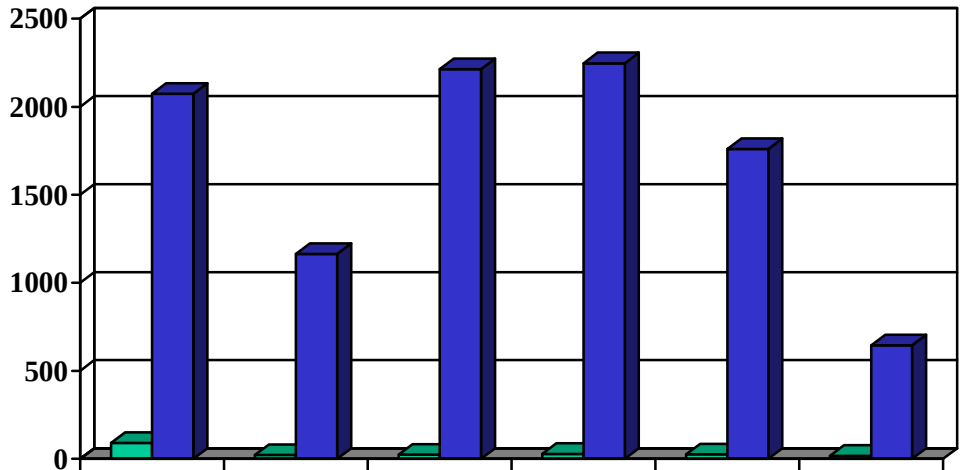
Source: S. Korea, Science and Public Policy Dec. 1997 Pakistan, PCST Report

Figure - 6: Distribution of Scientific Papers by Fields S. Korea and Pakistan

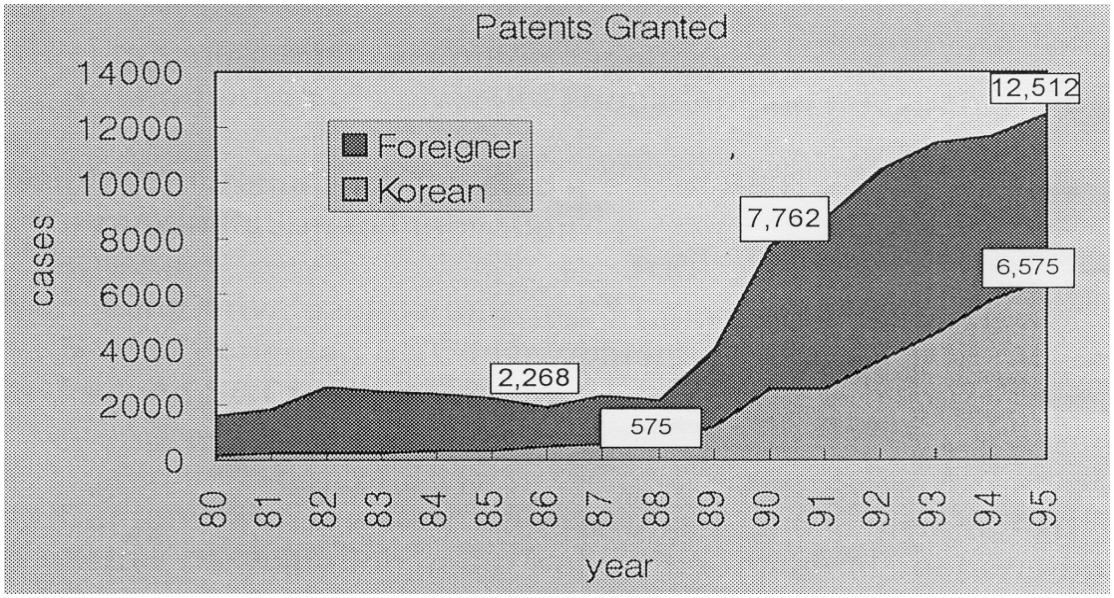
This indicates a strong orientation towards applied research in South Korea as well as close linkages established between academic research and industry.

Another important indicator of South Korea's rapid growth in industrial R&D is patent registration (Figure-7). Domestic Patent growth has significantly increased from 575 in 1987-88 to 6575 in 1994-95. In Pakistan the registration of patents from local origin shows a declining trend over the years. There were 90 patents (domestic) registered in 1976-1980 and only 17 in 1999-2000.

Pakistan



	1976-80	1981-85	1986-90	1991-95	1996-98	30-6-1999
Local Origin	90	22	24	28	25	17
Foreign Origin	2074	1164	2213	2247	1760	644



Source: Pakistan Patents & Design Office Karachi
Science & Technology Policy Institute (STEPI), Korea

Figure - 7: The Trend of Patents Granted

ROLE OF R&D ORGANIZATIONS

Establishment of KIST:

In 1966 the South Korean Institute for Science and Technology (KIST), a multidisciplinary research

institute, was established with the help of Battelle Memorial Institute on three basic principles[6]:

i. Autonomous Management, Research Ambience and Financial Stability: KIST Assistance Act, was promulgated in 1966, ensured an Endowment Funding System. The Endowment Fund was guaranteed by the government and could be used for basic operations and capital expenditure for construction.
ii. Contract Research System: All R&D work commissioned to the Institute was in the form of contracts whether from government or the private sector.
iii. Responsibility Centre Structure: Individual labs were supposed to be the basic unit of the management of the Institute. These labs were to earn enough from contract research to pay for human resources and facilities.

As the South Korean economy diversified and KIST was unable to meet ever-increasing demand, the government established the Government Research Institutes (GRIs) for strategic industries: chemicals, machinery and metals, electronics, shipbuilding etc.

In the early stages of industrialization, the private sector was reluctant to commercialise the technologies developed by KIST as they were sceptical of its engineering and production capability. Also KIST could not complete against foreign firms in supplying detailed blue-prints and other manufacturing know-how as well as being unable to assist industries in solving teething problems in the initial stages of production. Therefore KIST founded the South Korea Technology Advancement Corporation (K-TAC) a non-profit venture to commercialise ifs research.

One of the important roles that KIST played at this stage was in helping industries strengthen their bargaining power in acquiring foreign technology. Once imported such joint ventures provided a platform on which the firms could assimilate and adapt technology rapidly – KIST played a significant role in transferring technology to industry through reverse engineering. An important example is the production of polyester film for use in cassette tapes. When a Japanese company rejected South Korean requests for fear of losing its market in South Korea, a South Korean firm, in collaboration with KIST, successfully undertook a reverse engineering task to invent around the production technology. South Korea is now the world's major supplier for audio and videocassette tapes.

DIVERSIFICATION OF EXPORTS

South Korea's transformation from an agrarian economy to an industrial knowledge-based economy was achieved through policies of constant learning and innovation. During the 1950s and 60s, South Korea was exporting low- cost labour-intensive manufactures such as plywood, wigs, toys and textiles. During the 70s as skilled South Korean workers mastered foreign technologies and gained experience, they began exporting ships, steel, consumer electronics and construction services. By the mid-80s S. Korea moved towards the next phase of industrialization characterized by skilled, labour-intensive industries, computers, semi-conductors, memory chips, videocassette recorders, electronic switching systems, automobiles, industrial plants and other technology and knowledge intensive products.

In the 90s the S. Korean workers began working on the next generation products such as multi-media electronics, high definition TVs, personal telecommunication systems (Figure-8).

An important factor contributing to the economic growth of S. Korea as cited by Young (1993) and Krugman (1994) was the rapid expansion of employment in manufacturing, mainly due to the adoption of an outward, export-oriented development strategy that allowed for rapid increase of labour demand and incorporation of new entrants into economy.

An export-led economic growth model and appropriate system of incentives provided the direction for industrialization. Export oriented growth strategies helped S. Korea achieve industrial specialization, which involved constant innovation in the improvement of products and processes and generated a sustained demand for highly skilled human resources. Indeed export driven strategies are argued to be among the most important factors explaining the success stories of S. Korea[10].

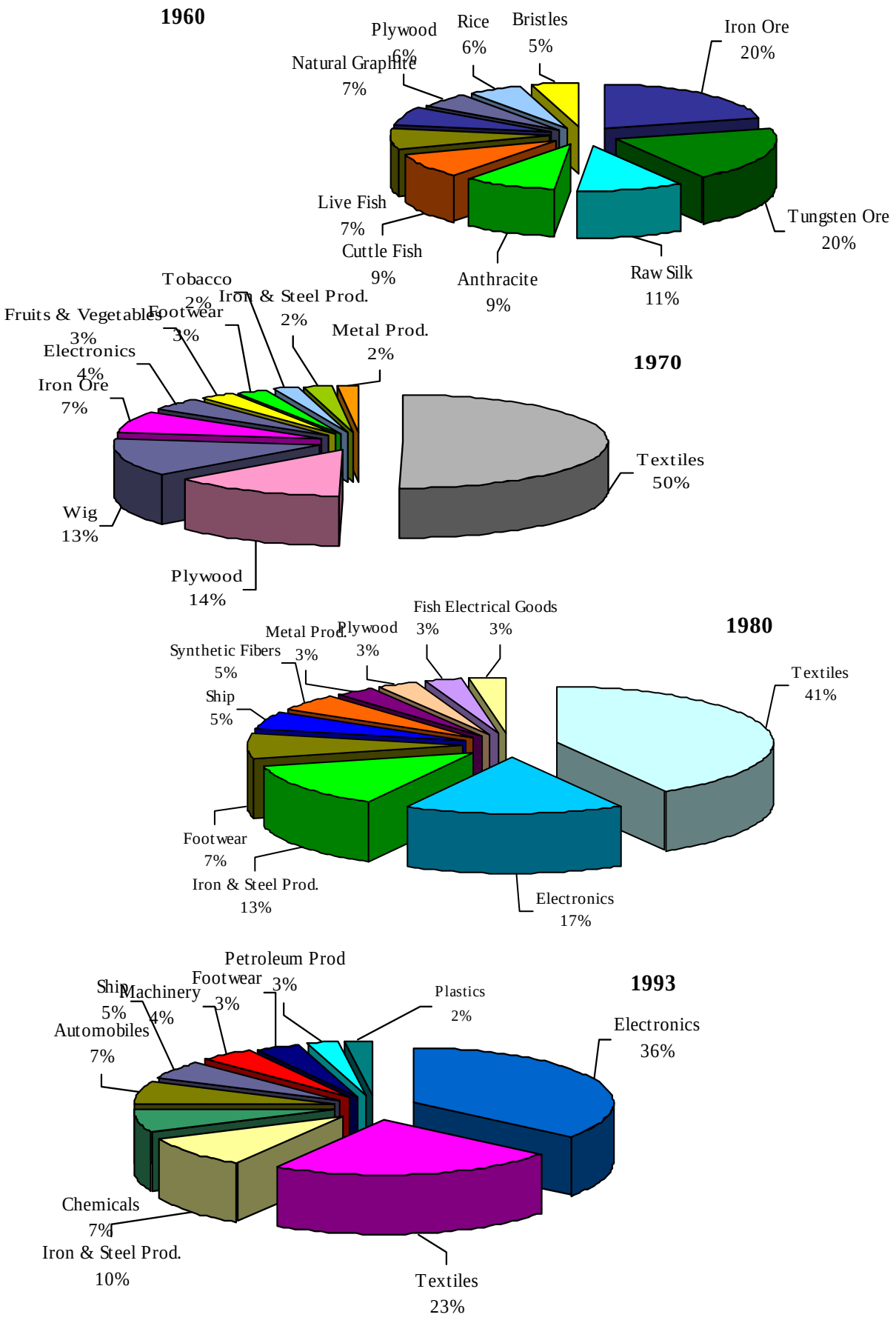
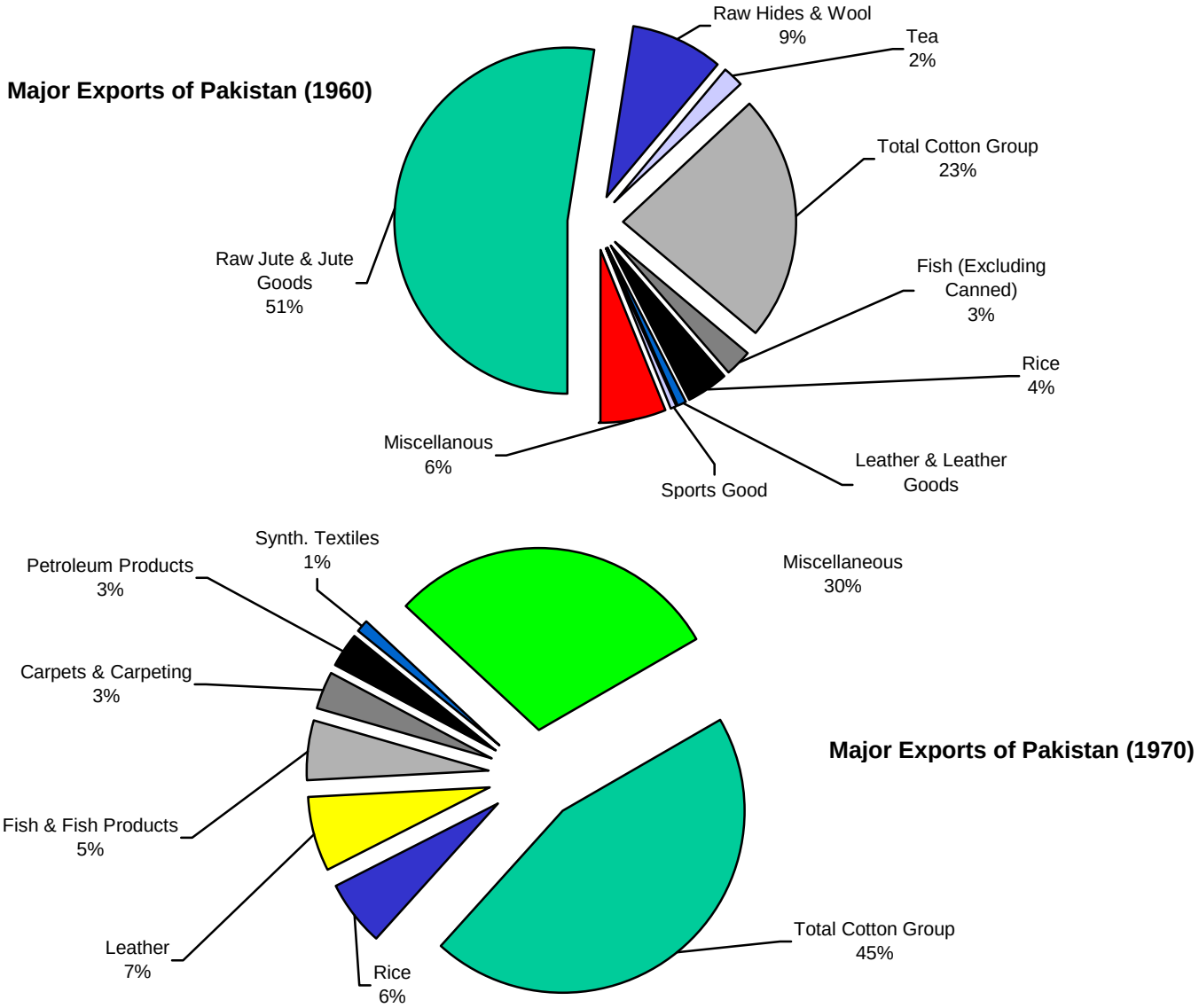


Figure - 8: Year Wise Diversification of Exports by S. Korea

Pakistan's exports of US$9.0 billion compare poorly with S. Korea's exports of US$142.0 billion (2001). Figure-9 shows the exports of Pakistan have not been diversified. On the contrary there has been concentration trend. Textiles comprise 63.5% of total exports out of which 60% is grey cloth and yarn instead of high value made-up textiles. During 1960-1971 Pakistan had 11% of the world market in textiles but today it is less than 2%. Pakistan is a major cotton producing country, but its textiles exports of US $5.1billion is three times less than those of S. Korea which exported textiles worth US $ 15.1 Billion in 1992.

"The structure of exports also indicates the level of technological development of a country, in particular the exports of engineering and other knowledge-intensive goods as well as the contribution of value added manufactures".

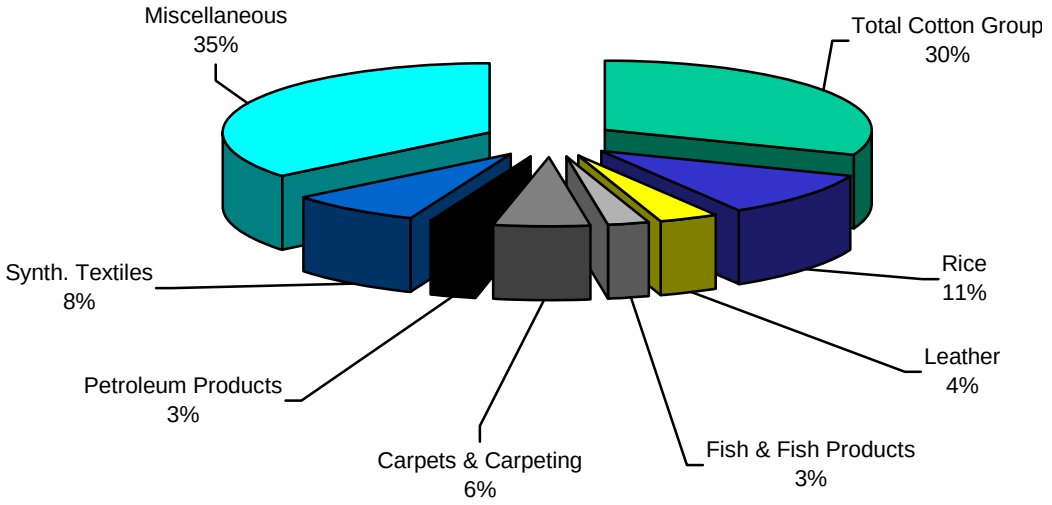
Pakistan spends almost $ 1.59 billion annually on the import of machinery and engineering goods. These include transport goods which comprise 19% of total imports. Despite building an over-capacity for production of engineering goods, indigenous production has been negligible.



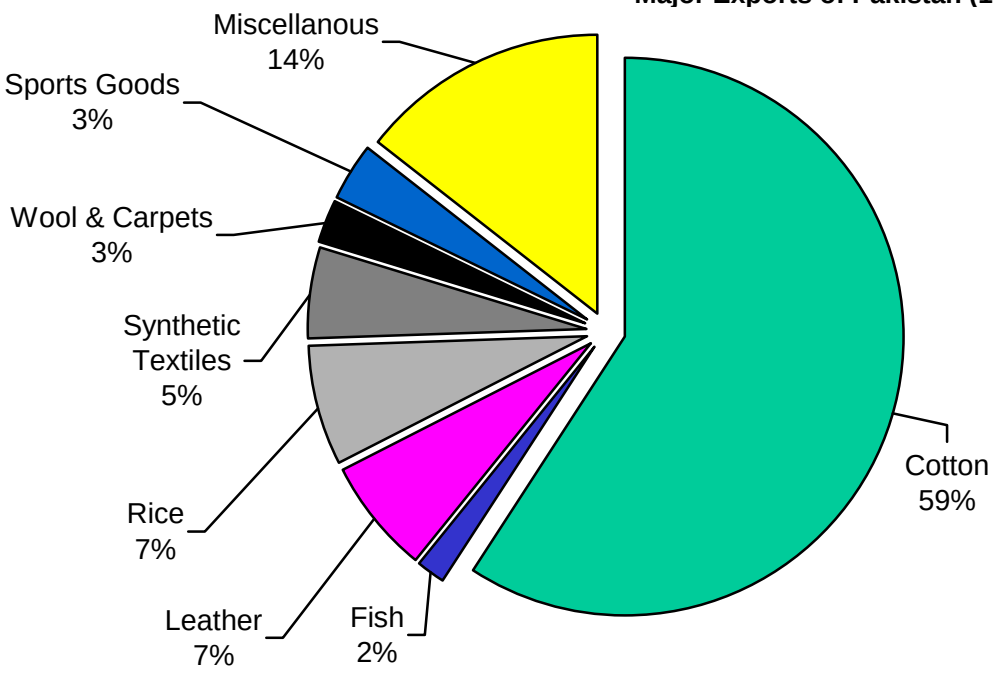
Source: Pakistan Economic Survey 1967-68, 1967-68

Figure - 9 (a)

Major Exports of Pakistan (1982-83)



Major Exports of Pakistan (1998-99)



Source: Pakistan Economic Survey 1983-84, 1999-2000

Figure - 9 (b)

The Deletion Policy announced in 1987 has helped in the assembly-cum-manufacturing processes of some of the engineering goods. Enterprises which opt for the deletion programme are provided concessionary import tariffs to import components/parts; the participatory enterprises are generally supposed to increase the use of local parts according to time schedule agreed with the deletion

monitoring cell of the Government of Pakistan. Since the announcement of this policy a large number of small vendors have registered. This has helped indigenization of some of the engineering goods, particularly in the electrical, transport and electronic sector.

INTEGRATION OF S&T POLICY WITH OTHER SOCIO-ECONOMIC POLICIES

"Countries that do not have a well-defined and discriminating industrialization strategy have only vague S&T policies of a general supportive nature. They do not have strong policy instruments. The incentives and inducements offered, only encourage a general infrastructure for industrial S&T but are incapable of guiding the development of scientific and technological capabilities for industry. The converse is also true Countries that have defined an industrialization strategy, established priorities, and determined the scope and nature of government intervention have formulated S&T policies that correspond to the aims of industrial development". (Science and Technology for Development: Main Comparative Report on Science and Technology Policy Instruments Project, by Franciso Sagasti International Development Research Centre, Canada).

The former statement is true for S. Korea and the latter befitting Pakistan. Table No. 2 shows the integration of S&T policy with other socio-economic policies of S. Korea.

Table - 2: Interactive Development Between Industrial Policy and S&T Policy

	Industrialization	S&T Development
60's	•Develop import-substitution industries • Expand export-oriented light industries • Support producer goods industries	•Initiate S&T education • Construct scientific and technological infrastructure • Promote foreign technology imports
70's	•Expand heavy and chemical industries • Shift emphasis from capital import to technology import • Strengthen export-oriented industrial competitiveness	•Expand technical training • Improve institutional mechanism for adapting imported technology • Promote research applicable to industrial needs
80's	•Transform industrial structure to advanced and balanced form • Expand technology-intensive industry • Encourage manpower development and improve productivity of industries	•Develop and acquire top-level scientists and engineers • Perform national R&D projects efficiently • Promote industrial technology development
90's	•Promote industrial structure adjustment and technical innovation • Promote efficient use of human and other resources • Improve information network	•Realign national R&D projects • Strengthen demand-oriented technology development system • Internationalise R&D systems and information networks •Construct S&T infrastructure

Source: Science & Technology Policy Institute (STEPI), S. Korea

The Ministry of Science and Technology was established in 1967 as the central policy making, coordinating and promotional body of the government. In order to train high-level manpower for growing requirements of industry and research organizations, the S. Korean Advance Institute for Sciences (KAIS) was established in 1971 in addition to a number of existing universities and colleges.

KAIS provided post-graduate programs in applied sciences and engineering in selected fields to produce a core number of engineers and scientists. In addition, the changwon Technicians College was established to turn out high-calibre technicians who enjoyed similar pay scales and benefits as university graduates. This institution trained skilled workers to become master foremen in needed theoretical backgrounds and administrative skills. Many vocational and technical training institutes were established to meet the rapid, almost explosive demand for skilled workers and technicians[7].

The S&T Policy was closely articulated with the industrial policy. For example when S. Korea launched the National Research Development Project (NRDP) in 1984 and later HAN project in 1993, the Ministry of Trade, Industry and Energy (MOTIE) carried out a survey of industry to identify relevant projects. The HAN project aimed at development of strategic industrial technologies. Preferential funding was also provided to export-oriented industry[1].

For S. Korean products to compete in an increasingly competitive international market, it became essential for the private sector to conduct in-house R&D. The government provided soft capital to enterprises for technology development by creating financial institutions such as S. Korea Technology Advancement Corporation (K-TAC), S. Korea Technology Development Corporation (KTDC), S. Korea Development Investment Corporation (KDIC) and S. Korea Technology Finance Corporation (KTFC) were created[1].

KTDC was established as an autonomous public enterprise to promote R&D projects of industry. It shares both the risk of failure as well as the benefit of success and offers three different types of financial support: long term loans, conditional loans and equity investment. The major activities of KTDC include support for all aspects of introduction, improvement and adoption of advanced technology up to the commercialisation of R&D. It also provides special services in the areas of technology advice, feasibility studies for R&D activities, technology transfer and management.

Both KDIC and KTFC were established as Venture Capital Companies. They provide funds in the form of equity investment, acquisition loans and conventional loans.

During the 50s-60s Pakistan also adopted a private sector led, export-oriented policy, which resulted in GDP growth rate almost parallel to S. Korea. But wealth was concentrated in the hands of few and the social sector was neglected. After 1971, banks and major private sector industries were nationalized and an inward-looking, import-substitution policy was adopted. The import-substitution industries catered mainly to high-income strata of urban population. Inequalities in income distribution prevented the emergence of mass markets for manufactured goods. The predominance of agricultural and artisan activities, which were not fully integrated into the market economy and the existence of a large sector of population engaged in informal services in urban areas, limited the purchasing power of the majority of the population, preventing them from joining the market for industrial goods. The situation was further aggravated by the fact that industry was unable to generate adequate employment opportunity to absorb the increasing labour force.

The S&T policy followed in the last fifty years was also not integrated with other socio-economic policies. There has been little networking among stakeholders of the National System of innovation. The Technology needs of the various sectors of the economy were never defined and there have been no attempt on the part of the government to forge such linkages.

NETWORKING OF INDUSTRY, ACADEMIA AND GOVERNMENT

During the intermediate stages of industrialization (in S. Korea) the government encouraged private sector to set up formal R&D laboratories – the inducements included tax incentives, preferential financing for setting up new laboratories and exemption from compulsory military service. Thus, the number of corporate R&D laboratories increased from 1 in 1970 to nearly 2,270 by 1995 reflects the seriousness with which S. Korean firms were pursuing more technology intensive development. Most R&D personnel in corporate laboratories were hired among GRIs or S. Korean scientists working in universities and firms abroad. The financial incentive system included preferential interest rates.

In 1977 the government established the S. Korea Scientific and Engineering Foundation under the Ministry of Science and Technology. The government also founded the S. Korean Research Foundation under the Ministry of Education in 1981. These Foundations funded basic research in universities. The government also enacted the Basic Research Promotion Law in 1989 explicitly targeting university research as one of the top national technological priorities. As a result contract research between universities and industry increased from W 1.0 billion in 1975 to W 169.2 billion in 1990. The proportion of

industry funded university research increased from 50% in 1975 to nearly 70% in 1970.

Table - 3: Networking of Industry-Academia –GRI Cooperation R&D

Networking	Manpower Cooperation	Non-Manpower Cooperation
Research Activity (Cooperative Research)	•Joint research in specific projects •Projects commissioned by private companies to universities and research institutes •Visiting researchers •Technology consulting to private companies	•Co-use research facilities •Exchange of technology information •Technology transfer •R&D cost sharing
Education Activity	•Exchange of professor and researcher -Professors lecturing at private companies -Researchers lecturing at universities Exchange of students -Field training at private companies - Researchers participating in the graduate course Industry's participation in training programs at universities	•Offering research facilities to universities (donation or allowance of free use) •Exchange of training materials and information •Providing scholarship (Private companies strategy to secure high-calibre manpower)

Source: Science & Technology Policy Institute (STEPI), S. Korea

Another important feature of the university-industry relationship was the emergence of technology based venture firms. One example is Madison. The founder of this company had a Ph.D. in electronics engineering and his four co-founders were graduate students at a laboratory that undertook research at KAIST on ultrasonic scanner technology. Madison in now one of the most dynamic ultrasonic scanner producers in the world accounting for 25% of global market in portable models.

In the wake of increasing demand for R&D by industry, the S. Korean government established specialized GRIs in important sectors of industry such as chemicals, biotechnology, systems engineering and aerospace to service the growing needs of the private sector.

In 1989 S. Korea introduced two major national R&D projects. The Industrial Generic Technology Development Project (IGIDP) and the National R&D Project (NRD). The Ministry of Trade, Industry and Energy (MOTIE) undertook a survey to identify urgent R&D projects in industry and offered financial support to GRIs and university laboratories to undertake projects jointly with private sector.

In the early 1980s the 15 R&D institutes were restructured to create 9 institutes. The basic reason for restructuring was to make individual research institutes reach critical mass quickly. The GRI's are now funded on project based system.

In Pakistan, over the years a large number of R&D institutions were created without creating a demand for their services in the production sector. Most of these institutions suffered due to lack of appropriate management structure, continuous funding, skilled manpower and other essentials for research. Linkage between universities, R&D organizations and the government are still not developed. Faced with the lack of demand for their services by the production sector, most of the R&D institutions originally designed to provide services to industry have gradually deteriorated. The skilled manpower has been leaving the country for better prospects in the developed world.

TECHNOLOGY TRANSFER POLICIES

Industrial technological capability can be built either through indigenous R&D or international technology transfer. Developed countries have followed the former model whereas S. Korea has followed the latter

model. Foreign technology is often acquired through formal and informal means. The formal mode includes direct foreign investment and technology licensing while the informal mode encompasses a much wider spectrum such as imitation, training provided by foreign suppliers, studying abroad, importation of capital goods, out-sourcing and networking with foreign firms.

During the early stages of industrialization in the 1960s and 1970s, the informal mode was more important as channels of foreign technology transfer. In the 60s S. Korean firms found that trade related activities such as employers training abroad, technical assistance from suppliers of parts and raw material, and technical assistance from buyers were important modes of technology transfer.

It is important to mention here that during the early stages of industrialization, S. Korean companies allowed access by foreign companies to their market conditional to the transfer of technologies and the establishment of local R&D facilities and in some cases to joint research projects. Licensing contracts and Original Equipment Manufacture (OEM) arrangements were the main source of knowledge and expertise through which the S. Korean firms enhanced their core business capabilities (under OEM arrangements a local firm follows the foreign firm client's specifications/materials quality and design to produce goods that are sold under the buyers own brand name). Major clients in the automobile, electronics and semiconductor industries provided local producers with design and engineering support and blue prints.

Formal mode of technology transfer played an important role in the late 1970s. The growth of heavy and chemical industry in the late 1970s and 1980s was possible through the formal mode of technology transfer. Most of the technology in this period was imported through licensing and direct foreign investment. International sourcing and networking also contributed to industrial technology capability building. In the late 80s many S. Korean export industries graduated from the OEM strategy and started international marketing under Own Brand Name (OBN). Private companies began investing in research in the mid 80s. The number of corporate R&D Laboratories increased to 455 from 65 during this period and this trend continued in the 90s. Thus in 1994 there were more than 2000 corporate research laboratories.

Table - 4: Technology Transfer Policy in the 1960s

S. Korea	Pakistan
Industrial Development Targets	
- Development of Light Industries for Export - Building up base industries: fertilizer, refineries, fibre, etc.	-Industrial policy based on developing Private Sector -Import substitution. Building up an industrial base from indigenous raw materials mostly agro based industry.
Technology Required	
-Mature Technologies, Capital Imports	-Mature Technologies
Technology Transfer Policy	
-Earlier Stage (1962~1967): Relatively liberal policy for imports from developed countries. - Later stage (1968): Restrictive policy due to worsening Balance of Payment	-No technology transfer policy was formulated.
Major Modes of Technology Transfer	
-OEM, Capital imports, etc.	-Capital Imports/Turnkey Plants

OEM: Own Equipment Manufacturing.
Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

Table - 5: Technology Transfer Policy in the 1970s

S. Korea	Pakistan
Industrial Policy	
-Development of heavy Chemical and Engineering industries -Protection of domestic industries; Strategic industry-targeting policy.	-Import substitution, Nationalization of Banks and large consumer goods industries. -Protection provided to consumer goods industry. -Establishment of large industrial units under public sector.
Technology Required	
Mature technologies, Shift from Capital Imports to Technology Imports.	-Turn key plants/ Capital Imports. -Mostly obsolete Technology was imported
Technology Transfer Policy	
Restriction on DFI and FL.	-No specific policy -Technology transfer did not accompany knowledge transfer.
Major Modes of Technology Transfer	
-OEM -Capital imports -Technical training (as part of turn-key plant imports)	Limited reverse engineering.

Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

Table - 6: Technology Transfer Policy in the 1980s

S. Korea	Pakistan
Industrial Policy	
-Development of technology-intensive industries: electronics, automobiles, etc. -Policy readjustment from "protection" and "government-led industrialization" to "competition" and "private-led industrialization" - Liberalization of trade and investment	-Mostly import substitution, denationalization of agro based industry and some engineering units. -Grant of tax holiday for export industry, duty free import of raw materials and machinery for less developed areas. -Establishment of Export Processing Zone in Karachi.
Technology Required	
- High technologies	-Capital intensive technologies.
Technology Transfer Policy	
- Gradual Liberalization of DFI and FL	-No specific Policy. -Formulation of deletion policy.
Major Mode of Technology Acquisition	
-FL -DFI -Indigenous R&D	-From foreign sources. -Limited foreign investment.

Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

Table - 7: Technology Transfer Policy in the 1990s

S. Korea	Pakistan
Industrial Policy	
-Development of high-technology and knowledge based industries - Private sector-led industrial development - Liberalization of trade and investment - Protection of intellectual property rights	-Efforts towards privatisation of public sector industrial units:- -Exports of manufactured good comprising textiles and food products. -Establishment of Export Zones in other areas of Pakistan. Attempts towards liberalization and attraction of foreign investment. Intellectual property laws have been revised expect the plant protection law. Measures to strengthen MSTQ system
Technology Required	
- Core technology, High technology	-
Technology Transfer Policy	
-Globalisation of S&T - Liberalization of FL, DFI - Support of S&T exchanges, strategic alliances	-Technology transfer policy was approved but mostly remains un-implemented.
Major Mode of Technology Acquisition	
-Global sourcing - Strategic alliances - FL, DFI	-No institutional mechanism for sourcing technology. -Technology Information system is weak. -Strategic alliance only in limited areas of research. Capital Imports.

Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

CONCLUSIONS

Both Pakistan and S. Korea became independent about the same time. In the 1950s and 60s both followed private sector-led industrial policies. The direction of S&T policies in that period for both countries was to achieve economic growth through rapid industrialization. In order to help industry several important R&D organizations and universities were established to produce the requisite manpower for R&D.

However, the difference between the two countries was investment in human resources development and the general uplift of the social sector. Pakistan lagged behind on both fronts where as S. Korea's investment in human resource development and health resulted in lower population growth rate, equal distribution of wealth and relative political stability. The policies of indigenous capability-building helped expand the tertiary education programs and raising their quality. Building first-rate educational institutions required enormous financial and intellectual investment but this was considered an essential long term economic investment.

In Pakistan the nationalization of industry and the financial institutions after 1971 had an adverse effect on industrialization as private sector investment decreased considerably. The import substitution strategies led to the choice of more capital-intensive technologies and favored large-scale enterprises. The trade policy combined with the protectionist measures for enterprises discouraged demand for research in the production sector. R&D organizations as well as universities were also deprived of appropriate funding and effective institutional management. These strategies encouraged the use of imported technologies (mostly turn-key plants) and consequently domestic science and technology efforts could not make a substantial contribution towards economic growth in the country.

In contract, S. Korea adopted aggressive export-oriented industrial policies, which were backed by measures for creating a conducive environment for promotion of research and development activities both in the public and private sectors. The resulting expansion in export of value-added products provided the financial resources required to accelerate the rate of innovation and generate new and better paid jobs

S. Korea's S&T policy was geared towards encouraging innovation, technology-imports from foreign sources, reverse-engineering and technology development, building strategic alliances and above all technology diffusion at all levels of society. Through promotional measures which included the promulgation of several laws/ordinances and through tax incentives to the private sector, S. Korea created the pre-requisites for technological development. This integrated approach allowed the creation of a nexus between technological, managerial, organizational and institutional upgrading and the overall economic and social development processes.

In the case of Pakistan, each five year development plan acknowledged the need for linking S&T efforts with industrialization strategies and in turn with the economy but there was no concerted effort by the respective ministries to forge linkages. The S&T effort therefore could not benefit the production sector.

The integrated approach adopted by S. Korea supports the notion that economic performance depends on the establishment of self-reinforcing relationship among education, R&D and learning, the principal activities leading to the expansion of knowledge base, innovation processes, productivity growth and international trade.

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