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**Korea's Innovation System:
Challenges and New Policy Agenda**

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AND NEW POLICY AGENDA**

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1. INTRODUCTION: THE ROLE OF THE INNOVATION SYSTEM IN A KNOWLEDGE-BASED ECONOMY

Korea's innovation system is still based on the catch-up model. The private sector, which is responsible for the lion's share of gross R&D spending, is still preoccupied with the strategy of quick technological development, and most public sector R&D programs are highly mission-oriented but very weak in diffusion. The overall strategy of Korea's technological development is oriented more heavily toward technological widening rather than deepening. This R&D strategy is the result of Korea's overall strategy of catch-up growth: market expansion *cum* industrial widening.

Late-industrialising countries such as Korea can borrow new foreign technologies, allowing second-mover advantages. This, in turn, enables them to achieve rapid economic growth, depending on how effectively they use the borrowed technologies. The use of foreign technologies fundamentally conditions the nature of innovation systems in late-industrialising countries so that innovation is primarily adaptive rather than creative. This is a natural consequence, as there is no need to repeat the same process of technological development that has been performed by frontier countries. However, as economies grow and economic structures evolve towards more knowledge-based and technology-intensive industries, the late-comer advantages no longer apply. At this time, the challenge is not just how to successfully adapt the borrowed technologies, but how to assimilate the knowledge/technology generating mechanism.

We use the concept of NIS as a framework to see how a country institutionalises the knowledge/technology generating mechanism. (See Box 1.) We define the role of the national innovation system (NIS) in a knowledge-based economy (KBE) as a generator and diffuser of the knowledge/technology required for economic development. And we note that a KBE has two implications: first, industrial activities are becoming more technology- or knowledge-intensive; and, second, the industrial structure is focusing more on technology- or knowledge-intensive sectors. (See Box 2.) Whereas current discussions on the KBE in Korea seem to be more inclined toward the latter implication of a KBE, this report will try to emphasise equally the importance of these two aspects of a KBE.

The NIS performs its role through diverse functions of three main actors in the innovation system: government, university and industry,. Each of these sectors has its own goals and working mechanism. Consequently, interfaces among these sectors, whether institutional or functional, are crucial in determining the success or failure of the national innovation system and its contribution to economic development. (Figure 1-1)

Korea's innovation system (KIS) is frequently criticised as being inefficient or low in productivity. Table 1-1 compares Korea with five advanced countries in knowledge-related activities. The table indicates that in input measures, Korea is just equivalent to G-5 countries, whereas performance is substantially lower. Overall we agree with the self-diagnosis shown in Table 1-1.

Table 1-1: Korea's Comparative Stance in Knowledge-related Activities

							(G-5 Average = 100)	
Input Index	Flow Index			Stock Index			Average	
	R&D expenditure over GDP	Education expenditure over GDP	In-company training	Researchers per capita	University grad. Share per capita			
	117.2	101.6	83.5	65.4	83.3		90.2	
Performance Index	Output Index			Impact Index			Average	
	Patent application per capita	Scientific papers per capita	Knowledge contribution to economic growth	Share of KBI in manufacturing	TBP receipts over GDP			
	54.9	3.4	23.9	57.0	11.1		30.0	
Process Index	Infrastructure Index			Utilisation Index				Average
	Computer per capita	Internet host per capita	Share of supporting research personnel	Professor per student	Commercialisation of research results	University share of R&D	Employment rate of female univ. graduate	
	45.8	14.7	28.8	34.6	74.1	62.6	60.7	45.9

Source: Korea Development Institute, 1999.

However, low productivity in R&D is a moot question. Indicators are always problematic, and international comparison based on indicators tends to ignore country-specific factors, which are mostly institutional or systemic. We see the current debate over Korea's low productivity in R&D as a question of systemic mismatches or systemic failures caused by sticking with the catch-up model of economic growth and technological development.

In many respects, Korea's potential research capability is not inferior to that of many other OECD countries. High R&D spending and relatively well-educated human resources are among the potential assets. Private enterprises have accumulated skills and technologies from dynamic production experiences. But the KIS is rather weak in systemic linkages and interfaces among innovation actors. We see the challenge faced by the Korean economy as reshaping Korea's innovation system from the old catch-up model to a new one. Faced with a turbulent financial crisis, Korea has already noticed the importance and urgency of renovating its innovation system, and has initiated several important policy measures. We will discuss some of these, and show that policies should be centred on how to assimilate and even indigenise the knowledge/technology generating mechanisms; this requires a more long-term perspective.

There are three key words: indigenisation, deepening, and integration. Indigenisation means that Korea needs to build up an indigenous knowledge base that can act as a new engine of growth. We will show that

Korea's knowledge-generating mechanism has serious drawbacks: among others, the weakness of the universities' research capabilities. Building up an indigenous knowledge base requires a long-term perspective and a consistent policy framework, deepening contrasts as well as widening them. The old catch-up model of aggressive market expansion cum industrial widening neglected the technological deepening of industrial activities, which unnecessarily weakened the indigenous knowledge base. The need for technological deepening calls for a new strategy from both government and industry. The new strategy should focus on the integration of the innovation system. We will show that the KIS overall, and governmental R&D programmes in particular, have been mostly mission-oriented and targeted. We see that this heavy mission-orientation is the legacy of the catch-up model. The validity of this model in a KBE is questionable, and is the root of the poor integration of the innovation system. Korea will be able to improve its innovation system through indigenising its knowledge base and placing more emphasis on technological deepening cum diffusion and integration.

Box 1: The National Innovation System (NIS)

There is no single accepted definition of a national innovation system; what is important is the web of interaction or the system as a whole. The concept of a national innovation system rests on the premise that understanding the linkages among the actors involved in innovation is key to improving a country's technology performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of creating and using knowledge, as well as the technologies themselves. These actors are primarily private enterprises, universities and public research institutes and the people within them. The linkages can take the form of joint research, personnel exchanges, cross-patenting, purchase of equipment and a variety of other channels. From OECD, National Innovation System, 1997.

Box 2: What does Knowledge-Based Economy mean?

Although the importance of a knowledge-based economy is clear, the exact concept of a KBE is still evolving. In 1966, the OECD defined KBE as "economies which are directly based on the production, distribution and use of knowledge and information." The implications of a KBE are twofold: first, industrial activities are becoming more technology- or knowledge-intensive; and, second, the industrial structure is focusing more on technology- or knowledge-intensive sectors. While acknowledging the difficulties of determining the indicators for a KBE, the OECD (1999) uses the share of high-technology manufacturing, medium-high-technology manufacturing and some service sectors such as communications and finance as the proxy for KBE (p.18.). Despite some advantages, these indicators may lead to misunderstanding the meaning of KBE.

The OECD classifies industries according to the absolute magnitude of R&D intensities: high-technology industries have high R&D intensities. This classification may unintentionally neglect the importance of the technological upgrading of, say, non-high-technology industries. For example, the changes in technology intensity, which are measured as R&D plus acquired technology divided by production, vary widely across sectors between 1980 and 1990 (see Table 1-2 below). Among the high-tech sectors, electrical machines (MH3 in the table) shows negative changes and communications equipment (H4) shows almost no change. In contrast, all the non-high-tech sectors show positive changes, among which shipbuilding (ML2) shows the highest percentage of changes, above many of the high-tech sectors, and non-ferrous metals (ML4) and petroleum refineries (ML7) also show high percentages of changes. Table 1-2 clearly shows the trend toward increased usage of technology/knowledge in non-high-technology industries.

Table 1-2: Technology intensity in manufacturing sectors

	High-tech industries		Medium-high-tech industries			Medium-low-tech Industries				Low-tech industries	
	H1 H3	H2 H4	MH1 MH4	MH2 MH5	MH3 MH6	ML1 ML5	ML2 ML6	ML3 ML7	ML4 ML8	L1 L3	L2 L4
Total technology intensity	17.30 11.35	14.37 9.40	6.55 3.84	4.44 3.03	3.96 2.58	2.47 1.44	2.21 1.35	1.76 1.33	1.57 1.10	0.88 0.73	0.78 0.65
Changes between 1980 and 1990	1.24 2.98	3.18 0.07	1.86 1.17	0.76 1.34	-0.29 0.58	0.27 0.34	0.79 0.29	0.31 0.53	0.53 0.32	0.20 0.17	0.22 0.10

Source: Calculated from OECD (1999), p.106.

Note: H1=Aircraft; H2=Office & computing equipment; H3=Drugs & medicine; H4=Radio, TV & communications equipment; MH1=Professional goods; MH2=Motor vehicles; MH3=Electrical machines excl. commun. equip.; MH4=Chemicals excl. drugs; MH5=Other transport equipment; MH6=Non-electrical machinery; ML1=Rubber & plastic products; ML2= Shipbuilding & repairing; ML3=Other manufacturing; ML4=Non-ferrous metals; ML5=Non-metallic mineral products; ML6=Metal products; ML7=Petroleum refineries & products; ML8=Ferrous metals; L1=Paper, paper products & printing; L2=Textiles, apparel & leather; L3=Food, beverages & tobacco; L4=Wood products & furniture.

In contrast, the OECD (1992) emphasises the importance of the diffusion of new innovations, and notes that core innovations are more widely used by other sectors. (See Table 1-3.) For instance, the *Survey* shows that textiles, a low technology industry, is the first user sector of innovations in mechanical engineering and machinery and instruments, and the second user sector of innovations in chemicals.

As noted, an important aspect of a KBE is that industries are more knowledge- and information-intensive. The problem of the indicator approach is that it accounts only for the shares of higher R&D intensive sectors and ignores the importance of upgrading the knowledge or information content of industrial activities.

Table 1-3: The sectors of use of “core sector” innovations, 1945-83 (Percentage of total use)

	Mechanical engineering And machinery	chemicals	Instruments	Electronics	Total sample
Own use	14.2	24.9	9.9	37.4	30.5
Other manufacturing	58.1	32.1	47.9	11.7	34.0
Non-manufacturing	27.7	43.0	42.2	50.9	35.5

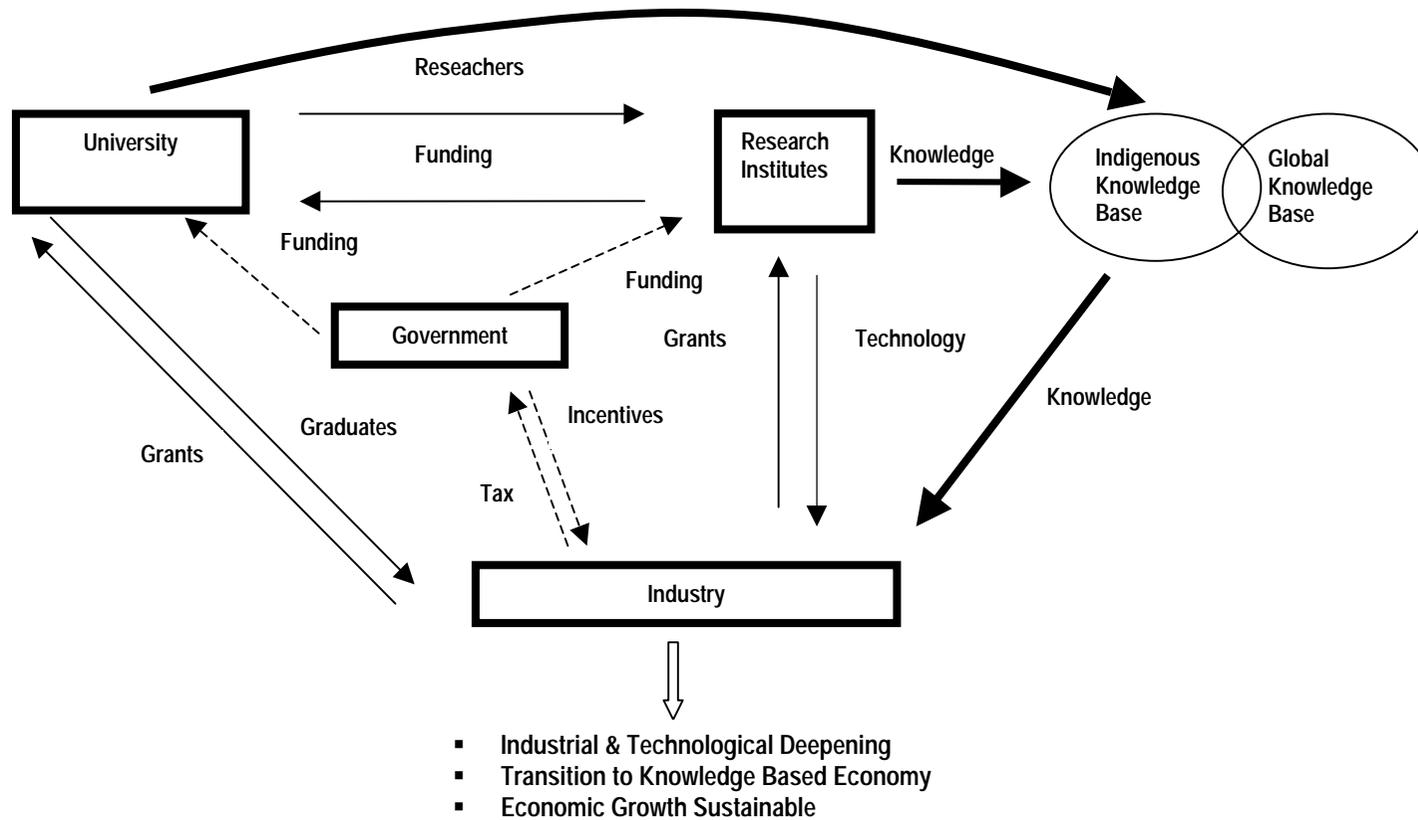
Source: SPRU, *Innovation Survey*, 1984, cited in OECD, *Technology and The Economy*, 1992, p.54.

OECD (1992), *Technology and the Economy: The Key Relationships*.

OECD (1996), *The Knowledge-Based Economy*.

OECD (1999), *OECD Science, Technology and Industry Scoreboard 1999: Benchmarking Knowledge-Based Economies*.

Figure 1-1: Innovation System & Economic Growth

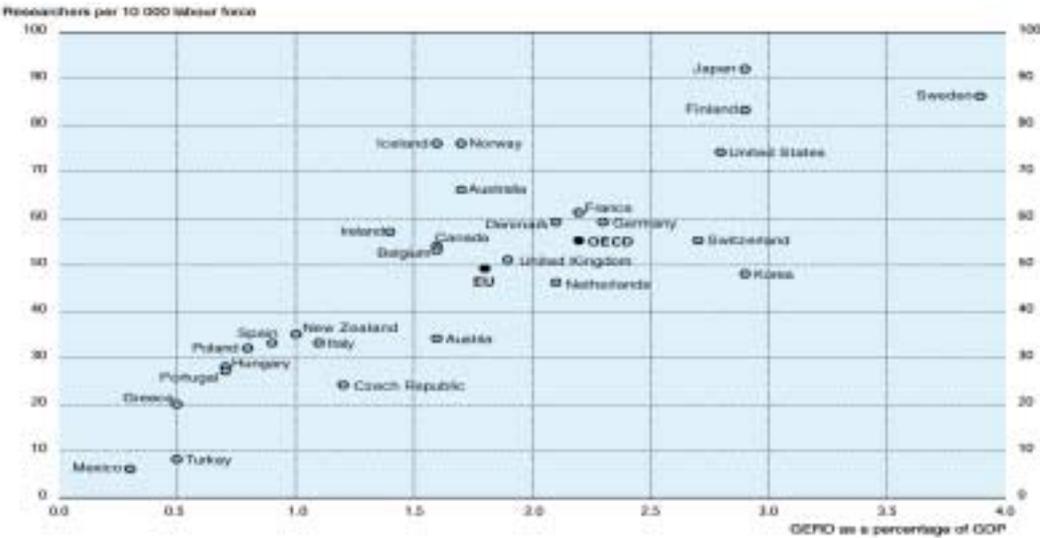


2. PROFILES OF KOREA’S SCIENCE, TECHNOLOGY AND INNOVATION ACTIVITIES

R&D activities

In comparison with OECD countries, Korea’s science, technology and innovation (STI) activities show many idiosyncrasies (See Figure 2-1 and Table 2-1). For example, 1) Korea’s gross R&D intensity, that is the R&D expenditure over GDP, is very high. Korea belongs to the top group of R&D intensity, along with Sweden, Japan, Finland, the U.S. and Switzerland. And Korea’s researchers per 10,000 of the labour force are roughly equivalent to those of the Netherlands or the EU average. 2) Korea shows the lowest government share in R&D financing, followed by Japan, which implies that Korea’s private sector share of R&D financing is the highest. Korea’s business sector R&D intensity is also very high, exceeded only by Sweden. 3) Scientific and technical articles per unit of GDP of Korea are one of the lowest figures. 4) Korea’s technological strength, which is expressed by multiplying the number of patents with an index of their impact or expressed in GDP units, is also one of the lowest. Some other characteristics of Korea, which do not appear in the table, are as follows: 5) A high proportion of larger companies in overall R&D spending, and low R&D intensity of SMEs. 6) A low proportion of higher educational institutions in R&D spending. 7) As channels of international technology transfer, (until recently) there has been more emphasis on arm’s length licensing rather than on FDI.

Figure 2-1: Gross domestic expenditure on R&D as a percentage of GDP and researchers per 10,000 of the labour force



Source: OECD, STI Scoreboard 1999.

Table 2-1: Income and technological performance, 1995¹

	Income level, 1996 GDP per capita as % of OECD average	Indicators of scientific and technological performance							
		Gross domestic expenditure on R&D as a % of GDP, 1995	Researchers per 10 000 of the labour force, 1995	Government financed R&D as a % of GDP, 1995	Government financing of R&D as a % of total R&D, 1995	Business expenditure on R&D as a % of business GDP, 1995	Scientific & technical articles per unit of GDP, 1995 ²	Technological strength per \$ of R&D, 1995 ³	Technological Intensity, 1995 ⁴
United States	140	2.6	74	0.9	34.6	2.1	20	410	10.4
Norway	128	1.7	73	0.8	43.5	1.4	21	..	..
Switzerland	126	2.7	46	0.8	28.4	2.2	37	..	..
Japan	121	2.8	83	0.6	20.9	2.2	15	354	10.6
Iceland	118	1.5	72	0.9	62.9	0.8	23	..	..
Denmark	117	1.8	57	0.7	39.2	1.7	31	87	1.6
Canada	114	1.7	53	0.6	33.7	1.4	25	203	3.3
Belgium	112	1.6	53	0.5	26.4	1.4	20	111	1.8
Austria	111	1.5	34	0.8	47.6	1.1	18	125	1.9
Australia	107	1.6	64	0.8	47.5	0.9	24	..	..
Germany	107	2.3	58	0.8	37.0	1.9	21	215	5.0
Netherlands	106	2.0	46	0.9	42.1	1.3	31	170	3.5
France	103	2.3	60	1.0	42.3	1.9	20	115	2.7
Italy	102	1.1	33	0.5	46.2	0.8	13	101	1.0
Sweden	100	3.6	68	1.0	33.0	3.9	41	147	5.3
United Kingdom	98	2.1	52	0.7	33.3	1.8	29	160	3.2
Finland	96	2.3	61	0.9	35.1	2.2	35	114	2.7
Ireland	92	1.4	59	0.3	22.6	1.4	16	69	1.0
New Zealand	88	1.0	35	0.6	52.3	0.3	29	..	..
Spain	77	0.9	30	0.4	43.6	0.5	16	21	0.2
Korea	72	2.7	48	0.5	19.0	2.3	5	25	0.7
Portugal	70	0.6	24	0.4	65.2	0.2	7	8	0.0
Greece	67	0.5	20	0.2	46.9	0.2	16	..	..
Czech Republic	64	1.2	23	0.4	35.5	0.9	15	..	..
Hungary	47	0.8	26	0.4	47.9	0.4	20	115	0.7
Mexico	36	0.3	6	0.2	66.2	0.1	2	15	0.0
Poland	35	0.7	29	..	64.7	0.4	17	..	..
Turkey	30	0.4	7	0.2	64.5	0.1	4	..	..

¹ Or latest available year.

² Scientific and technological articles per billion US\$ of the GDP. See National Science Foundation (1998)

³ Technological strength is determined by multiplying the number of patents with an index of their impact. This index measures how frequently a country's recent patents are cited by all of a current year's patents. The patents refer to those granted at the US patent office. Data are from CHI research.

⁴ Technology intensity compares the technological strength of a country with its GDP expressed in PPP\$. See *Science, Technology and Industry Outlook 1998* for details.

Source: OECD Secretariat calculations on the basis of MSTI database, CHI research, National Science Foundation (1998), and *Science, Technology and Industry Outlook 1998*.

The nature of R&D expenditures in Korea¹

It is sometimes very difficult to make direct international comparisons using national R&D statistics, since the classification standards are not always the same. For instance, R&D statistics are affected by whether or not capital expenditures are included. Capital expenditures are included by half of the OECD countries for which information is available (Australia, Austria, the Czech Republic, France, Iceland, Italy, Japan, Korea, the Netherlands, Portugal, Switzerland and Turkey). In the case of the United States, capital write-downs are included in place of capital expenditures in the business enterprise sector. And conventional classification of R&D expenditures has limitations in terms of revealing the nature of R&D activities. For instance, R&D activities classified by character of work, basic research, applied research and experimental development tend to lose their meaningfulness since, among other factors, the borders of these areas become blurred and the distinction between these activities involves an important element of subjective assessment. Korea's national R&D statistics contain information on R&D expenditures by type of usage and cost, which helps to clarify the nature of R&D expenditures in Korea.

Table 2-2: R&D Expenditures by Type of Usage and Costs, 1997

		(Unit: %)								
		All industry	Manuf	Chem prod.	Non-m. m. p.	Basic metal	Fab. m. p. & machinery	Elect. Prod.	Comm. equip.	Motor veh.
Type of Usage	Product	84	88	81	84	64	86	89	88	94
	Process	16	12	19	16	36	14	11	12	6
Type of Costs	Wages	35	35	40	39	27	34	37	31	39
	Others	42	42	44	39	58	31	47	48	33
	Cap. exp.	23	23	16	23	15	35	16	21	28

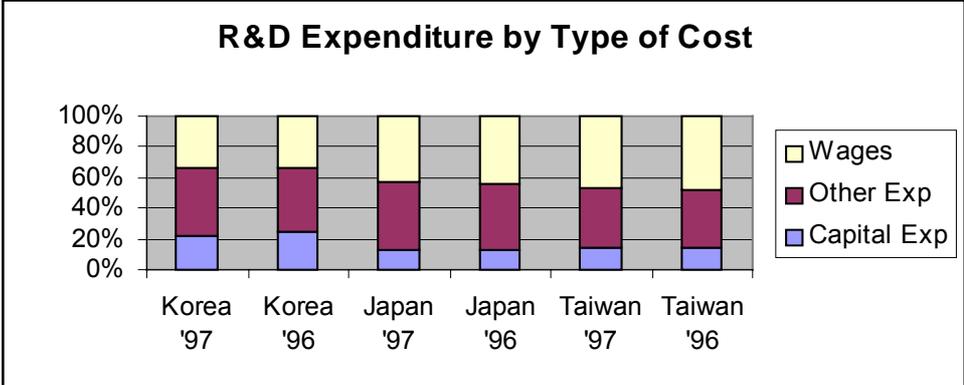
Source: MOST, *Report on the Survey of R&D in Science and Technology*, 1998.

1). R&D expenditures by type of cost shows how the money is actually spent. Statistics are available for three countries. Compared with Japan and Chinese Taipei, Korea shows a higher proportion of capital expenditures and a lower proportion of wages. As of 1996, Korea's capital expenditures share is 24.3%, whereas those of Japan and Chinese Taipei are 12.8% and 14.0%, respectively. And both the public and private sectors show almost the same patterns in higher share of capital expenditures in Korea. Capital expenditures include investments in both land and machinery for R&D. The high price of land in Korea may account for some of the high capital expenditure, but Japan is also infamous for this. The mirror image of high capital expenditures share is the lower share of wages for researchers and research personnel. The

¹ Ministry of Science and Technology, *Report on the Survey of Research and Development in Science and Technology*, 1998 and other years. (*R&D Survey*) Moon-Seob Youn and Jin-Gyu Jang, *Technological Innovation in Korean Manufacturing Industry*, STEPI, 1997. (*Innovation Survey*.)

higher share of capital expenditures, along with the lower share of wages, partly explains the low productivity of R&D in Korea.

Figure 2-2: R&D Expenditures by Type of Cost



2). Korea’s *R&D Survey* reports a very interesting entry, the type of usage of R&D expenditures in business enterprises. The usage types are process- or product-related. Since most of the OECD member countries do not contain this entry, it is impossible to make an international comparison, but the Korean report indicates a very important aspect of R&D activities in Korea: namely, that R&D activities in Korea are primarily oriented toward product innovation. In contrast, Korea’s first *Innovation Survey* shows that Korean firms are very active and successful in both product and process innovation. The *R&D Survey* seems to contradict the *Innovation Survey*. A literal interpretation of the survey results would imply that Koreans firms are spending less on product innovation, but are nevertheless very successful in this regard.

There are a number of possible explanations for this seemingly contradictory result. First, the *R&D Survey* focuses mainly on the input-side, while the *Innovation Survey* focuses on the output-side. Consequently, there might be conceptual discrepancies regarding process/product innovation by survey respondents. Second, the R&D survey is based on a one-year term, while the innovation survey covers a three-year time span. Third, the R&D survey asks respondents to specify the exact amount of spending in each category, whereas the *Innovation Survey* specifies only dichotomous answers, whether or not product/process innovation has been achieved. The last reason probably explains the seeming contradiction. Qualitative responses don’t necessarily contradict quantitative information, but cannot reveal the intensity of R&D efforts in product/process innovation.

Keeping the above qualifications in mind, it can nevertheless be concluded that the R&D activities of Korean firms have been mostly product-oriented. This conclusion is supported by

many anecdotal cases. Even for the Samsung Group as a whole, “it is a very recent phenomenon that we (Korean firms and Samsung in particular) endeavour to make process innovation.” (Interview with Mr. Wook Sun, President of Samsung Advanced Institute of Technology (SAIT) on December 1, 1999 in Seoul) As one of two main flagship R&D institutes that is not directly related to a subsidiary company of the Samsung conglomerate, SAIT is more future-oriented and intends to do more basic research than any of the other Samsung companies. But most of the future-oriented basic research at SAIT involves predicting future product trends, in order to prepare and direct SAIT research activities, and those of other Samsung companies.

Table 2-3: Innovators in Korean Manufacturing

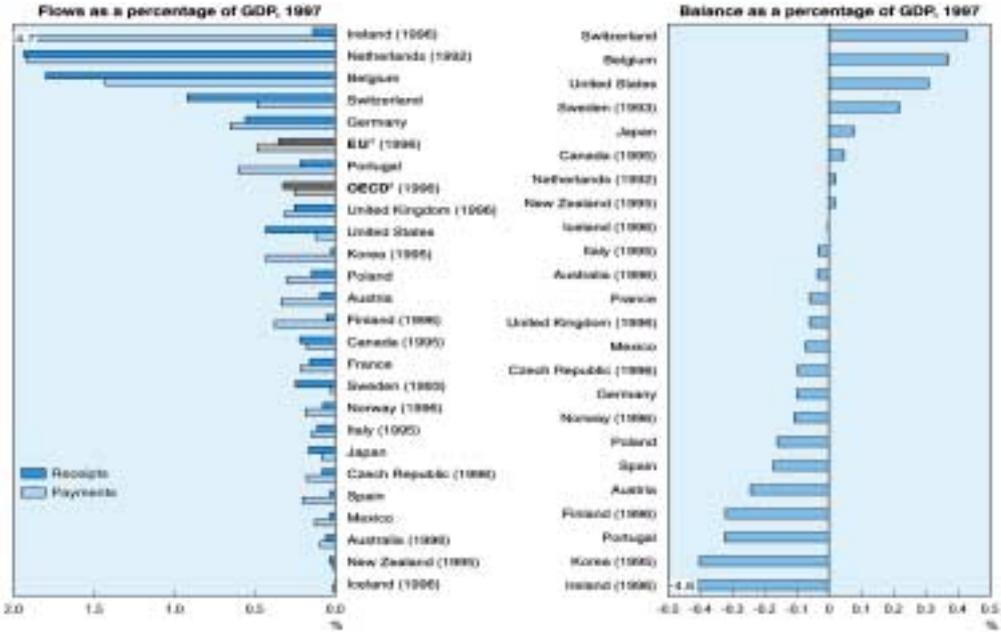
Manufacturing sector		Percentage of innovators		
Size	No. of Firms	New product	Existing product	Process
All	20 603	43.2	43.1	37.7
20-49	11 875	40.6	41.7	36.7
50-99	4 712	41.9	40.8	34.1
100-299	3 169	48.4	46.0	40.0
300-499	306	59.2	55.6	54.2
500 +	541	71.1	71.7	67.8

Source: Calculated from Youn and Jang (1997).

Technology balance of payments (TBOP)

TBOP measures the international transfer of technology: licenses, patents, know-how and research, and technical assistance. These are payments for production-ready technologies. Although a deficit position in TBOP does not necessarily indicate low competitiveness, it does show the characteristics of a country’s technology and innovation activities. Figure 2-3 shows that, for TBOP, Korea has one of the highest deficits of all the OECD countries, exceeded in this group only by Ireland. However, the sources of the deficits in Korea and in Ireland are quite dissimilar. The high magnitude of Ireland’s technology payments is due to the strong presence of foreign affiliates, which import technology extensively from their countries of origin. In the case of Korea, technology payments are mostly related to the arm’s length licensing fees of domestic firms, whereas foreign affiliates maintain only a very low share of technology payments.

Figure 2-3: Technology Balance of Payments



Source: OECD, *STI Scoreboard 1999*.

Flow of R&D funds

The flow of R&D funds in Korea shows several systemic aspects of the KIS. (Table 2-4) First, self-financing percentages are very high in both public and private sectors. Close to 100 percent self-financing for national & public research institutes, such as the Industrial Standard Centre and the National Health Institute, and for government-funded organisations, such as Korea Telecom and the Korea Electricity & Power Company, are understandable, because the research activities of these institutions do not necessarily require extramural inflows. Ideally, higher inter-flows among GRIs, universities and industry are more desirable, since this is an indicator of higher interaction among innovation actors. The reality, however, is the opposite. GRIs depend on the government for more than 80% of their financial support, but the outflows from GRIs to universities and industry are very small, 6% and 0.5%, respectively. Industry also shows a very high percentage of self-financing, more than 90%, and outflows from industry to GRIs and universities are minor as well, 13% and 4%, respectively. In contrast, universities show the most diversified fund-raising activities, although this is mainly the result of poor public/governmental financial support for research.

Table 2-4 also shows that financial resources are highly unequally allocated. Private enterprises hold the lion’s share of both R&D investment and spending; the government sector holds a moderate share, and the university sector holds a very low share. Roughly two-thirds of total R&D funds are provided by private enterprises, while public research institutes and universities are responsible for very minor shares, 15% and 10%, respectively. Within the university sector,

there is a strong contrast between national/public universities and private universities. National/public universities rely primarily on government funding, while private universities are mostly self-financing; this implies that government funding of private universities is very low. Private enterprises' research grants to universities also account for a low share.

Table 2-4: Flows of R&D funds in Korea, 1997

(Unit: 100 million won)

<i>Performed by</i>	<i>National & public Re. Inst.</i>	<u>GRI</u> s	<i>Other non-p. org.</i>	<i>Nat'l & Pub. Univ.</i>	<i>Private Univ.</i>	<i>Gov't-invested org.</i>	<i>Private Enterprises</i>	Total
<i>Financed by</i>								
Government	99.67	82.87	19.85	64.47	30.86	1.21	4.67	25,897.88 (21.25)
Government-funded institutes	0.08	4.47	0.90	6.58	5.24	0.12	0.47	1,808.43 (1.48)
Other non-profit Organizations	0.01	0.13	40.87	2.57	1.57	0.63	0.36	1,326.81 (1.09)
National & public Universities	0.00	0.01	0.07	8.42	0.13	0.00	0.02	393.73 (0.32)
Private universities	0.00	0.01	0.03	0.18	47.99	0.00	0.00	4,021.29 (3.30)
Government-funded organizations	0.05	8.38	31.37	3.25	1.31	97.90	0.11	10,355.34 (8.50)
Private enterprises	0.17	4.13	6.90	14.45	12.14	0.09	94.31	77,936.62 (63.96)
Foreign sources	0.01	0.01	0.01	0.09	0.76	0.05	0.06	117.96 (0.10)
<i>Total</i>	3,805.4 (3.12)	15,106.2 (12.40)	1,777.3 (1.46)	4,361.5 (3.58)	8,354.4 (6.86)	8,363.4 (6.86)	80,089.5 (65.72)	121,858.1 (100.00)

Source: MOST, *Report on the Survey of R&D in Science and Technology*, 1998.

Note: Numbers except for the total are percentage shares of each column. Numbers in parentheses under totals are percentage shares of the gross total.

The allocation pattern of the government R&D budget

Compared with other OECD countries, the Korean government's R&D budget is significant (See Table 2-5). As of 1998, the absolute amount of Korea's total R&D budget in terms of current PPP dollar is roughly equivalent to that of all the Nordic countries - Norway, Sweden, Finland and Denmark - together. Therefore, the question is how the budget is allocated. There are some idiosyncrasies in the Korean R&D budget. First, in terms of the high share of defence budget R&D, only the US, the UK, France and Spain are above Korea. Second, there is a very high share of Economic Development Programmes (EDP) as a percentage of Civil GBAORD - 35.0% compared with the OECD average of 23.2 %. Third, there is a very low share for Health and Environment Programmes (HEP) - 4.3 % compared with the OECD average of 23.7%. Fourth, there is a very low share for the General University Fund (GUF); among the reported countries, Canada is the only country lower than Korea in GUF share of civil GBAORD. In addition, Korea has given a large share of the civil R&D budget directly to government research institutes (GRIs) - 37.0%. Since HEP, GUF and SP are subtracted from all the related government programs and relevant GRIs, the budget given directly to GRIs can be re-classified

into EDP and NOR. Furthermore, since most GRIs are doing mainly mission-oriented research, most of this budget given directly to GRIs can be reclassified into EDP, which implies that in reality the EDP share will be substantially higher than 35.0%².

Table 2-5: Government Budget Appropriations or Outlays for R&D (GBAORD), 1998

	Total GBAORD (M. PPP \$)	Defence budget R&D share	Civil budget R&D share					Others
			EDP	HEP	GUF	NOR	SP	
Australia*	2531.3	7.2	21.1	15.4	34.1	23.5	.. ^{††}	
Austria*	1233.9	0.0	11.7	8.2	65.8	14.0	0.1	
Canada*	2759.5	6.1	45.7	27.8	(18.1) [†]	11.0	12.0	
France (1997)	13076.2	28.0	18.8	12.6	22.9	26.8	15.6	
Germany (1997)	15572.5	9.6	22.8	12.7	42.2	17.3	5.3	
Italy (1997)	6210.7	3.5	16.5	17.6	49.2	12.6	4.2	
Japan**	18602.3	4.8	34.6	6.9	39.3	12.6	6.6	
Korea	4454.7	16.3	35.0	4.3	22.6	^{††}	0.4	37.4^{†††}
Netherlands	2996.6	3.4	23.6	11.7	45.5	11.5	3.4	
Spain	3760.0	30.0	33.1	13.4	36.4	7.7	7.8	
UK (1997)	8915.3	37.7	13.6	32.8	29.7	18.9	4.3	
USA[°]	73639.0	54.1	15.6	47.4	..	12.5	24.5	
Total OECD	164771.4	31.1	23.2	23.7	..	14.6	11.9	
Nordic countries	4773.0	4.0	28.2	14.7	32.7	9.6	2.7	

a) Source: OECD, *Main Science and Technology Indicators*, 1999. Ministry of Science and Technology, *R&D Budget Statistics*, 1999.

b) Note: EDP= Economic Development Programmes; HEP= Health and Environment Programmes; GUF= General University Fund (MOST's budget for KAIST and KJIST and MOIR's budget for tech. colleges are included); NOR= Non-oriented Research Programmes; SP= Space Programmes. Numbers in each category are percentage shares of civil GBAORD.

c) * Federal or central government only. ** Excluding R&D in the social sciences and humanities.

d) ° Excludes public GUF and most or all capital expenditure.

e) † 1994. †† Included elsewhere.

††† Most of others are Direct Budget for GRIs - 37.0% of the civil budget's R&D share. National Research Institutes (11.7%); Ministry-affiliated GRIs (4.1%); GRIs under the Research Council for Economic Society (3.5%); GRIs under the Research Council for Humanities Society (1.7%); GRIs under the Research Council for Basic Technology (4.1%); GRIs under the Research Council for Industrial Technology (5.2%); GRIs under the Research Council for Public Technology (6.3%); Supporting Institutions (0.3%).

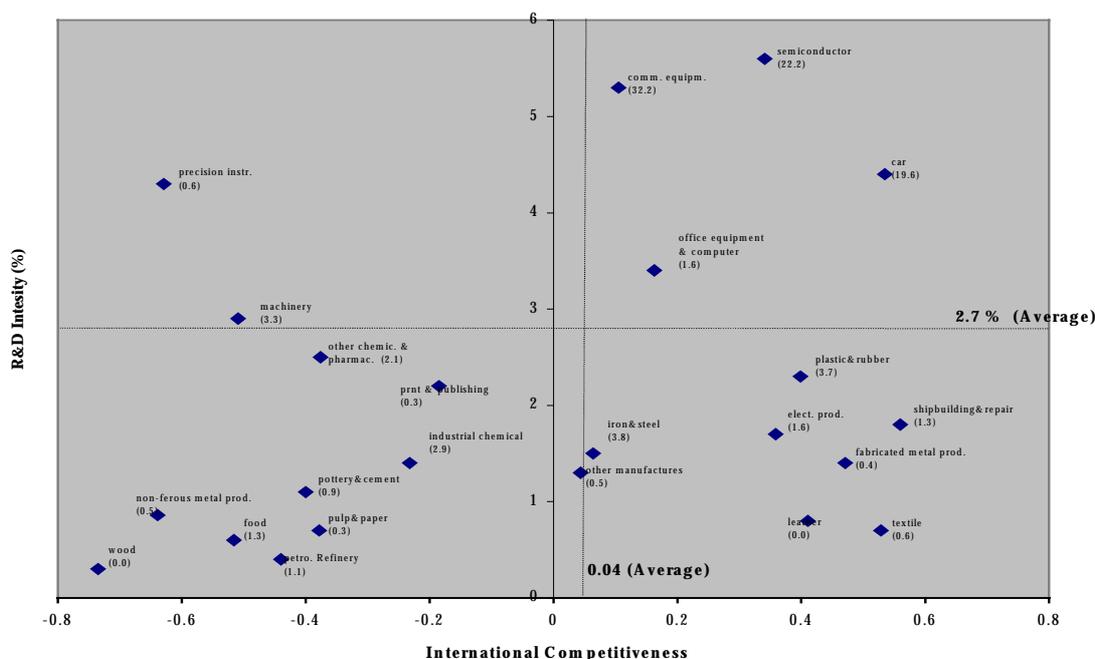
Korea's R&D activities and international competitiveness

Korea's industrial R&D spending is highly concentrated within a small number of industries (Figure 2-4). ICT sectors (communications equipment, semiconductors, computers, and

² The share of NOR is not clear. Calculation at detailed programme level would give the most accurate figure, but this is not available. The boundaries of NOR-share can be inferred from the R&D Survey. In 1997, total R&D expenditure is 12,185.8 billion won, of which 23.4% is government-financed. The Survey reports that the amount of R&D performed for "Advancement of knowledge" is 361.0 billion won, and for Defence R&D, 532.2 billion won. Based on this, the share of R&D for the advancement of knowledge, or NOR in the Table, turns out to be 15.6%. Since the 361.0 billion won for the advancement of knowledge includes both government-financed and non-government-financed R&D, this figure will be the upper boundary of the NOR share in 1997. But since most of the R&D for advancement of knowledge is performed by universities, this figure apparently includes the GUF share. Subtracting the university share gives the lower boundary of NOR share, 3.7%.

electrical and electronic products) account for 57.6% of the total manufacturing R&D expenditure, followed by the automotive sector (19.6%), chemicals (9.8%), machinery (3.9%), and iron and steel (3.8%). All of these industries, except for chemicals and machinery, make a positive contribution to the trade balance. Furthermore, Korea is one of the major exporters of high-tech products, although the value content of Korea's exports, including high-tech products, is still low. For instance, Korea's up-market share in EU-15 countries is below the OECD average, while its down-market share is one of the highest, exceeded only by that of Turkey, the Czech Republic, and Poland³. Korean industries, despite high R&D intensity, have not yet been successful in harnessing R&D potential to added value in their products.

Figure 2-4: R&D intensity and international competitiveness in Korean Manufacturing



Note: International competitiveness is defined as (exports - imports)/(exports + imports) for each sector. Numbers in parentheses are each sector's share of total manufacturing R&D expenditures

Characteristics of Korea's STI activities

Since STI activities are interrelated and their link to economic activities is not always linear, it is very hard to determine the causal relationships. For instance, low performances in patents and scientific publications are not only the "outputs" of STI activities, they are also the "inputs" of next-stage STI activities. An indicator might therefore give different implications. Indeed,

³ For more information, see OECE *STI Scoreboard 1999*.

Korea's STI profiles do give dual implications. Korea's R&D activities are usually characterised as being "high input but low output". But low productivity in R&D is a moot question, as there are always multiple relationships between "inputs" and "outputs". Furthermore, these multiple relationships are mostly embedded in country-specific factors, which are primarily institutional or system-related.

The profiles of Korea's STI activities provide clues from which we can infer systemic aspects of innovation activities. Indicators on R&D expenditures imply, at minimum, high innovation potential in terms of high R&D intensity and a relatively large pool of human resources. However, at the same time they raise the question of why the private sector, especially conglomerates, tends to spend large amounts of money on R&D. The high magnitude of payments for technology indicates that Korea is still heavily dependent on foreign sources for technologies, mostly through licensing rather than FDI. The last point also indicates that Korea does not fully utilise various channels of international technology transfer. The unbalanced allocation of resources revealed in the flow of R&D funds and the allocation pattern of the government's R&D budget suggests that Korea does not make efficient use of available R&D resources. This is also confirmed by the fact that industrial R&D spending is highly concentrated on a small number of industries, such as ICT, automobile and chemicals. Yet the value contents of these industries are still low, which indicates that Korean industries are not fully utilising the R&D potential for increasing the value of their products.

3. THE CATCH-UP MODEL IN BRIEF

The configuration and constellation of the KIS has largely been shaped by overall economic development strategies, namely the catch-up model. This model has brought both limitations and advantages to the KIS. The limitations of the catch-up model and the challenges presented in transition to a knowledge-based economy will be discussed in the next section. This section will briefly review the process of building technological capability within the broader framework of economic development. The development strategies which have influenced the shape of the KIS can be summarised as follows: 1) government-led mobilisation of strategic resources for achieving development goals; 2) export promotion *cum* rapid market expansion; 3) selective industrial promotion, notably in the heavy-chemical industries; 4) governmental support for the growth of big business; 5) utilising foreign technologies; and 6) constructing S&T infrastructure, institutions and R&D programmes for industrial demands. The last two points are the main focus of concern in this section.

Although Korea, as a late-industrialising country, has depended heavily on foreign technologies, it has also made concerted efforts to accumulate technological capabilities. At the initial launch of its economy-wide economic development plan, Korea was poorly endowed with factors necessary for industrialisation except for a plentiful labour force. Furthermore, the technological competence of Korean firms was far below world standards. Consequently, it was inevitable or natural to look toward foreign sources for technologies. After the industrialisation process launched in 1962, there was remarkable growth in imports of foreign. The process of technological capability building in Korea is characterised as a dynamic process of the interplay between imported technologies and indigenous R&D efforts.

Reviewing the process of industrialisation since the 1960s, there appears a general pattern of technological development across industries with some industry-specific variations. Table 3.1 presents the pattern in Korea's machinery industry. The table shows that technology transfer and in-house R&D are two principal modes of building technological capability in the machinery sector and other industries in general.

Table 3.1: The technological capability building process in Korea's machinery industry

	<i>The process of development</i>	<i>Technology imports</i>	<i>Production and R&D</i>
1960s – 1970s	Policy goal: establishment of production base	Packaged technology: turn-key based plants	Knock-down type production system
	Characteristics: heavy dependence on imported technologies	Assembling technology	OEM-dominated Almost no in-house R&D
Early 1980s	Policy goal: promotion of self-reliance	Unpackaged technology: parts/components-related technology	OEM/own brand: high ratio
	Characteristics: Import-substitution, localisation of parts/components production	Operation technology	Product development In-house R&D begins
Late 1980s – 1990s	Policy goal: export-promotion by means of expansion of domestic market	Materials-related technology	OEM/own brand: low ratio
	Characteristics: beginning of plant exports, learning advanced and core technologies	Control technology Design technology High-quality product tech.	Product innovation Process improvement

During the early stages of industrialisation, technologies are imported in packaged forms. Turn-key based plant imports were most common during those years, and assembling technologies were imported for the purpose of knock-down production and/or OEM. Then, afterwards, self-sufficiency in technology was enthusiastically pursued, although it was not achieved in a short period. Localisation of some technologies was one of the main goals both for government and private firms. In this period, imported technologies changed to un-packaged ones and the importation of operation technology increased in order to enhance productivity. After achieving, to some extent, the goal of promoting self-reliant technologies, the next step was to get Korean products into world markets. In order to do this, it was necessary to expand domestic markets. In this period, imported technologies were relatively more sophisticated and advanced, involving material-related technologies and control and design technologies. Throughout all periods, the ratio of OEM to own brand name (OBN) has steadily decreased.

The pattern of technology transfer differs slightly across industries, particularly in the early years. Unit production industries, such as shipbuilding and machinery, relied mainly on formal transfer in the form of licensing and consultancy for the initial erection of production facilities and product design. Mass production industries, such as electronics and automobiles, also depended on formal transfer but to lesser extent. Instead, more emphasis was placed on

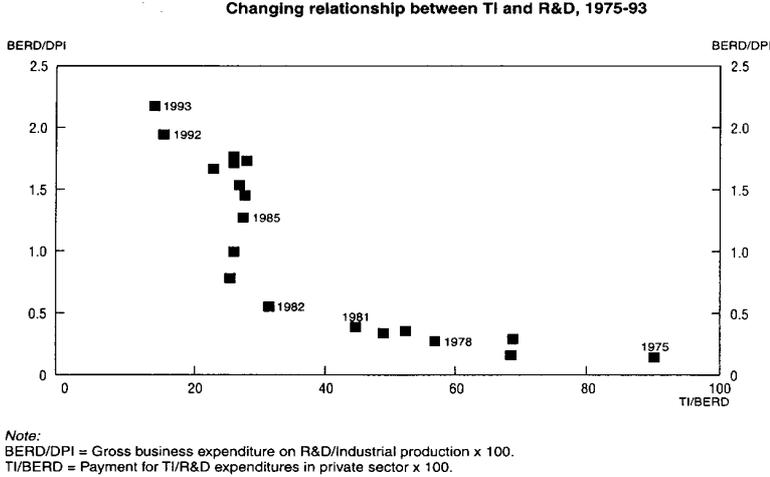
engineering efforts for implementation. Continuous process industries, such as chemicals, cement, paper, and steel, were established on a turn-key basis.

Since the early stages and throughout the 1970s and 1980s, technology imports prevailed, and are still an important source of technological innovation. Recently, however, the outsourcing of foreign technologies has become more sophisticated, and the modes of technology transfer have become diversified and complex. Exchanges or alliances, for the mutual benefit of both parties, are beginning to take the place of unilateral technology imports. Furthermore, interest in foreign technologies is shifting towards more high-tech areas and/or design technologies, and the scope of foreign partners has widened considerably.

The growth of R&D activities in the private sector shows a similar pattern. During the earlier period of industrialisation, systematic in-house R&D efforts were hard to find out. It was not until the 1980s that Korean firms endeavoured to build in-house technological capability by institutionalising R&D activities. In the early 1980s, the R&D activities of private firms focused on the adaptation and assimilation of imported technologies. Product development was the main feature of R&D in those years. Since then, with a base of accumulated experiences and knowledge, a number of firms in some specific industries have been able to make some product innovations. Throughout these years, efforts to improve the production process have continued.

The pattern outlined above is clearly illustrated in Figure 3-1, which plots the trend of the relationship between technology imports (TI) noted as payment for foreign technology licensing fees and indigenous R&D efforts noted in terms of R&D expenditures over industrial production from 1973 to 1993. The trend changed substantially over the years. Indigenous R&D efforts remained at an insignificant level until the early 1980s, but since then R&D intensities have increased considerably. Consequently, the overall relationships between imported technologies and indigenous R&D efforts have changed from substitution to being complementary. Figure 3-1 shows that the trend of relationships changed around 1982. The turning is not accidental; this year marks the launch of NRDP, when private enterprises began to establish in-house R&D laboratories.

Figure 3.1: The changing relationship between TI and R&D



The changing relationship between TI and R&D originated mainly from two sources: increased R&D efforts in the private sector, and governmental policy changes. Throughout the 1980s TI increased steadily and maintained its pace. At the same time, however, systematic in-house R&D efforts in the private sector have begun to prevail. Underlying this change, three driving forces, inter alia, have been influential. First, as the Korean economy moved to technology-intensive industries, foreign sourcing of technology could not meet the required technological standards. As foreign firms become more reluctant to release their technologies, it becomes harder to acquire advanced technologies by depending solely on the conventional means of technology imports. Second, the cost advantage of cheap skilled labour was exhausted after the early 1980s. Therefore, Korean firms felt the need to develop their own technological capabilities.

Underlying the changing relationships, both the private sector and the government have made concerted efforts to develop technological capabilities. First, there has been a fundamental shift in business strategy. In earlier years, international competitiveness relied mostly on such cost factors as low wages and scale economies based on mass production. And as imported technologies were of a kind that required simple assimilation and adaptation, there was no need to organise R&D activities. In later years, in contrast, as the cost advantage of cheap skilled labour was exhausted and the economic structure was transformed into more technology-intensive sectors, there was a pressing need for institutionalised R&D activities. The private sector met this need by establishing in-house R&D laboratories. Accordingly, the pattern of international technology transfer has changed substantially, towards more sophisticated and complex forms.

In accordance with the stages of economic development, the Korean government has successively changed the orientation of S&T policy. In the earlier years, more emphasis was put on building the infrastructure for technological development, whereas in later years the emphasis shifted towards more specific targeted technological development. In the early years of launching full-scale economic development plans, the Korean government recognised very clearly that science and technology would play important roles in the coming years. In the 1960s, two noteworthy policy measures were initiated in this regard: the establishment of KIST (1966) and of MOST (1967). These two institutions, together with KAIS, which was established in 1971, have exerted powerful influences over the S&T community in Korea. MOST has been the main designer of Korea's overall S&T policy; KIST has played the role of technological functionary in responding to industrial demands for rapid economic growth; and, KAIS (later KAIST) first implemented the concept of the research-oriented university into the Korean higher education system. Subsequently, several important policies have been successively enacted; among others, the establishment of specialized GRIs since the 1970s, and, since the early 1980s, full-scale national R&D programmes.

The process of building technological capability is best considered from the aspect of the choice of technology. The fact that most imported technologies are in a mature stage of development shows that products are already standardized in the world market. Moreover, in order to compete with foreign firms in world markets, i.e. produce standardized products without having technological superiority, cost advantage has to be achieved by economies of scale. Consequently, technologies that render economies of scale in production have been preferred. The choice of technologies of this kind is exemplified by large plants in petro-chemicals, semi-conductors, shipbuilding, steel, and the automotive industry. Most of these industries demonstrate economies of scale in production as well as large plant size. In looking at industrial linkages, Korean industries in general show vulnerable backward and forward linkages when starting a new venture. For instance, when the semi-conductor industry was launched, there were neither adequate backward linkages to the equipment and raw materials sector nor forward linkages to the computer sector. The strategy of development for both government and private firms has been to assume that such lacking elements as components and raw materials will come from foreign sources. Combining imported technologies with cheap labour in the earlier period and fully exploiting human factors in the later period has enabled Korean firms to compete in foreign markets. In general, Korean firms have shown adroit movement in the operation of imported plants and the absorption of imported technologies. The choice for big technology is also closely

related to the government's aggressive export-promotion policy and to large firm oriented industrial policy.

Challenges ahead

The Korean economy is facing a new environment quite different from the past. First, there are new technologies in such fields as ICT, biotechnology and new materials. Although the impact of these new technologies on economic activities has not yet been fully identified, the implications are straightforward: economic activities will be more knowledge-intensive, and the transition to the knowledge-based economy requires fundamental changes in work and production organisations, industrial relations and in the structures of governance. Second, the world economy is becoming more integrated in both trade and investment; this fosters (and is caused by) freer movement of capital and production activities across national borders. The trend toward globalisation emphasises the importance of the global integration of national economic activities. That the Korean economy has matured and developed at a level comparable to advanced economies implies that the available stock of advanced technologies drawn on through conventional technology transfer is exhausted. How well are Korean firms responding to these changes? Can the Korean economy achieve sustainable economic growth in the future? The answer is not always affirmative. Past technological development is no guarantee for the future. The Korean economy must be as successful at making innovations as it has been at imitation and learning in the past.

The process of building technological capability in Korea seems to be successful. Among various explanations for Korea's success, it is very important to note that the assimilated technologies and products made thereby are mature and standardised. Mature technologies/standardised products mostly require intensive efforts for assimilation and adaptation. Further innovation critically depends on whether more learning efforts are made after the initial stage of assimilation and adaptation. Since Korean business has expanded the range of industrial activities, the technological activities of in-house R&D labs have also expanded very rapidly. Consequently, most in-house R&D efforts have been directed toward learning "new" technologies for expanded business areas. As businesses enter more knowledge- and technology-intensive sectors, the need for organised R&D activities increases. Korea's business enterprises have opted for "internalising" these activities, due, among other factors, to the weakness of the domestic knowledge base.

Under the new economic setting, both domestically and internationally, the conventional ways of technological development will not be as effective as they have been in the past. Standing at the crossroads, faced with new challenges, private firms need a new strategy. The task for

Korean private enterprises is to make the transition from borrower to innovator. This presents several issues for discussion.

First, the industrial structure shows the weakness of upstream sectors, particularly in the capital goods industry. This weakness is closely related to the predominance of large firms, notably Chaebols, and the government's industrial policy. In accordance with the aggressive export-promotion policy which complements the tiny domestic market, the imported technologies are both mature in life cycle, and able to render economies of scale in production. Consequently, large-scale investment has been made by a few large firms, with the aid of favourable government support. The production structure has centred on end products, and ignoring support firms and industries has resulted in heavy dependence on the foreign sourcing of materials, parts, and components (See Table 3-2). This chronic phenomenon renders the Korean economy vulnerable to external changes in the foreign market. Accordingly, strengthening upstream industrial linkages is one of the most urgent tasks for the Korean economy.

Table 3-2: Imports Dependency

	(Unit: %)				
	Korea			Japan	
	1985	1990	1995	1990	1995
General Machinery	41.0	26.9	28.7	3.3	3.7
Special Machinery	46.9	45.6	49.8	4.5	4.2
Computer & office equipment	42.2	31.4	27.9	6.0	12.6
Communication equipment	24.9	15.7	21.6	3.6	7.3
Semiconductor	47.8	44.8	27.9	10.5	18.4
Motor vehicle	2.8	3.0	2.3	5.1	6.5
Motor vehicle Parts	19.8	7.1	10.1	0.7	0.9
Ship	8.7	12.3	17.6	3.2	1.1
Other transport	45.0	46.7	52.3	14.6	12.4

Note: Imports Dependency = Imports / (Total Production + Imports) *100.

Calculated from Input-Output Tables, BOK and MITI, various issues.

Source: Korea Development Institute (1999).

Second, related to the first issue, a small number of Chaebols and research institutions are dominating innovation activities. The dominance of Chaebols, per se, is not an evil. The problem lies in the diffusion of innovation. The internal diffusion of technological innovation is not so active in Korea. The lack of domestic diffusion among firms is well demonstrated by the fact that repetitive importation of foreign technologies is common. Furthermore, the diffusion from research institutions to private firms is not as effective as expected. More organic cooperation between domestic firms, particularly between large firms and SMEs, and more active collaboration between research institutions and private firms are imminent.

Third, technological cooperation between domestic firms and foreign firms should be promoted. In the past, the Korean economy has benefited from the inflow of advanced foreign technologies. Now, new modes of cooperation such as cross-licensing and strategic alliances need to be utilised more. Furthermore, private enterprises have to increase outward-oriented

cooperation as suppliers of technology. The rapid increase in technology exports in recent years is a good sign, but additional efforts are required.

Fourth, facing rapid changes in technological opportunities and the expansion of globalisation, private enterprises need to strengthen the development of human resources and international R&D networks. Other infra-structural systems such as R&D management, IPRs, dispute settlement, etc., also need to be developed.

4. KOREAN INNOVATION SYSTEM: MAIN FEATURES AND WEAKNESSES

Korea's catch-up model has been quite effective in accomplishing development goals in a short period of time. The Korean economy has rapidly initiated a wide range of industrial and technological activities. Yet, the catch-up model has limitations as well as advantages. The fundamental question is whether the KIS based on the catch-up model can meet the challenges raised by the KBE. Despite its achievements in accumulating R&D capabilities and resources, it seems that Korea doesn't take full advantage of its R&D potential. Compared with other OECD countries, Korea's performance in R&D is quite poor. Ironically, low productivity in R&D stems from the very success of the catch-up model of economic and technological development in the past.

4.1 The fundamental weakness of the basic knowledge-generating mechanism

General research orientation of the KIS

The primary function of the innovation system is to generate knowledge and to diffuse it for industrial use, yet the KIS seems very weak in this regard. An indicator is the share of R&D expenditures devoted to basic research. By definition, basic research activity aims to increase the general knowledge base rather than focusing on a particular application or use. Korea shows a very low share of GERD devoted to basic research; indeed, it is one of the lowest in the OECD countries. And in most OECD countries basic research is performed by the higher education sector, whereas Korea is the only country where the business sector takes a larger share than the sector for higher education. (Figure 4-1) Overall, the KIS is more inclined towards the end-stream of the research pipeline, which may hamper the accumulation of the basic knowledge base in the long run (Figure 4-2).

The idiosyncrasies in the Korean system indicate, first, that role division among innovation actors is not yet clearly established. In particular, the universities and research institutes are widely engaged in a whole spectrum of R&D activities. Universities are performing almost equally all the stages of R&D; research institutes are more involved in experimental development, which is generally considered the primary realm of industry. This implies that, when faced with limited resources, the conventional role of universities and public research institutes in generating basic knowledge will shrink. Second, as universities and research institutes relatively ignore basic research, business enterprises must perform basic research

themselves. As industry moves toward more knowledge- and technology-intensive sectors, there is an increased need for fundamental understanding of technological phenomenon, which in turn requires more basic research. Yet, it is rather questionable that industry is engaged in basic research primarily to increase the general knowledge base. Rather, industry's basic research activities seem to be oriented toward long-term product development.

Figure 4-1

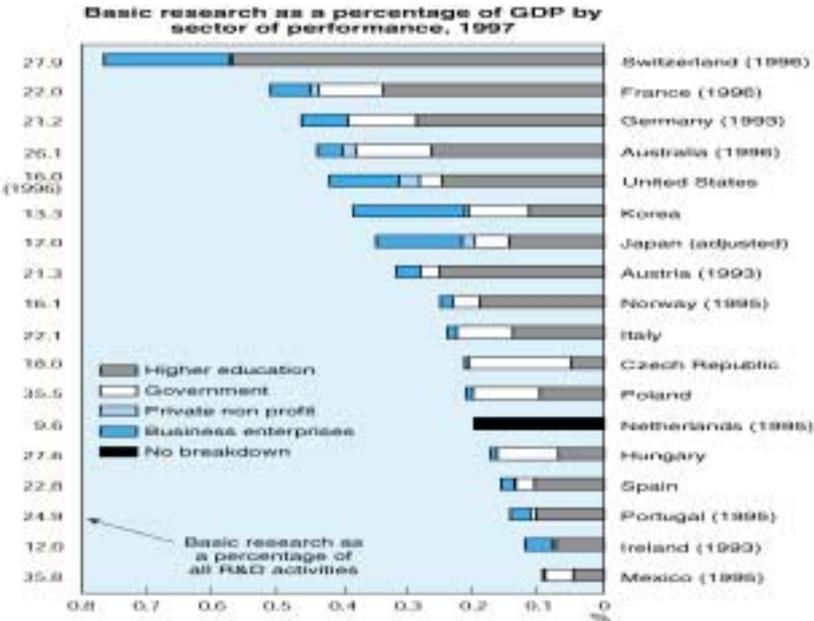
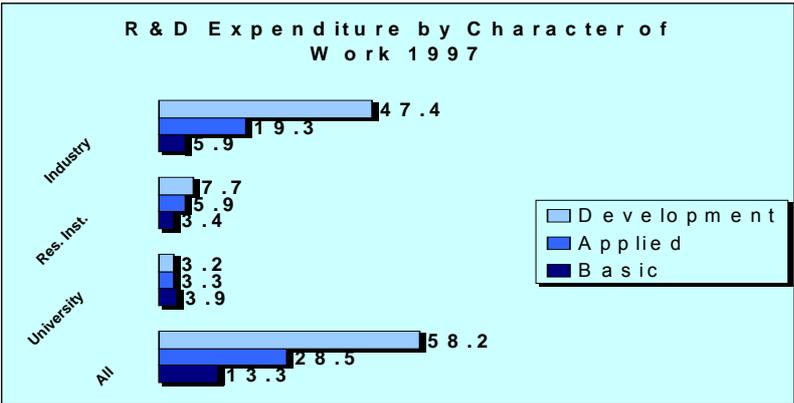


Figure 4-2



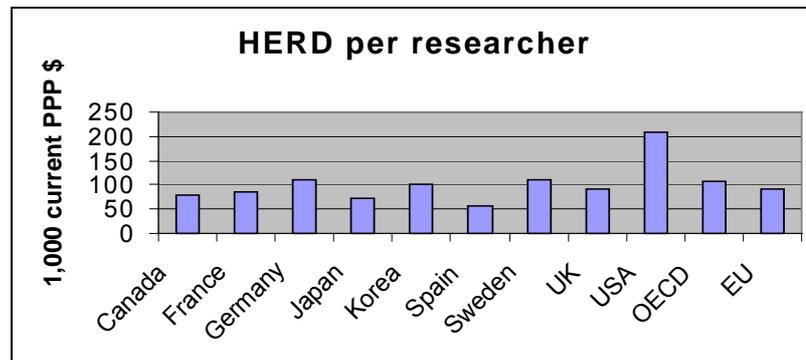
University research: High input but low performance

The role of the university in the KIS is unclear, and the productivity of university research is questionable. Korea's universities are usually characterised as being weak in research and primarily oriented toward general education. The performance of the university sector is quite poor. For instance, most Korean universities, with very few exceptions, show very poor

performances in publishing scientific papers. There are several possible explanations for this poor showing: a high student-teacher ratio and heavy teaching burden, an inadequate research infrastructure, such as experimental facilities and lack of research manpower, especially the inadequacy of supporting personnel, a low level of research funding and financial support, and so on. Some of these explanations are borne out by reality; in particular the student-teacher ratio is still high and teaching is quite a demanding burden. And the number of researchers, say per labour force, in the higher education sector is far below the OECD average.

However, the shortage of manpower alone doesn't sufficiently explain the poor performance. The ratio of R&D personnel to researchers, which shows the proxy for research infrastructure, is almost equivalent to those of most OECD countries. And, quite contrary to the general perception, research funds for universities in Korea seem to be relatively well available. Figure 4-3 shows higher-education R&D expenditure (HERD) per full-time equivalent researcher in OECD countries. Korea shows a higher amount than the EU average, marginally below the OECD average. In fact, taking into account the high share of the USA, Korea is higher than most of the OECD member countries. There must be some institutional problems. The lack of incentives for research and lack of appreciation for research are frequently cited. Until very recently, research has not been a primary concern in most Korean universities. In recruitment and promotion, the quality of research has not been very much appreciated.

Figure 4-3



Source: Calculated from OECD, Main Science and Technology Indicators, 1999.

In addition, there is the question of how university research is proceeding in Korea. As explained above, university research is not particularly focused on basic research. University participation in wider R&D activities, rather than in basic research, may imply better relationships between the universities and other innovation actors. However, this causes serious bias in university research orientation and weakens the indigenous knowledge base. It is closely related to the flow of R&D funds, which will be discussed in more detail later. Compared with

GRI, public funding for university research in general is very low; and there is a sharp contrast between private universities and national and public universities, in which public research funding for private universities is quite low, half the level of national and public universities. Consequently, universities tend to seek other funding, mostly from private enterprises, which might bias the university research orientation away from enhancing the generic knowledge base.

4.2 The private sector R&D system

The limitations of internalisation

Since the early 1980s, Korea's private enterprises have consistently and rapidly increased R&D spending, with large companies, notably Chaebols, taking the lead in this process. As was previously explained, rapid market expansion *cum* industrial widening have brought newer technological demands to the KIS. Since there has been a wide gap between the domestic knowledge base and the technological requirements of fast-moving industrial and production activities, private enterprises have had to opt for in-house research. The "internalisation" of the technology base by private enterprises has obvious advantages. Internal technological capabilities are apparently a basic requirement for business success. They enable companies to monitor market trends, to pre-empt competitors and to reap higher profits through economic rents. The problem is whether internalisation is accompanied by increased learning or technological deepening; this is where Korea seems to face serious bottlenecks.

The cost of excessive internalisation in wide ranges of technological activities is apparent in many respects. In addition to the high financial burden of maintaining them, big research labs are not so flexible; the fixed cost for dismantling the organisational structure in order to meet new needs is often enormously high. Organisational inertia coming from large size, whether governments, international organisations, or business enterprises are concerned, is also quite high. Furthermore, there is a trade-off between industrial/technological widening and deepening, in that excessive internalisation and industrial/technological widening frequently do not allow enough time to develop a deep understanding of technology. Korea is a case in point. The internalisation of R&D activities by Korean conglomerates has not come from specialisation; rather it is the result of the diversification of business activities, which require mostly 'quick product development' and 'adroit adaptability'. This system neglects learning and blocks further development of the KIS.

Another limitation of excessive internalisation is that it may weaken the need for closer cooperation with other innovation actors. For Korean conglomerate groups, this is the case both domestically and internationally. This is quite contrary to the current trend for the increased

“externalisation” of R&D activities in most OECD countries. Strong internal ties between subsidiary companies weaken the incentive for cooperation with companies in other groups. Intra-group mobility of R&D resources is an advantage; but weak inter-group mobility is a disadvantage, as information mostly flows within a group, not between groups. This pattern of resource and information mobility is also typical of relations with other innovation actors, particularly regarding relations with supporting SMEs. A vicious circle of self-propagating internal ties is blocking further development of the KIS.

The structural imbalance between large companies and SMEs (Figure 4-4 and Figure 4-5)

The problem of weak SME is the negative mirror image of the dominance of large companies. R&D resources are increasingly concentrated on large companies. Over the last decade, the share of the top 20 companies’ R&D expenditures out of the total BERD has steadily increased. In contrast, there has been no substantial increase in SMEs’ R&D intensity. The polarisation of the private sector R&D system between increasingly internalised large companies and technologically stagnant SMEs raises a serious problem for the KIS. A more fundamental problem is that only a very small portion of all SMEs are technologically agile. One indicator is the absolute number of SMEs that are performing R&D activities. As of 1995, in manufacturing only 0.7% of small enterprises with fewer than 100 employees were performing R&D. 19.1% of medium enterprises with between 100 and 299 employees were performing R&D, while two-thirds of large enterprises with more than 299 employees were engaged in R&D.

In the KBE, industrial and production activities become technologically more demanding and complex, and the existence of supporting industries is a key factor in a company’s ability to compete internationally, where SMEs play a very critical role. The KIS is very weak in this regard, due mainly to the weakness of SMEs. Accordingly, the mutually reinforcing producer-user interactions that are considered an essential source of learning in NIS literature are lacking in the KIS. In Korea, it is very hard to find industrial clusters based on an interactive chain of learning in production and innovation activities.

Figure 4-4

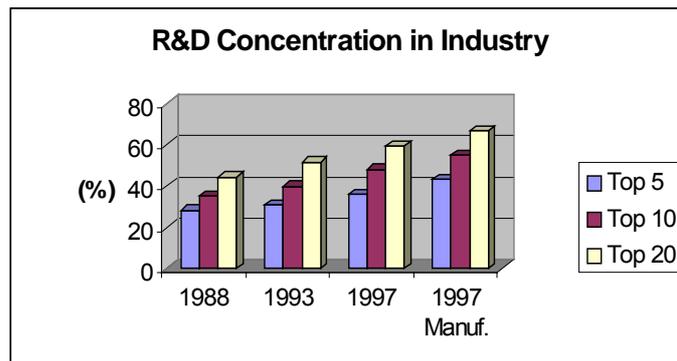
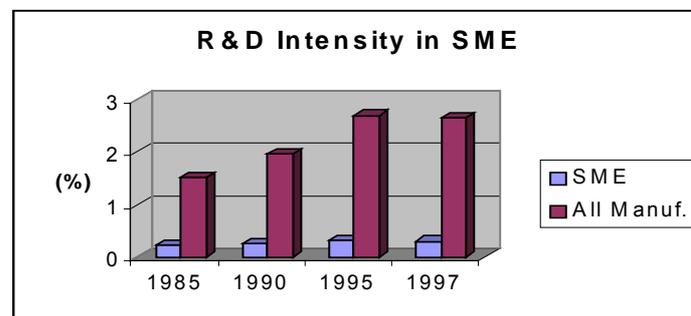


Figure 4-5



4.3 Government policies and programmes

The effectiveness of the government's R&D support policy

Korea has developed and introduced various policy systems and measures in order to promote technological innovation in private enterprise. The government's R&D support system includes 1) a tax incentive system, 2) a financial incentive system, 3) a procurement system, 4) a technical information support system, 5) a human resource support system, 6) a co-operative research promotion system, 7) an SME technology support system, 8) a new technology commercialisation support system, and 9) a system to promote the establishment of research laboratories. There are various detailed policy measures underlying these categorical systems⁴.

It is very hard to make an objective assessment of the effectiveness of these policy systems and measures, because, among other reasons, evidence is incomplete. However, some important issues in particular warrant more consideration. First, the appropriate scale for the government's supportive measures. The *Industrial Technology White Paper 1998* of the Korea Industrial Technology Association (KITA) points out that the absolute amount of financial support

⁴ For a brief historical overview see OECD (1996), Part I, Chapter VIII, Section 4. All policy systems and measures are compiled in detail in MOST (1999), *Technology Innovation Support System*.

measures is too low to have any substantial effect on the innovation activities of private enterprises. Several other reports also express the need for increasing the absolute amount of governmental support measures⁵. The appropriate scale for the government's R&D support is an issue that deserves more in-depth and comprehensive study. Yet, in order to rationalise increasing governmental support, it is imperative to evaluate the effectiveness of incumbent policy measures and thereby determine more efficient resource allocation. Information in this area is very limited, and it's hard to find a comprehensive analysis. There is some partial evidence; a recent STEPI report that covers 7 tax incentive measures and 6 other measures concludes that these measures, even though they are the most important of a group, are only marginally helpful in promoting business enterprises' innovation activities. The STEPI report emphasises the need for streamlining and restructuring overly complex support measures (See Box 3.).

The KITA's *White Paper* summarises the problems associated with government's support systems as follows: 1) mismatches between the objectives of the government's support measures and industrial needs; 2) the lack of complementarity and substitutability between financial measures and tax-incentive measures; 3) the difficulty of securing credit-loans for SMEs; 4) the limitations of mobilising funds through market capital; 5) high interest rates for bank loans; 6) underdevelopment of the venture capital system; 7) and other factors such as various banking regulations and practices. In particular, the *White Paper* puts critical focus on the problem of various ministries' overlapping policy measures, which result in smaller scale resource allocation and inefficient management of funds, rather than increasing efficiency through inter-ministerial cooperation.

Box 3: The effectiveness of governmental R&D support measures

Based on innovation survey of 3,472 manufacturing companies, a STEPI report[¶] shows very interesting findings. (1) Schumpeterian hypothesis holds: the bigger the company in terms of the number of employees, the higher the probability of making innovations. And, the older the company, the higher the probability of innovation. (2) The higher the share of foreign-held stock, the higher the probability of innovation. In addition, the report investigated the effectiveness of seven tax-incentive measures and six technology-support measures. (3) Overall, the assessments were not positive. The report raises doubts about the effectiveness of more than 100 of the government's R&D support measures. Furthermore, the policy measures have different effects on the innovation activities of LEs and SMEs. LEs are more concerned with process innovation, whereas SMEs focus primarily on new product development. (4) Tax-

⁵ For instance, according to Won-Young Lee (1998), Korea is utilising only one-tenth of the possible public support measures that are allowed under WTO subsidy rule. Lee, W-Y, "Proposal for improving tax and financial incentive systems," STEPI, 1998.

incentive measures such as special depreciation allowances for new investment are more effective in promoting LEs' process innovation; in contrast, special tax exemptions for technology-intensive start-ups are more effective in promoting SMEs' new product development. (5) Technology support measures such as the government's procurement system for new technology products, and the technology transfer system from public research institutes and universities are very effective support for SMEs' product development, whereas LEs utilise different support measures, such as on-site technical assistance and technical personnel training programs for process innovation.

Based on the findings, the report emphasises the need to streamline various policy measures and to make better considered budget allocations toward more effective support for companies' R&D activities. The report shows that some tax-incentive measures are significantly effective, as are a few technology support measures, such as on-site technical consultancy, systems for training technical personnel, technology transfer from public research institutes and universities, information provision services, military service exemption for researchers, and the governmental procurement system. The last four are more effective for SMEs' product development than are the others.

Wi-Chin Song and Taeyoung Shin, *Determinants of Success of New Technology Based Firms and Innovation Policy*, STEPI, 1998.

SME support policies

Despite numerous government policy measures, the technological capabilities of Korean SMEs are still far below optimum. This raises two questions concerning government policy: whether support measures have not been sufficient, or whether policy measures were inappropriately implemented.

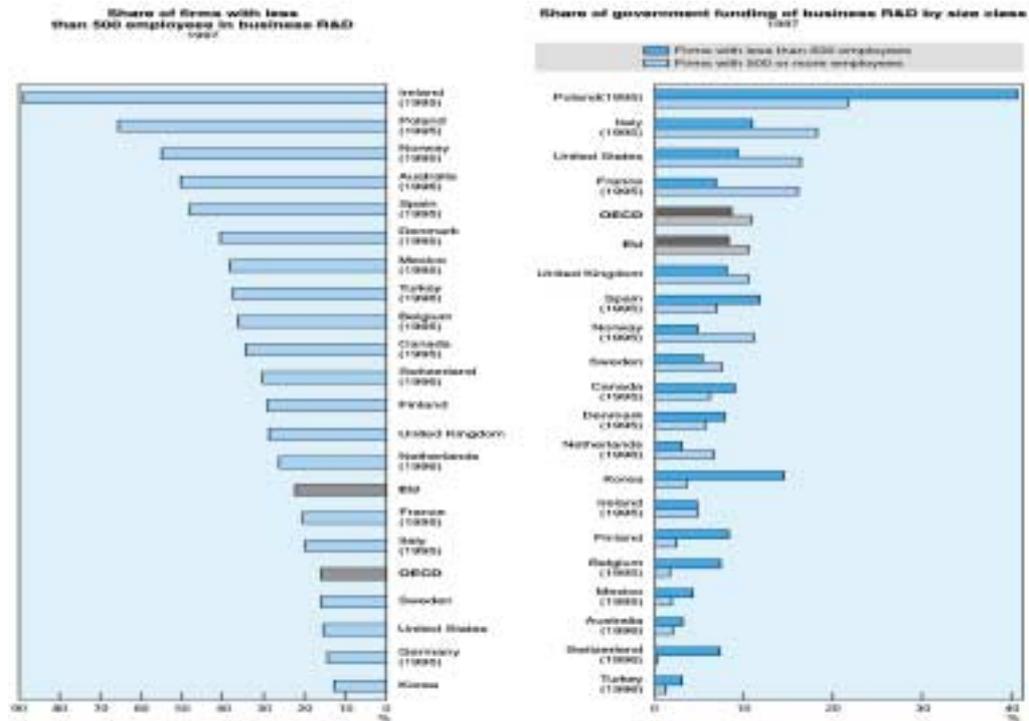
As mentioned above, the absolute amount of public funds seems very limited, especially for SMEs. Furthermore, SMEs have difficulties in accessing public support measures. Even in the case of "policy banking", which was especially arranged for technology-based SMEs by the government, the banks require collateral, mostly real estate.

For enterprises performing R&D, government funding is very favourably allocated toward smaller enterprises. (See Figure 4-6)

The appropriateness of policy measures is still questionable. The aforementioned STEPI report shows that many technology support measures, including the technology reserve fund system, are not so effective in increasing the innovativeness of SMEs. In contrast, some technology support measures, such as the government procurement system and the technology transfer

system from public research institutes and universities, are very effective in enhancing SMEs' new product development. But more government funds are allocated for non-effective measures.

Figure 4-6: Funding of business R&D by size classes of firms



Source: OECD, *STI Scoreboard 1999*.

The role of defence research

Until recently defence research in Korea has not played a significant role in upgrading national research capabilities (See Box 4). The integration of defence research in the national innovation system is weak. The R&D budget for defence is spent in two ways: on MOD (Ministry of Defence) R&D programmes (16.2%) and on direct support for three research institutes affiliated with MOD (83.8%), of which the ADD (Agency for Defence Development) is the major institution. Some portions of these two allocations flow into the civil sector for contract research or for procurement of ‘research and development’ equipment: in 1997 the university spent 1.9% of the defence R&D expenditure, while industry spent 19.5%.

It is hard to conclude that defence research is actively connected to civil research in Korea. Some defence research was contracted to the civil sector. From 1990 to 1995, ADD commissioned 549 research items to the civil sector, where most of the contractors were universities, spending a total of 14 billion won. Some signal success cases involving spin-off,

spin-on or spin-up have resulted; and MOD has established three “Centres of Research Excellence” at universities. But the overall picture is not positive. Recently, however, the Korean government has come to recognise the importance of defence research in the national innovation system, and has initiated several important policy measures. In 1998, the “Dual-Use Technology Activity Promotion Law” was enacted. Korea has just started to make more effective use of defence research for civil technological activities.

Box 4: The evolution of defence research in Korea*

Substantial defence industry and research activities emerged during the early 1970s in Korea. Although there had been defence-related industrial and research activities in earlier years, they were very crude in nature. In 1970, the government established the ADD (Agency for Defence Development) for doing defence research. Some researchers from the KIST joined the ADD. Since its inception, the ADD has maintained its status as the major defence research institution in Korea. During the 1970s, national defence policy consistently pursued the goal of self-reliance, which helped ADD to establish its role. National defence policy had also directly and indirectly contributed to achieving the industry’s goal of promoting the heavy & chemical industries. Many defence industries which had received preferential government support for participation in the MOD (Ministry of Defence) programmes were also heavy & chemical industries. Furthermore, it seems that in the 1970s, defence research, or ADD research, had greatly contributed to the upgrading of technological capabilities in the emerging heavy-chemical industries. Many spin-off and spin-on cases indicate that virtuous interactions between defence and civil research took place in the 1970s. The national defence policy on weaponry procurement changed in the 1980s: from early self-reliance based on indigenous research and development to foreign procurement, accompanied by technology imports with the emphasis on economy and efficiency. As policy orientation changed, the government laid off 850 R&D personnel and substantially cut the ADD budget, consequently weakening the ADD research capabilities. Since this time, defence research has not made any meaningful contribution to civil research, and has been poorly integrated into the national innovation system. The government has only recently recognised the importance of defence research and tried to re-establish the linkage with other sectors of the national innovation system.

* Based on Sung-Bum Hong, *Dual Usage Paradigm and Technology Development Strategy*, STEPI, 1994. (In Korean)

National R&D Programmes (NRDP)⁶ and the role of GRIs

Korea's national R&D programmes (NRDP) were first introduced by MOST in 1982 as "Special R&D Programmes (SRDP)". The SRDP were followed by other ministries' technology development programmes in later years; together these now comprise the NRDP. The goal of the NRDP was clear from the beginning: to develop technology in order to enhance industrial competitiveness. In order to achieve this, the government recognized the need for upgrading industry's technological capabilities, and assumed a very important and active role in complementing the private sector. Despite several changes - for instance, in 1990 the NRDP programmes were reorganised according to "project mission", and central management by MOST was devolved into each responsible ministry - the goal of the NRDP has been maintained.

The launch and implementation of the NRDP is closely related to the role of the GRI. Before 1982, a substantial part of the GRI budget had relied on contract research from industry. But as industries began to establish in-house research laboratories in order to strengthen internal technological capabilities, the needs from industry decreased. Responding to this and to other changes in the research environment, in 1980 the government restructured the GRIs by reducing their number from 16 to 9, through reorganisation and merger. At the same time, government defined the role of the GRIs as "leading cooperative research among industry, academia and research institutes, conducting creative generic technology and long-term complex big projects with the emphasis on basic and applied research areas, and being fully responsible for developing public/welfare technologies"⁷. The NRDP offered a tremendous opportunity to revitalise GRI research, which was intended to complement research areas that would not be pursued by the private sector alone. (See Table 4-1 for a brief summary of the process of GRI development and its changing role.)

⁶ For a general explanation of national R&D programmes, see OECD (1996), Part I, Chapter VI.

⁷ Ministry of Science and Technology, *Thirty Year History of Science and Technology*, 1997, p.214.

Table 4-1: The process of GRI development and its changing role

	Period of Inception-beginning (1960-1970)	Period of Structural Adjustment (1980s)	Period of Take-off (1990s)
Domestic condition	Weak research capability of private enterprises and universities	Partial improvement in research capability of private enterprises and universities	Industry-led innovation system Increased research capability of universities
Mission & Role	<ul style="list-style-type: none"> ○ Goal-oriented research in line with technological demands from the government and industry ○ GRI's leading role in industrial technology development 	<ul style="list-style-type: none"> ○ Adjusting the role and character as an agency for implementing the government's R&D programmes ○ Big R&D projects which require nation-wide drive; central role in cooperative research among industry-university-research institutes 	<ul style="list-style-type: none"> ○ More emphasis on future-oriented large complex advanced technology development ○ Rising necessity of redefining GRI role and preparing new take-off basis
Research area	Imitation of simple technology in growing industry	Improvement of mature technology Imitation of future advanced technology	Development of future advanced technology through creative research

Source: MOST, *Thirty Year History of Science and Technology*, 1997, p.271.

It is very difficult to make objective assessment of NRDP. There are great achievements: for instance, the successful development of DRAM in successive generations has been made possible through NRDP programmes coordinated by the government research institute, ETRI, with the active participation of private enterprise - Samsung, Hyundai and Gold Star. In terms of “output”, it is reported that, up until 1997, 687 items were successfully commercialised, 482 patents were granted in foreign countries, and 4,126 scientific papers were published in international journals.

Against these and other achievements, however, there have been incessant discussions on the effectiveness of NRDP and the appropriate role of the GRI. Although the Korean government has tried to balance the NRDP between mission-oriented and diffusion-oriented programmes, it is very hard not to conclude that overall, the NRDP is highly mission-oriented. Strategic targeting also prevails in the national TRD programmes of OECD countries and EU framework programmes. The issue is how to use public R&D resources more efficiently and how to build a diffusion mechanism within the programmes. Korea has tried to build separate diffusion programmes. This strategy is not effective.

In describing the general orientation of the NRDP, we note above that the rationale of the NRDP and the *raison-d'être* of GRI are to support and complement industry's research by conducting more upper-stream and public research that would not be sufficiently pursued by industry alone. As is shown in Figure 6, however, most GRI research belongs to the end-stream of research, experimental development. This contradiction gives several implications: first, the lack or relative neglect of long-term basic research, which unnecessarily weakens the basic science/knowledge base of the KIS; and second, the overlapping of research with the private sector, which means wasted resources and crowding-out instead of complementing.

The weakening of the science/knowledge base of the KIS is clearly related to the general orientation of the NRDP. The concentration of public R&D resources into GRIs puts the university into a minor role in the national innovation system. In 1998, 65% of NRDPs were commissioned to GRIs as main contractors, whereas universities and industry received only 9% and 2%, respectively. University researchers participate widely in most NRDPs; but their roles are minor. Taking into account the fact that universities hold 58% of PhDs in full-time equivalent terms, or 75% in crude terms, the contract pattern and actual budget allocation of the NRDP is strongly unfavourably biased against universities.

The problem of overlapping with the private sector is also very severe. Many NRDPs target research aiming to complement private research. In particular, the principle of additionality of public research, which states that public research should be a kind of trigger for private research by adding the appropriate amount of funds, is very questionable in the NRDP. A recent STEPI report noted that more than half of the companies that participated in the NRDP show that they would do the project even without government support⁸. There are many reasons for this. There must be a problem in planning, in that the NRDP was not planned to clearly reflect the needs of industry and to identify the elements lacking in private research. Yet another problem is that most of the private partners of the NRDP are big companies, notably Chaebols; these are already ‘grown-up’ enough to implement most of the commercially slanted research topics of the NRDP. The bias towards big companies reinforces the structural imbalance in private sector research and raises the issue of the diffusion of national research activities, which is one of the means of encouraging the broader participation of private enterprises.

Although the government has tried to balance its programmes between mission-oriented and diffusion-oriented ones, the performance of Korea’s NRDP as a whole has been unsatisfactory in utilising national R&D results (See Box 5.). There are several causes. The lack of policy co-ordination has often been cited as the main culprit. Several measures, including establishing the NSTC (National S&T Council), specifically to harmonise the R&D programmes of various individual ministries, have been implemented to cure this; but the results are by and large less than expected. The problem is deeply related, once again, to the general orientation of the NRDP. It seems that the NRDP and its mission-agency GRI have not yet clearly identified what they have to do in the public interest.

Although the government implemented several NRDP projects aimed at helping SMEs, SMEs have consistently played a very minor role. From 1983, when MOST introduced the ‘New

⁸ Hwang, Yongsoo *et al*, *An Assessment of Government R&D Programs*, STEPI, 1997. Based on a survey of researchers who participated in the NRDP, the report also points out other problems: the lack of programmatic differences among the programmes; the significant bias towards commercial technology; short-sighted time horizon for R&D; discrepancy between R&D objectives and R&D performance/impacts; and inconsistencies of R&D policies and ineffective program management.

Technology Commercialisation Programme” for SMEs, to 1997, the total amount spent for the “SME Support Program”, one of ten categories of the NRDP, accounts for only 2.4% of the funds spent. Basically the government established a separate program to support SMEs; in contrast, in most other NRDP programmes, SME participation has been negligible and large companies have been the main research partners.

Box 5: Under-utilisation of national R&D results - STEPI Report[¶]

Based on surveys and interviews with 947 principal researchers who participated in the NRDP, including those of MOST and other ministries in the past three years, the report analyses how effectively national R&D results are utilised. The findings are as follows. First, diffusion services from GRIs to private enterprises have moderate effects, whereas those from universities are less satisfactory. Second, there are bottlenecks in diffusion. 42% of GRI and university respondents point to the lack of technological capability on the part of private enterprises; in contrast, 40% of private enterprise respondents point to the lack of technological know-how and knowledge of GRIs and universities in solving the technical problems of private firms. Third, public R&D institutions, including universities, have responded that private firms are not interested in technology diffusion from them, and also point out that private firms lack absorptive capacity. Private firms have responded that the efforts of public R&D institutions to increase public awareness of national R&D projects have been insufficient. Fourth, it has been found that the best way to diffuse new technological knowledge generated by GRIs is to transfer technical personnel trained in GRIs to private firms. Finally, university professors have not been actively involved in technology diffusion due to their heavy teaching burden. GRI researchers have not efficiently extended their R&D results to commercialisation. Moreover, there is no professional organisation to effectively link universities and GRIs to private firms. The report concludes that all of these factors are agents in the under-utilisation of national R&D results in Korea.

Table: Policy Orientation of Korea's NRDP

	Mission-oriented NRDP	Diffusion-oriented NRDP
Programmes	<ul style="list-style-type: none"> ○ NRDP by MOST ○ HAN ○ Alternative Energy Tech 	<ul style="list-style-type: none"> ○ Industrial Generic Tech Dev. Programme (MOCIE) ○ Information & Communication Technology Programme (MOIC)
Areas of Technology	<ul style="list-style-type: none"> ○ Core industrial technology ○ Advanced/generic tech, basic science ○ Big S&T, nuclear & energy 	<ul style="list-style-type: none"> ○ Industry's common bottleneck technology ○ Core technology of key industry ○ Future potential advanced technology ○ Aerospace industrial technology ○ Component technology for, e.g. elect. & automobile
Characteristics of Technology	<ul style="list-style-type: none"> ○ Technology-push 	<ul style="list-style-type: none"> ○ Demand-pull
Project Selection Procedure	<ul style="list-style-type: none"> ○ Top-down ○ Concentration 	<ul style="list-style-type: none"> ○ Semi-bottom-up ○ Concentration and decentralisation mixed
Primary Research Institution	<ul style="list-style-type: none"> ○ Government-led; LE-centred ○ GRI & Universities' major role 	<ul style="list-style-type: none"> ○ Government support; Emphasis on SME ○ Private enterprises' role important
Technology Diffusion System	<ul style="list-style-type: none"> ○ Spin-off; trickle-down ○ Additional research needed for commercialisation 	<ul style="list-style-type: none"> ○ Spin-on; Trickle-up ○ Developing process technology for industry ○ Development of proto-type and mass-production tech. ○ Standardisation of technology and products

Source: Chai Kon Oh (1997), *A Study on the Promotion of the Effective Diffusion of National R&D Results*, STEPI.

[¶] Chai Kon Oh (1997), *A Study on the Promotion of the Effective Diffusion of National R&D Results*, STEPI.

4.4 Weak global linkages

Knowledge and technology are flowing across borders through various channels. The conventional means for Korea to utilise global knowledge/technology sources are arm's-length licensing and the 'brain gain' of Korean scientists and engineers returning from abroad. These two means are still useful and will have to be encouraged more in the future. Yet these two means, particularly licensing contracts, also have limitations. Licensed technologies are protected and mostly already mature, so that the potential for further successive innovation is relatively low. The KDB report shows that most technologies licensed to Korea are in the mature stage of their life cycle⁹. At best, licensees try to make improved products based on licensed technologies; this is also shown in the KDB report. In recent years, the number of Korean students going to study abroad is significantly decreasing¹⁰. This implies that brain gain benefits will consequently decrease in the future.

Aside from these two means, other means of knowledge/technology transfer have not been used extensively. For instance, the FDI played very minor role before the financial crisis, and joint ventures were not popular in Korea. Consequently, Korea did not grasp the opportunity to take advantage of knowledge/technology inflows from multinational activities¹¹. Figure 4.7 shows the cross-border ownership of inventions in OECD countries. Big countries such as the US, Japan and Germany show a lower tendency for cross-border ownership, since the absolute number of local inventors is high; in contrast, smaller countries tend to show higher co-ownership in order to best use their limited inventive resources. Korea seems far less internationalised in this regard.

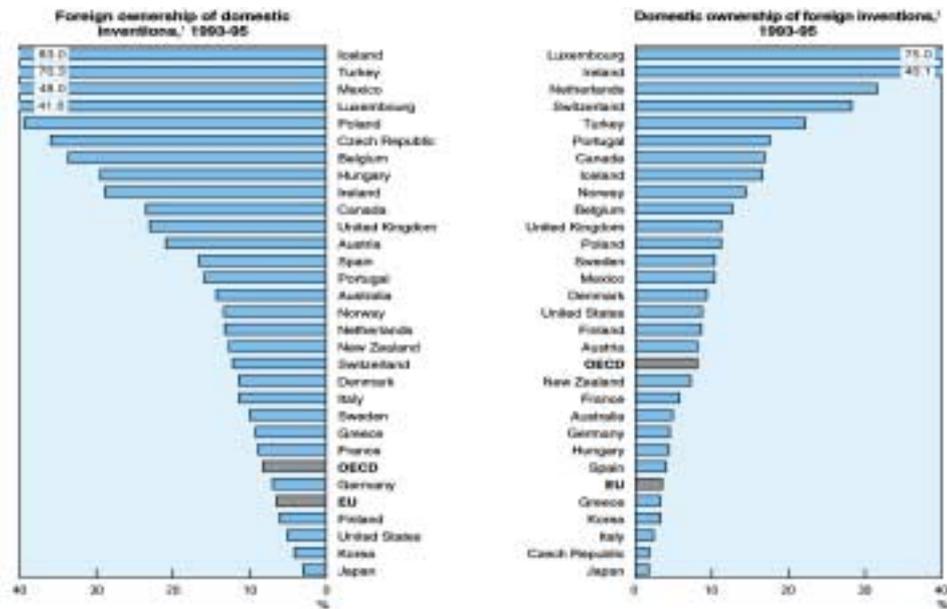
In the areas of science and technology research, Korea is also weak in global linkages. Figure 4.8 shows cross-border co-authorship of scientific articles and co-invention of patents that provide an indication of the level of internationalisation of scientific and technological activities. Korea shows the lowest records except for Turkey and for big countries such as the US, Japan, Germany and Italy.

⁹ Korea Development Bank, *Analysis of the Effects of Technology Imports*, Seoul: KDB, 1993. (In Korean.)

¹⁰ According to the National Science Foundation, the number of Korean science and engineering PhDs awarded in US universities peaked at 1,143 in 1994; afterwards it has rapidly decreased. (NSF, *Science and Engineering Indicators*, 1999.)

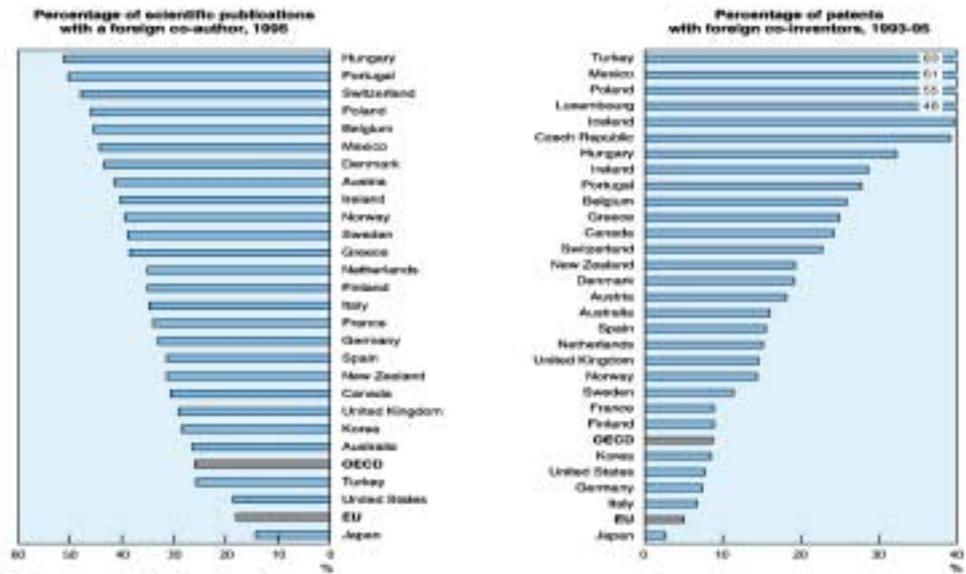
¹¹ Some OECD countries show positive evidence on the role of the FDI in upgrading indigenous technological capability. Meyler (1998) shows that in Ireland, foreign multinational enterprises substantially contribute to Irish technology via undertaking R&D in Ireland and/or transferring the benefits of R&D work undertaken elsewhere. Direct R&D undertaken by MNEs in Ireland accounts for two-thirds of all R&D in Ireland. (Aidan Meyler, "Technology and foreign direct investment in Ireland," Technical Paper No. 98/10, Economics Department, Trinity College, 1998.) Djankov and Hoekman (1999) show that the FDI had a great positive impact on total factor productivity in Czech enterprises. (Simeon Djankov and Bernard Hoekman, "Foreign investment and productivity growth in Czech enterprises," Policy Research Working Paper 2115, World Bank, 1999.)

Figure 4.7: Cross-border ownership of inventions



1. Share of patent applications to the European Patent Office owned by foreign residents, in total patents invented domestically
 2. Share of patent applications to the European Patent Office invented abroad in total patents owned by country residents.
 Source: OECD, based on data from the European Patent Office.

Figure 4.8: International cooperation in science and technology



Source: OECD, based on data from National Science Foundation and Science Citation Index.

Source: OECD, based on data from the European Patent Office.

5. THE NEW POLICY AGENDA¹²

New challenges: the KIS in transition to a KBE

The current status of the KIS has both bright and dim sides. Compared with other OECD countries, there is very high potential. Within a very short period of time Korea has accumulated great technology development capabilities; in particular, the private sector's willingness and ability to spend on R&D, and the presence of large number of relatively well-educated researchers, are very valuable assets. Indeed, Korea is one of the major exporters of high-tech products all over the world. Yet, as has been shown above, Korea seems to stick to the out-dated catch-up model, the applicability of which is very doubtful in the KBE. The most serious problem of the KIS is the weakness of its indigenous knowledge-generating mechanism. An important factor in this scenario is the bias of overall research orientation toward end-stream R&D, which seriously undermines the indigenous knowledge base. Furthermore, the lack of system linkages is pervasive; this seems to be a structural problem in Korea. The weakness of the indigenous knowledge-generating mechanism, the bias of overall research-orientation and consequent wasted resources, and the lack of systemic linkages - together these factors are the major reasons for Korea's low R&D productivity.

Korea needs a more fundamental approach. First of all, Korea should balance its overall research orientation. It is apparent that current research orientation is too biased toward end-stream R&D, which emphasises immediate usage and commercialisation. This bias was caused by the unclear division of labour among innovation actors, and also by the government's technology policy orientation. Due to the shortage of public support, universities are seeking 'profitable' research items. The private sector, particularly Chaebols, should change its R&D strategy to establish partnerships with other innovation actors. Balance should be restored between large firms and SMEs. The role of GRIs needs to be redefined, to put more emphasis on developing generic and public technologies, and preparing to satisfy future demands through more basic research. In order to achieve this change, the government should reorient its R&D programmes toward more diffusion, and both domestic and international system linkages.

¹² In collaboration with the Korean government, the OECD published the *Review of National Science and Technology Policy: Republic of Korea* in 1996. It concluded with "Main (policy) recommendations," which have been widely circulated and referred in Korea. The general implications of the recommendations are still valid; and the Korean government has initiated several policy changes based on the recommendations. This section will try to derive policy agenda in the more specific context of the KBE from an NIS perspective.

5.1 The Changing rationale of STI policy in a Knowledge-based economy

The changing nature of innovation processes, including their linkages with more basic research activities, calls for an adaptation of the technology and innovation (STI) policy.

Competitive markets are necessary in order to stimulate innovation and derive the benefits from knowledge accumulation at both the corporate and individual level. At the same time, firms are not “simple algorithms to optimise production functions”, but learning organisations whose efficiency depends on numerous and often country-specific institutional, infrastructural and cultural conditions. Therefore, in addition to correcting market failures (by providing public goods, IPRs, and subsidising R&D), governments have a responsibility to improve the institutional framework for knowledge interactions among firms and between market and non-market organisations. In particular, most OECD countries are introducing new policy and institutional measures aimed at stimulating the economy-wide diffusion of public R&D results.

Another key feature of a KBE is that agglomeration economies at the regional level, network externalities and dynamic economies of scale in clusters of technologically-related activities are important means of increasing returns to private and public investment in R&D. This causes most OECD countries to shift their STI policy from conventional sectoral promotion to the cluster approach.

Finally, the experience of the most successful OECD countries demonstrates that increasing the efficiency of STI policy requires improved policy co-ordination and evaluation mechanisms.

5.2 Improving framework conditions

The new STI policy context has a direct implication for the Korean economy; specifically it raises the need to improve the framework conditions for STI policy. There is a corresponding need to increase the productivity of conventional means of implementing the government’s STI policy. Conventional ways for the government to influence national R&D systems are to choose research areas, to prioritise allocation of funds and to evaluate government policy itself. There is ample room to improve the productivity of government policy in all of these areas.

Further improvements in framework conditions for innovation:

STI policy needs to be more closely linked to other government policies. Two policy areas, among others, are of immediate concern: to develop human resources in S&T and to close market gaps in financing innovation. For the former, it is essential to put in place an education policy for swiftly adapting the university system to changing social and economic needs. Policies for flexibility on the part of employers are also important in mobilising human resources for innovation. (See Box 3 in Section 4.6) Concerning the latter, creating a healthy

financial market environment becomes more and more important in promoting new technology-based firms or engendering venture capital. All these policies and others, such as a policy on competition, which were conventionally not considered to be within the main focus of STI policy, come to have as much influence as direct STI policies. Consequently, closer cooperation between responsible ministries is indispensable for effective STI policy.

In addition, current reforms regarding corporate governance, the competition regime, and openness to foreign investment will have a positive impact on innovation capabilities and incentives in the Korean economy. They should be pursued and complemented in other areas which impinge on innovation performance, such as tax and labour market policies.

Expanding public support for more basic research and SMEs

The appropriate scale of public support for R&D, i.e. the government's R&D budget, is not easy to calculate; yet, as mentioned above, the current scale is much less than is needed. The Korean government has pledged to increase its R&D budget over the coming years. Increasing the R&D budget and making the government's role more proactive are prerequisites for meeting the challenges raised by the KBE. Two undertakings in particular deserve keen attention. First, the government needs to prioritise the areas that most urgently require public support. Two areas are on the priority list: upgrading the indigenous knowledge base, which implies increasing basic research in the universities, and expanding the SME technology base. To accomplish this, the government should initiate a comprehensive analytical study on the priorities for public support. Second, the government should establish clear criteria for evaluating government policies. Among the criteria, system efficiency and additionality should be explicitly noted.

Improving the R&D incentive system: This system is excessively complex and needs to be streamlined, in particular through better coordination among the numerous funding bodies and evaluation. At the minimum, the government's incentive measures should answer the following questions: Do they increase private R&D expenditures beyond what firms would undertake without their support? And, are they superior to alternative policy instruments in achieving the specified goal?

Evaluation of government policy: Presently, mechanisms are too weak to assess the effectiveness of government policy. As a rule, no new measure should be undertaken without prior assessment of its rationale and expected impact on performance. The monitoring mechanism should be strengthened.

Policy Co-ordination: Government policies, particularly R&D programmes, need to be carefully co-ordinated. Without programme level co-ordination, the effectiveness of the newly established NSTC (National S&T Council) is questionable, because there are many possible sources of

duplications in S&T policy measures in Korea (See Table 5.1). Policy efficiency can be greatly increased by answering the following questions: How should areas be chosen? How should research funds be allocated? What are the best evaluation mechanisms?

Table 5.1: Possible Source of Duplications in S&T Policy Measures in Korea

	MOST	MOCIE	MIC
R&D Programme	MOST National R&D Programme (330.2 b. won)	Industrial Technology Program (253.1 b. won)	Information and Telecommunication Technology Programme (405.6 b. won)
Research Centre or R&D Consortium	SRC/ERC (45) RRC (37)	Technopark (6) TIC (6)	Software Centre (6)
Information Service Agency	KORDIC	KINITI	-
R&D Management Agency	KISTEP	ITEP	ITA (Institute of Information Technology Assessment)

Source: Korean Government, 1999.

Respecting and protecting IPR¹³

In order to protect the results of technological development as well as to comply with relevant provisions of the agreement on TRIPs (Trade Related Aspects of Intellectual Property Rights) which went into effect on January 1, 1995, the Korean government has substantially revised intellectual property laws. Nevertheless, Korea has often been regarded as being weak in protecting intellectual property rights. For instance, the IMD (1997) points out that the protectiveness of IPRs in Korea ranked very low in comparison with the high numbers of patent applications and registrations for both natives and foreigners. For more effective implementation of IPR protection regimes, the government needs to make more efforts in the following fields:

Streamlining the administrative structures: Current administrative structures for protecting IPRs need to be streamlined. At present, the Korean Patent Office is in charge of patents, utilities and trademarks; the Ministry of Culture is responsible for copyrights; the MOIC is in charge of computer programmes; plant seeds are registered with Ministry of Agriculture;

Strengthening the examiner's expertise and thereby shortening the examination period: As of 1995, the average period for IPR examination was 36 months in Korea; this is very much longer than other countries such as the US (17 months) and Japan (24 months). The main causes of the delay are large increases in the number of patent applications, and the government officials'

¹³ The bankruptcy of *Hangul & Computer Co.* (HCC) was a valuable lesson for Korea, namely, that knowledge-creating activities cannot be sustained without active respect and protection for intellectual property. Until its bankruptcy in 1998, HCC was the leader in Korea's word-processing software market. Even *Microsoft*, with its aggressive marketing campaign, could not outpace HCC in Korea. One of the reasons HCC went bankrupt was the proliferation of pirated copies of its software. Following HCC's bankruptcy, the Korean public have initiated voluntary campaigns to buy original products, helping to resuscitate *Hangul* software.

inadequate examination expertise. For more effective IPR protection, Korea needs to strengthen examiner expertise and shorten the examination period.

Increasing information service on IPRs: For better use of and access to new knowledge, whether publicly patented or not, the government should increase public information services. Government should make more efforts for more effective documentation and the compilation of a knowledge/data base. The quality of existing institutions for providing information services, such as KINITI, should be upgraded

5.3 Enhancing the indigenous knowledge base

One of the key issues in enhancing the indigenous knowledge base is upgrading university research, which requires substantial efforts aimed at adapting the system of education. Korean universities have grown voluminosly over the recent years: the number of doctoral degrees awarded in science and engineering by Korean universities has increased more than eleven-fold, from 160 in 1980 to 1,920 in 1995. Nevertheless, the quality of research is frequently criticised. Korean universities need to change in order to supply both qualified graduates and a knowledge base. This adaptation should have two primary aims: (i) the creation of Centers of Excellence and (ii) the general upgrading of university capabilities in training R&D personnel, innovation managers and entrepreneurs.

In achieving these aims, the government can and should be a catalyst. First, it is most urgent to increase and redirect public support toward more basic research. Second, government can design a framework within which universities compete and specialise, based on the quality of their research. Finally, the government should consider how to better define role divisions among universities, GRIs and industry, as well as promote closer partnerships.

Promoting Centers of Excellence: Based on transparent reviews (the participation of foreign experts is recommended for this purpose), a small number of universities should be turned into Anglo-Saxon type universities with a strong emphasis on research. KAIST and POSTECH have shown that this can be achieved (See Box 6). These two institutions have demonstrated that with an objective management system, secure public funding and autonomy, Korean universities can be highly competitive research-oriented institutions.

Universities' complementary functions to the KIS: The most direct contribution universities make is to supply qualified graduates to industry. One can refer to the technical school system in some European countries, e.g. the system of *Fachhochschulen* in Austria. Most successful education systems in OECD countries show that university research and training is at the core of

(regional) innovation clusters. For example, Dublin City University in Ireland has been continuously changing its curriculum in response to business needs. Some Korean universities are swiftly moving in this direction (See Box 7).

Science policy for upgrading the knowledge base: The science policy, if any, of most OECD countries is changing to put more emphasis on the technological and industrial applicability of scientific research. Underlying this change is the fact that the domestic science base is well advanced by the high research capabilities of either universities (in the US and UK) or national research centres (France). In contrast, Korea needs to focus more on upgrading its basic science and research base. Korea has already activated some policy measures: for instance, MOST has ERC/SRC/RRC programmes managed by the KOSEF; and the MOE (Ministry of Education) has long supported university research through its Academic Promotion Fund. Nevertheless, it is highly recommended to make further secured public funding available for more basic and long-term research.

Box 6: Can the KAIST and POSTECH models be extended to other universities in Korea?

Korean universities are usually criticized as being more oriented toward general education and weak in research. There are, however, exceptions. In a recent survey on Asia's best science and technology schools¹¹ *Asiaweek*, a weekly magazine based in Hong Kong, ranked the Korea Advanced Institute of Science and Technology (KAIST) and Pohang University of Science and Technology (POSTECH) as first and second, respectively. In sharp contrast to other Korean universities, these two universities are highly research-oriented. KAIST boasts the top record for citations in international journals per teacher in the *Asiaweek* survey, whereas journal articles per faculty member of POSTECH are roughly equivalent to those of America's typical research universities, such as Carnegie-Mellon University.

These two flagship universities in science and technology are relatively young; KAIST was established in 1971 and POSTECH in 1986. In view of their young age, their achievements are particularly outstanding, and may be due to the following factors: First, the goal was clear from the beginning. These are engineering schools, with the aim of producing and supplying the top-notch scientists and engineers required by the Korean economy. In achieving this goal the two schools departed from the traditional Korean university system and recruited faculty for doing top-level research, and they coupled this with an achievement-based promotion system. Second, from their inception, these two schools have secured support and funds; KAIST from the government, (the Ministry of Science and Technology), and POSTECH from the state-owned Pohang steel company, POSCO. As a result, the overall infrastructure for research and education substantially surpasses that of other Korean universities. For instance, POSTECH supplies in-campus housing to all students and faculties. Third, together with the above two

factors, these two institutions have almost full autonomy from the (frequently negative) influence of the Ministry of Education.

Not all Korean universities will be able to transform themselves into research-oriented universities like these two schools. A few universities, however, should be transformed into more research-oriented ones. The lessons from KAIST and POSTECH are straightforward. First, introduce systems for research quality recruitment and promotion. In addition, the current faculty recruitment system of most Korean universities, which recruit only younger professors, should be changed. This means that the higher ranked professorships should also be open to new faculty recruitment. POSTECH is adopting this system. Second, more secure budgetary sources should be sought. Government support should extend to private universities as well as national universities. POSTECH has substantially lowered its budgetary dependence on POSCO, from almost 100 % in the early years to about half in recent years. The POSTECH model indicates that high-quality research universities can attract various funding sources, eventually enabling them to achieve financial independence from the government. Third, universities should have full autonomy. The recent government initiative to liberalize the establishment of universities is a highly welcome measure in this regard.

¹¹ *Asiaweek* also ranks 79 multi-disciplinary universities in Asia. The rankings of the Korean universities are as follows: Seoul N U (3); Yonsei U (9); Korea U (16); Ewha Woman's U (26); Sungkyunkwan U (28); Sogang U (35); Pusan N U (40); Hanyang U (43); Chonnam N U (48); Kyungpook N U (53); Kyung Hee U (55); and Chungnam N U (62).

Box 7: The case of Taegu-Hyosung Catholic University (TCU)

In response to changed socio-economic demands, TCU, an education-oriented four-year multi-disciplinary university in Korea, has made several changes in its university management system. TCU has given top priority to the task of upgrading the research quality of professors. Among other steps, TCU closed the in-campus journals where TCU professors usually published their research results without undergoing an objective referee procedure, and introduced an annual salary system that will be regularly reviewed in terms of research output. The former is intended to increase research quality, and the latter to remunerate quality research. In addition, TCU allows students to have multiple majors, so that students can choose studies to suit their own needs and thereby prepare for industrial demands after graduation. The result is quite successful. TCU was selected as an outstanding university by a recent Ministry of Education Evaluation.

5.4 Redefining the role of GRIs and private sector

As the technological development process becomes more integrated with scientific research, it becomes very hard to clearly delineate the borders among, say, basic research, applied research and experimental development. However, regardless of the research spectrum, there are some R&D areas where business enterprises will be more concerned vis-à-vis other areas, where public interest is strong but the market alone cannot support research. In this regard, a clear division of labour between innovation actors and close cooperation as well is indispensable for the most efficient use of available R&D resources. Korea needs to make more concerted efforts in this regard.

The Private sector R&D system

The need to define the role of Chaebols in R&D: There is a strong need for reorientation of the private sector R&D system, particularly of Chaebols, toward a more specialised and flexible model. Chaebols' R&D should be oriented toward strengthening the core competence of specialised business. As discussed above, the limitations of the excessive internalisation of R&D activities are apparent. Chaebols must make a clearer division of labour in R&D. The trend for increased public/private partnership of R&D in OECD countries demonstrates the importance of clear role divisions and cooperation among innovation actors. Korea already seems to be moving in this direction; following the financial crisis big companies have made painful efforts to restructure their R&D laboratories through merging research labs and reducing the number of researchers. Specialised R&D laboratories are burgeoning in Korea¹⁴. Through industrial and competition policy the government can and should play a more proactive role in this. Furthermore, structural imbalance in the private sector R&D system needs to be corrected¹⁵.

The public research system

In January 1999, the Korean government enacted the *Law for the Establishment, Administration and Promotion of Government-funded Research Institutes* (GRI Law, hereafter). In accordance with this law, various GRIs under each ministry have been transferred and merged into five Research Councils under the Prime Minister's Office. In particular, S&T research institutes have been transferred to the three S&T Research Councils – Fundamental, Industrial and Public.

¹⁴ According to the KITA, during the one-year period of 1998, the number of private research institutes increased by 700, the highest increase ever recorded, and this trend of mushrooming private research institutes is expected to continue. The KITA also notes that this boom is triggered by the government's policy of promoting venture businesses, and given further impetus from the spin-off of laid-off researchers from large companies.

¹⁵ A key policy agenda in renovating the private sector R&D system is the strengthening of SMEs' technological capabilities. The SME issue is related to many policy areas. In this paper, it will be dealt with in the section on cluster-based innovation policy.

The GRI Law and restructuring are aimed at inducing administrative innovation and effective human resource management, and enhancing productivity in research projects. It is too early to assess the effect of this restructuring. Nevertheless, the Korean government should take more fundamental issues seriously.

(1) *Redirecting GRI research-orientation toward more basic and long-term research through secure public funding.* When restructuring GRIs in 1980, the Korean government defined the role of the GRI very clearly; this definition is still valid (See the quotation in Section 3.4 on the NRDP and the role of the GRI). Notable changes have occurred over the years, including rapid increases in both university and private sector research capabilities. Responding to these changes, the government has introduced several minor and major policy measures for GRI renovation; the task is yet to be completed. In order to make restructuring effective, the research orientation of GRIs should also change. This implies that government funding for GRIs should be secure for more basic and long-term research.

(2) *How to position GRIs in relation to other innovation actors:* The current role division of GRIs and other innovation actors overlaps with universities and the private sector. In particular, it seems that the government uses GRIs as agencies for undertaking ministerial R&D programmes. This strategy has serious drawbacks, and its effectiveness is questionable. (This will be discussed separately later.) For instance, GRIs are not performing the role of educating R&D personnel, which is one of the key functions of public research institutions in many European countries. In the longer-term perspective, the government should consider how to integrate GRI research capability with the universities' main function of education.

(3) *Consistent long-term policy design is required:* GRIs are one of the key policy instruments through which government can orchestrate nation-wide innovation activities. Therefore, the government should establish a consistent long-term plan for the position of GRIs in the NIS. Accordingly, the Korean government may consider creating a GRI Realignment Commission, equally composed of representatives from government, industry, the university sector and GRIs. Ideally, the Commission would have an advisory board composed of eminent foreign experts including Korean expatriates. The Commission would be run on long-term basis and would be expected to submit guidelines for designing the configuration of the NIS in general and GRIs in particular. Critical institutional redesign factors include greater autonomy, mission rationalisation, institutionalising co-ordinating mechanisms, and job retraining and relocation programmes for displaced employees.

5.5 More emphasis on diffusion and system linkages

National technology policies across the OECD countries are converging towards two main objectives. First, to fill the gaps where this would yield the highest social return, instead of directing public support according to pre-defined sectoral or political priorities; and, second, to improve linkages among all the actors of the innovation system and provide these actors with market-compatible incentives. In particular, policy measures are shifting from conventional subsidisation to public/private partnerships, through which industrial needs are introduced into even earlier phases of projects and the economic values of R&D activities can be maximised. Even for “mission-oriented” programmes to be effective, there is an increased need for adopting a systemic approach which can provide a framework for a more market-driven and bottom-up definition of objectives, and more decentralised implementation procedures¹⁶. A clear policy implication is: against these backgrounds, there is ample room to improve the performance of the KIS by introducing mechanisms for diffusion and system linkages.

Need to put more emphasis on diffusion of the NRDP: As is shown in the previous section, the effectiveness of diffusing and utilising the R&D results of both mission-oriented and diffusion-oriented Korean NRDP programmes is very low. To increase effectiveness, the government should make more concerted efforts in consultation with all the concerned parties. Accordingly, it is highly desirable to build diffusion mechanisms within the NRDP through public/private partnership. More effective measures for promoting much wider participation of industry and universities, starting with the early phases of project planning and implementation, should be introduced. Spin-off activities of university and GRI researchers should be encouraged in a way that complements the original function of public research institutions. The current system of private enterprises’ participation in the NRDP needs to be re-examined in that the additionality of public funds is questionable. Furthermore, SMEs’ access to public research, which enables much wider diffusion of public R&D results, should be extended.

Who will play the role of bridging institutions and how? In line with putting more emphasis on diffusion of the NRDP, it is very important to institutionalise the diffusion mechanism. There are two ways to do this: to give incentives to existing research institutions in a way that induces these institutions to make more efforts for diffusion, and, to establish intermediary bridging institutions. Korea is already moving in line with the first way. The second option also deserves consideration. For instance, despite its many achievements, Taeduck Science Town as a whole has often been criticised as being weak in industrial linkages. The government could induce GRIs in the Town to make more efforts; or, establish a new specialised Institution at Town.

¹⁶ For more detailed explanations, see OECD, *Technology, Productivity and Job Creation*, 1998.

Intermediary institutions in the private sector: There are various kinds of intermediary institutions which can strengthen the linkage from public and higher-education research to industry. Korea lacks these intermediary institutions. University-industry interface units and technology centers are popular in OECD countries. In order to fully integrate the KIS, these intermediaries should play more important and active roles. The high concentration of private R&D in Chaebols has prevented the development of independent service firms which play a significant role in the diffusion of knowledge in more advanced countries, and allow more efficient outsourcing of technological, management and organisational services. As noted above, the growth of specialised small research labs spun-off from large firms after the financial crisis offers a good opportunity to fill the gap in system linkages in the KIS. The government should assist the growth of these specialised firms, for instance by allowing them access to the public research system and results.

Science-Industry relationships: Government policies promoting basic research should be aiming at enhancing science-industry relationships. These relationships are complementary when universities are able to act as ‘knowledge suppliers’ to industry. Improving these relationships implies removing regulatory obstacles and improving co-ordination between the education policy of the MOE, the S&T policy of MOST and the industrial policy of MOCIE, which should all be highly integrated. Scientific as well as business communities should be jointly involved in the definition of research priorities and their implementation. One of the objectives in this area would be to facilitate the creation and development of research-based spin-offs from the public sector.

Strengthening global linkages: Korea’s scientific and technological activities need to be better integrated with global networks. As of 1998, only three Korean journals are included in the 3,487 journals of the SCI. The government should foster a more internationalised science community in Korea by, for instance, making grants and fellowships available to Korean universities and public research institutes for the employment of capable foreign scholars. Ideally, the government and public research institutes could establish an Advisory Board composed of eminent foreign scholars and Korean expatriates. Until recently, Korea has mostly used licensing contracts as the main way to introduce foreign technologies. Korea should diversify these channels. The government should take advantage of recent inflows of foreign investment to create linkages to domestic R&D activities. The restructuring of Chaebols and the surge of foreign investment provide an opportunity to diversify the sources of knowledge acquisition. The government should facilitate this evolution. The integration of Korea within international innovation networks also requires initiatives in other areas, such as international technology co-operation, namely international business alliances, scholarships, etc.

5.6 Increasing human mobility

Technical progress and the move towards a KBE is increasing the demand for skilled labour and spurring an upgrading of skills across economies. This raises several important policy challenges to governments, one of which is increasing human mobility (See Box 8). The movement of science and technology personnel between sectors, between large and small firms, and across national borders creates important conduits for technology transfer. The government should devise policy initiatives to increase human mobility in the KIS¹⁷.

Integration of GRIs with the University System: Recently the Korean government has allowed GRIs to establish specialised graduate schools. However, these specialised graduate schools are not fully integrated with the university system. If GRIs were affiliated with the university system, the research capabilities of both entities could be combined. Furthermore, complete integration would very naturally solve the problem of one-way movement of Ph.Ds.

Removal of (regulatory) obstacles that impair the two-way mobility of researchers between the public and private sectors. In general, the obstacles to mobility in the labour market for S&T personnel derive from regulations on employment (hiring and firing), pension rules, and wage bargaining arrangements. Regulations such as employment protection legislation can act as barriers to flexibility and mobility. In the public sector, researchers may not be willing to abandon permanent employment for employment in industry, even at a higher wage. Other factors that hinder mobility include age limits for junior faculty or research posts. The government needs to make further efforts toward reducing these obstacles.

More open recruitment is needed in high-level government positions with responsibilities in policy-making and implementation: The current government official recruitment system creates an invisible wall between the government and business. Furthermore, government should encourage much wider participation of business in the NRDP, not only as research partners but also as key players in programme design and evaluation.

Box 8: Government's role in generating highly skilled human resources and their deployment in the private and public sectors

At their ministerial meeting in June 1999, OECD/CSTP (Committee for Science and Technology Policy) Ministers concluded that sufficient personnel mobility and better information flows in the economy are essential to meet the 21st century's needs for highly skilled personnel. One month before the Ministerial meeting, the CSTP held a Workshop on Science and Technology Labour

¹⁷ Currently the mobility of scientists and engineers in the KIS is mostly one-way, from GRIs to universities. The problem has many causes. One of them is that, despite their large pool of researchers and research facilities, until recently GRIs have not performed the function of educating science and technology personnel. In contrast, CNRS, the French public research institution, the objective of which is to complement relatively weak university research, has actively engaged in educating PhD students.

Markets. The workshop responded to a finding by the OECD's 1998 report on *Technology, Productivity and Job Creation: Best Policy Practices*, that technical progress is increasing the demand for skilled labour and spurring an upgrading of skills across economies. The workshop results are published as "Mobilising Human Resources for Innovation". (DSTI/STP/TIP(99)2/FINAL) The workshop covered three themes: changing demand for and supply of science and technology personnel, the mobility of science and technology personnel, and improving the contribution of S&T personnel to scientific discovery, innovation and growth. Several important policy challenges were confirmed through the various experiences of OECD countries: 1) making S&T education and training policies more responsive to changing demands; 2) adapting the science system to new demands; 3) leveraging human resources in S&T to enhance science and industry relationships; and 4) enhancing framework conditions for the business sector to strengthen the contribution of S&T personnel to innovation.

5.7 From sectoral promotion to the cluster approach

The cluster approach has become one of the key policy tools for most OECD countries, as cluster-based innovation and technology policy convey many advantages. At base, the cluster approach links industrial innovation activities more systematically and thereby maximise the value-addition of production activities. At the centre of clusters are knowledge-creating institutions such as universities and research labs, from which private enterprises, in particular SMEs, can most efficiently utilise the knowledge base. The government promotes clusters in several direct and indirect ways. The government's cluster policies are closely interrelated with regional development policies, through which regional imbalances can be reduced (See Box 9). There are several implications for Korea:

Moving from a sectoral to a cluster approach to industrial innovation

Traditionally, the Chaebols have played the role of clustering institutions through subsidiary and subcontracting companies, while government has pursued a sectoral support policy. This division of labour is less and less viable. First, this only resulted in expanding business expansion for Chaebols. Second, the government's sectoral policy does not take into account the value- and technology-chains of production activities. Government should facilitate networking and clustering, especially by: 1) establishing framework conditions through a competition policy; 2) providing appropriate infrastructures and incentives; 3) improving coordination between regional and national policies; 4) acting as a catalyst through its public research policy.

Small and Medium-sized Enterprises

Without technologically agile SMEs, a cluster-based industrial and technology policy and regional innovation policy will not be able to achieve policy goals. But one of the most serious

bottlenecks in the KIS is the lack of technologically agile SMEs. The SME issue is not confined to innovation clusters but is widely and fundamentally related to almost all issues in the NIS. Systemic linkages among innovation actors will be more effective in knowledge diffusion when more SMEs are actively engaged through networking. For example, the flowering of innovative SMEs is generally strongly influenced by the financial market environment, of which an important aspect is the issue of venture capital.

The directions of the government's SME technology policy: In line with streamlining its R&D support system, the government should make a concerted effort to identify what SME need most. First, SMEs in general have a low awareness of the importance of innovation; this is particularly true of smaller enterprises. The government should increase information provision services for SMEs; according to the STEPI report this is very effective in enhancing SME innovativeness. Second, SME policies aimed at raising technological capabilities should be more concerned with enhancing the absorptive capacity of SMEs, through providing qualified R&D personnel and promoting more technology transfer from public research institutions. Third, the government should conduct a comprehensive review of overall support measures and reallocate government funds for maximum effectiveness. In accordance with this comprehensive review and reallocation, the implementation procedure needs to be re-examined. Step-wise supports based on development, as adopted by the US Small Business Innovation Research Programme and Small Business Technology Transfer Programme, are more desirable than an everything-at-once support system.

Expanding SME access to public research: In line with enhancing the absorptive capacity of SMEs, the government should expand SME access to the public research system. It is highly desirable to encourage SME participation in the NRDP, where until now large enterprises have been the main partners. Furthermore, the government needs to facilitate knowledge diffusion through networking, both horizontally - where, for instance, SMEs organize research consortiums with public research institutes, including universities - and vertically, where Chaebols act as main organisers and offer subcontracts to SMEs. The government can use various R&D support measures to encourage this networking.

Venture capital: Recognising the important role of venture capital in creating considerable economic and employment benefits, the Korean government has recently initiated several policy measures. In 1997, the Venture Business Promotion Law was enacted, and financial supports for venture business have been increased substantially over the last two years. These policy initiatives seem greatly contribute to cultivate the environment that risk-taking entrepreneurs mostly need; yet government should pay more keen attention to raise the effectiveness of these policy measures. Additionality of public funding should be taken into account more keenly. "The best public incentives stimulate private sector funding that would otherwise not have

occurred. In such government programmes, government funding is leveraged by private capital. The most desirable government programmes are those that strengthen the private venture capital sector and then, as private markets mature, are phased out. The economic and social benefits of such programmes continue long after the government's direct role has ended.”¹⁸

Box 9: Innovation and Technology Policy: Shifting from the sectoral to the cluster approach

Clusters are networks of interdependent firms, knowledge-producing institutions (universities, research institutes, technology-providing firms), bridging institutions (e.g. providers of technical or consultancy services) and customers, linked in a value-adding production chain. The cluster concept goes beyond that of a network of firms, as it encompasses all forms of knowledge sharing and exchange. The analysis of clusters also goes beyond traditional sectoral analysis, as it must account for the interconnection of firms outside their traditional sectoral boundaries. In several OECD countries, clusters are regarded as drivers of growth and employment. Governments can nurture the development of innovative clusters primarily through regional and local policies and development programmes and by providing appropriate policy frameworks in areas such as education, finance, competition and regulation. Some best practices are:

- *Creating a platform for dialogue between the government and the business sector (the Netherlands);*
- *Focused R&D schemes, innovative public procurement, investment incentives and the creation of “centres of excellence” (Sweden);*
- *Competition for government funding to provide incentives for firm networks to organise themselves on a regional basis (Germany).*

(OECD, *Managing National Innovation Systems*, 1999)

5.8 Toward a participatory innovation system

The regional innovation system in Korea

1) If any, the problem in Korea's regional innovation system and policy is that knowledge-creating institutions are not centred, due either to a weak regional knowledge base (more on this

¹⁸ European Venture Capital Association, “White Paper: Priorities for Private Equity – Realising Europe's Entrepreneurial Potential,” 1998. p. 11. It is questionable whether the recent sudden rise of venture capital in Korea will be sustained in the future. The sudden rise is in part due to the government's promotion policy. The fundamental question is the technological base of venture business. The first oddity lies in the fact that most venture business is concentrated in ICT sectors, whereas, in the U.S. and Europe, venture business and new technology based firms are spread across industries. Second, the Korean peculiarity is closely related to the “KOSDAQ fever”. Investors who are seeking a higher return tend to invest in the bandwagon, which is not grounded on the growth potential of firms in KOSDAQ. Finally, the requirements for joining KOSDAQ seem loose.

below) or to lack of policy coordination. Regional innovation policies are pursued independently by MOCIE (Technopark Programme), MOIC (Software Centre Programme) and MOST (RRC Programme); consequently the universities' role is minor. Policy coordination among MOST, MOCIE and MOE should be strengthened. 2) The location of both public and private research institutions is enormously unbalanced across regions. And, except in a few regional governments such as the Seoul Metropolitan and Kyoung-gi Provincial governments, the budgetary independence of most regional governments is very low. These two hindrances block the further balanced development of regional innovation systems. More concerted efforts are needed.

Decentralisation with empowerment: Conventionally centralised OECD countries are trying to make regional innovation systems more effective by delegating the central or federal government's power to local government, and there is a good deal of concern about not losing policy efficiency during the devolution process. The key issue is how to enhance local government's capabilities in policy planning, and how to streamline the coordination of central or federal government with local government. Decentralisation is considered to be desirable; but it must be accompanied by proper coordination cum empowerment of innovation actors, including local government and universities, in regional innovation systems.

Decentralisation of decision-making: The main actors in the KIS should be more involved in the policy formulation, implementation and evaluation process. In particular, this should facilitate the development of public/private partnerships as tools for implementing S&T and innovation policies.

5.9 Maintaining social cohesion

There is great potential in a KBE for increased social inequality, as rapid technological changes may cause biases toward specific production factors and the worker preparedness is different¹⁹. Furthermore, opening the market and liberalisation will penalize less-competitive industries and workers. Accordingly, maintaining social cohesion becomes an important policy agenda for OECD countries. Korea needs to pay particular attention to two areas (among others):

(Re)training workers: Currently in Korea, there is no significant institutional public programme for the training and re-training of workers. The government needs to establish a comprehensive training-retraining plan to meet the new requirements of the KBE. In collaboration with universities, government can introduce university study courses for workers. Austria utilises a

¹⁹ This is also the case in Korea. During the 1980s, technological change widened the educational wage differential across industries. (Kang-Shik Choi, "Technological change and educational wage differentials in Korea", Economic Growth Center Discussion Paper no. 698, Yale University, 1993.)

system of *Fachhochschulen* in each province for this. Finland has also established a public/private partnership programme to increase government and industry support for professional education. These policy measures exemplify ways of preparing for coming new demands, where the participation of industry will be the key to success. (See Box 10 for a description of a German training system.)

Industrial relations through tripartite consensus: Sound industrial relations are a prerequisite for improving stable productivity. Some European countries have achieved this by closer cooperation among labour, industry and government. In recent years Ireland has been among the lowest countries to lose working days due to workers' strikes. Underlying this is the successful social partnership of labour, industry and government. The tripartite consensus has been accomplished by agreement on wage increases based on economic performance. The Austrian form of social partnership is more fundamental than the Irish one, but these two are both built upon the consensus of concerned parties, and act as the basic social framework for the steady growth of productivity (See Box 11.). Korea's current industrial relations need to determine how to enhance productivity through tripartite concerted efforts; the establishment of an appropriate remuneration system will be key to this.

Box 10: The Training System in Germany

The training system in Germany is one of the key components of the German innovation system, closely linking public and private sectors of the economy. It is generally referred to as the dual system of vocational training (*Das Duale System der Berufsbildung*). The training system is rooted in the tradition of public responsibility to provide employment for all, and industry's uncompromising belief in the preservation of 'on the job training' as a compulsory prerequisite for the mastery of specific vocations. The training system in Germany is highly integrated into the educational system, which is largely in the public domain.

The education system in Germany consists of four broad categories of educational institutions. These are the primary schools, the secondary schools, the tertiary or higher institutions, and the vocational training schools. Tertiary education institutions include universities and polytechnical schools (*Hochschulen*). The universities are generally academic institutions while the polytechnical schools are more practically oriented. Some of the polytechnical schools specialize in particular disciplines such as engineering (*Technische Hochschulen*), teacher training (*Paedagogische Hochschulen*), etc.. The fourth category of educational institutions consists of vocational schools and institutes. Vocational training is organized into occupational areas (e.g. automechanic, electrical installation, welding, etc.) and in most cases lasts for three years. The apprentices spend three days a week in an industrial setting (mostly medium and large enterprises), and two days at the part-time vocational training schools. Where specialized equipment needed for training is not available in certain enterprises,

this equipment are made available at specialized training centers, which are largely publicly financed.

The dual system of apprenticeship has a relatively long history rooted in the traditional practice of the artisan craftsmanship of the pre-industrial revolution. It preserves the age-long axiom of 'on the job' training as the practical route to the mastery of a craft (*a la* skill in modern connotation). The German education system strategically built a theoretical component into the training to give the traditional apprentice the opportunity to acquire the theoretical background that traditional craftsmanship (or modern 'practical know-how') may not provide. The 'on the job' training is carried out in modern industrial enterprises with various chambers of commerce and industry collaborating with the government to ensure that both industrial and social interests are adequately satisfied in the operation of the Dual System. The highest level attainable in vocational training in industry is the certification of *Meister*, which literally means 'master' in the chosen vocation. This underlines the importance of learning where productive activities actually take place, and inculcates the objective of mastery into newly recruited trainees, as *Meister* signifies the ultimate training objective, and guarantees maximum achievable career attainment.

Box 11: Social Partnership in Austria: The Chamber (Kammer) System

The institutional arrangements that form the framework of the social partnership are unique to the Austrian economy. On both sides of the labour market, there exists a parallel set of voluntary organisations (trade unions, industrial associations, etc.) and self-governing incorporated bodies called chambers (Kammer). The chambers are financed mainly through contributions related to the wage bill, and membership is compulsory. The chambers on each side of the labour market are hierarchically organised with two central chambers for, respectively, workers and employers. In addition, farmers have a separate chamber.

The institutional centrepiece of the social partnership is the so-called *Parity Commission* for wage and price issues where, in addition to the central chambers, the Government and the Federation of Trade Unions are also represented. Four sub-committees are responsible for, respectively, the centralised surveillance of sectoral wage agreements, price developments and competition policy, wider issues of social and economic character, and international issues.

Within this set-up, the chambers represent their members *vis-à-vis* the legislative and administrative powers. They have the opportunity to present comments on drafts of government bills and they are also represented in many institutions. As a result, the social partners or, rather, their Chamber representatives, have a decisive influence on many aspects of policy.

Source: OECD, *OECD Economic Surveys: Austria 1997*, p. 128.

6. SUMMARY: TOWARDS A NEW MODEL OF INNOVATION SYSTEM

The challenges presented to the KIS require several fundamental and structural changes. Some are more directly related to particular innovation actors and activities; but some are, directly and indirectly, related to the much wider context of the economic system as a whole. The role of the NIS in a KBE is as the primary producer of knowledge which enables sustained economic growth; however, at the same time, the configuration and constellation of the NIS is conditioned by a much broader socio-economic context. Some of these changes are already underway in Korea, particularly in the wake of the financial crisis. Government, industry and research communities are all making painful efforts to reform. Some of these efforts are very positive, but some need to be more carefully designed.

The status of the KIS is not bad. The KIS has successfully accumulated research capabilities and has made several outstanding achievements. The issue is how to make the system more efficient and effective, and in particular how to strengthen the linkages among institutions and actors participating in the system. As the generator and diffuser of knowledge/technology required for economic development, the efficiency and effectiveness of the KIS critically depends on the linkages and division of labour between innovation actors. The findings are summarised as follows:

First, there are serious weaknesses overall in generating an indigenous knowledge base. The weakness of the indigenous knowledge-generating mechanism will limit the future growth potential of the Korean economy. There are many reasons, but the fundamental problem is, first of all, the weakness of the universities' research capabilities. Without an indigenous knowledge base and strengthened university research, transition to a KBE will be hopeless.

Second, there are imbalances within the private sector. Since the indigenous knowledge base is weak, large companies, notably Chaebols, are trying to heavily internalise R&D activities. This heavy internalisation will face limitations since no single Chaebol can undertake the whole spectrum of technological development. In contrast, SMEs are limited by their size and resource availability and cannot afford the costs of R&D; consequently they tend to be very weak in technological capabilities. There is a strong need for governmental initiatives to recover the balance.

Third, the configuration of the KIS is also problematic. Current role divisions among innovation actors are more compartmentalised than integrated. In particular, the current status of GRIs needs to be redefined. Balanced emphasis should be laid on the role of GRIs both in

contributing to the indigenous knowledge base and in targeting technology development. From a longer-term perspective, Korea should consider options for integrating GRIs with the university system.

Fourth, the linkages between innovation actors are very weak. Public and private research is largely separate. The almost complete absence of intermediary institutions seriously hampers the efficiency of the KIS. Korea can learn from the best practices regarding public-private partnerships in R&D in OECD countries.

Fifth, the government's policy framework should be re-oriented. The basic orientation of the government's R&D programmes should focus more on the diffusion of research results. Although the government's many R&D programmes claim to be diffusion-oriented, results are quite unsatisfactory. It seems that most of the NRDP are very client-oriented: various ministries are undertaking many R&D programmes with separate goals, seemingly to service mainly ministry-affiliated GRIs. The effectiveness of the existing coordination mechanism is questionable. Furthermore, the government's science, technology and innovation policies should have a broader perspective, based on the framework conditions of effective policies.

Sixth, integration with the global knowledge base should be facilitated. The restructuring of Chaebols and the surge of foreign investment provide an opportunity to diversify the sources of knowledge acquisition. The government should facilitate this evolution. The integration of Korea within international innovation networks also requires initiatives in other areas, such as international technology co-operation, including international business alliances, scholarships, and so on.

All of these areas, which were less critical during the catch-up period in the past years, are now main sources of the low productivity of Korean R&D, and are acting as bottlenecks to further development. Old models die hard; and they are blocking the successful transition to a KBE. The implications are quite clear: Korea should break up the old model and create its own new model. There are three key words for the new model: indigenisation, deepening, and integration. Indigenisation requires, among other factors, strengthening the universities' research capabilities. In a KBE, universities are the primary knowledge-generating actor. The current status of Korean universities requires substantial policy initiatives. Deepening the KIS requires the reorientation, first of all, of business strategy. Technological deepening will not be possible as long as rapid market expansion is the main business strategy. In line with the reorientation of business strategy, the government also needs to redirect the basic policy regime toward a more diffusion-oriented regime. And the government should be aware that innovation is couched in a much broader entrepreneurial and societal framework. Global integration requires strengthening of both domestic and international linkages. The current configuration of the KIS is highly

compartmentalised and client-oriented, and requires substantial restructuring. The issue of redefining the role of GRIs lies at the centre of restructuring.

Table 6-1: Transition of the KIS to a KBE

	Catch-up model	New model	Requirements
Univer- sity	<ul style="list-style-type: none"> ○ General education orientation ○ Minor role as knowledge producer 	<ul style="list-style-type: none"> ○ Higher research orientation ○ Primary source of new knowledge - Main producer of <i>both</i> graduates and knowledge 	<ul style="list-style-type: none"> ◇ Adapting the education system ◇ Strengthening research capability
GRI	<ul style="list-style-type: none"> ○ Targeted technology development ○ Whole spectrum of R&D 	<ul style="list-style-type: none"> ○ Higher contribution to knowledge base ○ Clear division of labour between university and industry 	<ul style="list-style-type: none"> ◇ Redefine the role of GRI ◇ Realigning GRI
Industry	<ul style="list-style-type: none"> ○ Rapid market expansion ○ Volume/cost advantage ○ Industrial/technological widening ○ Hierarchical production system 	<ul style="list-style-type: none"> ○ Secure market specialisation ○ Higher value-addition and economic rents via innovation ○ Industrial/technological deepening ○ More horizontal relationships 	<ul style="list-style-type: none"> ◇ New business strategy ◇ Capitalising on R&D resources ◇ Redefine the role of Chaebols ◇ Strengthening SMEs' technological capability
Government	<ul style="list-style-type: none"> ○ Developmental ○ Client-oriented ○ Mission-oriented ○ Sectoral promotion 	<ul style="list-style-type: none"> ○ Catalytic ○ Collaborative ○ Balanced with diffusion ○ Cluster approach 	<ul style="list-style-type: none"> ◇ Defining a new role ◇ Inter-ministerial coordination and partnership with industry ◇ Build diffusion mechanism in government R&D programmes ◇ Improvement in framework conditions
System as a whole	<ul style="list-style-type: none"> ○ Responsive to market and production needs ○ Compartmentalised ○ Centralised ○ Physical capital as main asset ○ Imitative culture 	<ul style="list-style-type: none"> ○ New engine of growth ○ Integrated ○ Participatory ○ Knowledge embodied in human resources as main asset ○ Creative culture 	<ul style="list-style-type: none"> ◇ Building up indigenous knowledge base ◇ Strengthening linkages domestically and internationally ◇ Promoting regional innovation system ◇ Maintaining social cohesion - New industrial relations - Higher emphasis on (re)training ◇ Respecting and protecting intellectual property rights

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