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Technological Capability Building in South Korea: Some Lessons for Pakistan

JAVED A. ANSARI and RAFIQUE A. KHAN

Recent economic upheavals raise important questions about the nature of the transformation that has taken place in the East Asian economics. Are these economics really catching up with the West? Is there growth process sustainable? Or will they suffer the type of systemic disintegration experienced by the East European countries during the 1990s—Paul Krugman (1994) and Young (1994) had demonstrated similarities in the East Asian and East European growth paths some time ago.

Technological upgrading is an important element in the development of a sustainable growth strategy. This paper seeks to describe policies and initiatives taken by the South Korean government to stimulate technological learning during 1960–1990—the decades during which the South Korean economy achieved a "miraculous" transformation. The description relics mainly on Korean sources and is based on our own field research in that country.

Section one describes the technological learning processes and Section Two presents a discussion of the policies that facilitated this learning. Section Three briefly addresses the question: Did this type of technological learning make a contribution towards enhancing the sustainability of Korean development processes? The concluding section briefly reflects on the lessons that seem relevant for Pakistan.

I. ESTIMATING TECHNOLOGICAL LEARNING IN SOUTH KOREA

The South Korean "miracle" may be summarised in one simple statistic. Income per capita has risen from about $90 in 1960 to over $10,000 in 1995 [ROC (1997)].[1] When General Park Chung Hee come to power in the early 1960s, South Korea was one of the world's most backward economies ridden with corruption and

Javed A. Ansari teaches at the College of Business Management, Karachi. Rafique A. Khan teaches in the Department of Economics, University of Karachi.

[1]These values are expressed at current prices exchanges rates.

regarded as virtually ungovernable. Today, South Korea has one of the most diversified manufacturing sectors and manufacturing value added growth has usually been in double figures on a annual basis during most of the last three decades [UNIDO (1997)]. Exports have increased from $40 million in 1962 to over $125 billion in 1995. The export profile has changed dramatically over this period. In the 1960s, South Korea exported textiles, clothing plywood, toys and wigs. In the 1970s, the major exports were steel, ships, construction services, and consumer electronics. By the mid 1980s computers, semi conductor memory chips, electronic switching systems, automobiles and turn key industrial plants had begun to dominate South Korean exports. Today Korean firms are internationally competitive in multi media electronics, high-density televisions, personal communication systems, and nuclear breeders. By 1994 South Korea ranked second in the world in terms of consumer electronics and steel, third in semi conductor memory chips, fifth in chemical fibres and petrochemicals and sixth in iron and steel and automobiles [KDB (1995)]. Such impressive results reflected rapid growth in technological capabilities.

Table 1 presents estimates of machinery and equipment per worker at constant prices for 28 manufacturing sectors in South Korea.[2] Over the 1960–1990 period the real value of capital employed per worker has tripled with the most rapid growth being concentrated in non electrical machinery, electrical machinery, transport equipment, non ferrous metals, fabricated metals and glass producing branches. Differences in the growth of physical capital stock per worker is quite marked between the capital and non capital goods branches—both consumer goods and intermediates lag significantly behind the capital goods sectors. Within these groups, glass, pottery, footwear and beverages have high investment growth rates. Variations in levels of physical investment have led to changes in the structure of industrial production and the share of the capital goods branches (JSIC 381 to 385) in manufacturing value added now exceeds 43 percent [UNIDO (1997)]. It was below 10 percent in 1965.

Physical capacity building during 1963–1990 was accompanied by rapid build up of human capital. The number of R and D performing institutes rose from 87 in 1964 (almost all in the public sector) to over 2000 in 1990—over 80 percent funded by private enterprises. Total R and D expenditure rose from Won 1.2 billion in 1963 to Won 33.5 trillion in 1990 with a private sector share of over 80 percent in that year. During 1960s however, the private sector share of R and D expenditure had been about 15 percent on an annual average basis. Human capability building was thus clearly sponsored by the state at the start of the industrialisation period.

Table 2 reports the distribution of research personnel in South Korea in 1988. Over 60 percent off these were engineers and 41 percent of engineering researchers

[2]Data presented in this section roughly cover the three decades (1960–1990) during which the decisive transformation of the South Korean economy was achieved. Difference in data sources however, does not allow a strict adherence to these terminal dates in all tabulations.

Table 1
Machinery and Equipment Stock per Worker
(in 1985 Constant Thousand Won)

		1963	1970	1980	1990	Index (1963 =100) 1990
1.	Food	1978	1707	3851	9889	500
2.	Beverages	1360	1342	5938	21262	1563
3.	Tobacco	2139	2645	2803	24872	1162
4.	Textiles	2362	2394	5400	12710	538
5.	Apparel	853	511	857	1137	133
6.	Leather	941	1606	3145	4205	447
7.	Footwear	380	804	2986	16141	2373
8.	Wood	2991	1696	2945	4433	148
9.	Furniture	375	400	760	1997	532
10.	Paper	3942	4250	7027	14506	368
11.	Publishing	2149	2110	4927	7133	332
12.	Ind. Chem.	30688	17340	19204	59378	193
13.	Other Chem.	1005	1437	4886	13147	1308
14.	Petrol Ref.	–	21937	80375	53268	242
15.	Petro and Coal	911	1825	3613	9588	1050
16.	Rubber	1303	1485	2692	2997	230
17.	Plastic	7789	2034	3452	5772	74
18.	Pottery	143	239	1668	4319	3020
19.	Glass	162	218	4792	8783	5421
20.	Non-Metal Min.	7839	6298	12220	33867	432
21.	Iron and Steel	5880	6644	28665	61688	1049
22.	Non-Ferr.	3679	5791	12719	19091	5189
23.	Fabricated Metal	1421	1377	4128	5874	4133
24.	Machinery	1706	2618	10000	15371	9009
25.	Elect. Mach.	2100	1648	52167	12417	5784
26.	Transport Eqpt.	2645	3356	9699	17994	6803
27.	Professional Eqpt.	1779	1036	1243	387	22
28.	Other	840	350	1726	3040	362
	Total	3916	3499	7525	12132	310

Source: Hark K. Pyo *A Synthetic Estimate of the National Wealth of Korea 1953–1990* KDI Working Paper No. 9212 Seoul 1992 and UNIDO data base.

Table 2

Researchers By Field of Science and Degree in South Korea, 1990

Field of Science	Total	Doctor	Master	Bachelor	Others
Total	56545	13419	17374	24240	1512
Natural Science	8665	3691	2664	2277	33
Mathematics	1157	621	341	193	2
Physics	1584	708	454	410	2
Chemistry	3004	1004	834	1153	13
Earth Space	445	236	126	81	0
Biology	1371	732	375	259	5
Others	1104	389	528	181	11
Engineering	34153	4432	9545	19150	1026
Machine, Ship and Airplane	8876	748	1970	5783	375
Materials	2660	596	819	1217	28
Electricity and Electronics	11993	990	3381	7232	390
Chemical	4208	632	1035	2469	81
Food and Genetic	1518	325	483	695	15
Textile	667	116	179	353	25
Atom	300	94	129	77	0
Natural Resources	196	80	58	55	3
Construction	2144	558	833	692	61
Others	1591	293	664	586	48
Medical, Pharmaceutical	6673	3342	2308	978	45
Medical	4574	2814	1270	489	1
Pharmaceutical	1020	367	288	364	1
Health and Nurse	888	123	667	79	19
Others	191	38	83	46	24
Agricultural, Forestry, Fishery	4415	1576	1487	1161	191
Agriculture and Forest	3861	1450	1293	983	135
Agricultural and Forest	3000	1101	1050	728	121
Animal and Dairy	599	228	160	200	11
Others	262	121	83	55	3
Fishery and Ocean	554	126	194	178	56
Others	2639	378	1370	674	217

Source: Ministry of Science and Technology and Korea Industrial Research Institute, *Major Indicators of Industrial Technology*. Seoul August (1990), p.131.

held post graduate degrees. Personnel involved in natural sciences represented 15 percent of the total, almost three quarters of these held post graduate degrees. The number of mathematics and physics specialists was hover low, about 5 percent of the total number of researchers. This illustrates the relative neglect of research and the strong emphasis placed on technology adoption and application.

This bias towards adoption and learning rather than creation and innovation is also evident in figures produced by the Ministry of Trade and the Ministry of Science and Technology on patents and technology imports during 1963 to 1990. The value of capital goods imported has risen from $172 million in 1966 to $25.5 billion in 1990. Patents granted within South Korea have grown at a much more modest rate from about 390 in 1969 to a little over 7500 in 1990. Moreover, even in 1990, Korea nationals received only about 30 percent of the patent approvals [Kim (1995)]. It is thus not innovation but "reverse" engineering which has been the main channel for technological upgrading in South Korea.[3]

But developing technological adoption capabilities has required a repaid growth of human skills. Investment in human skills as measured by educational and training expenditure by households and the government exceeded physical investment by 48 percent in 1969— i.e. at an early stage of the industrialisation process [Chang (1997)]. This compares with a human to physical investment ratio of only 43.5 percent in the United States in 1929 [Schlitz (1972)]. As Table 3 shows the share of junior and full college graduates in South Korean industry rose from 5 percent in 1973 to 15.8 percent in 1992. The share of unskilled workers fell from 44 percent to 7 percent during this period. The share of college graduates in South Korean adult population has increased from 5.4 percent in 1980 to 12 percent in 1990 and is expected to approach 20 percent by 2000 [Park (1988)]—one of the highest ratios in the world. Over the period 1965–1985 there was persistent excess of the supply of college graduates, relative to demand yet during the 1970s and 1980s the average wages of collage graduates (at entry level) were usually more than double that of high school graduates [Kim (1990)]. In 1960, engineering and natural science entrants in tertiary institutions accounted for 27.8 percent of the total student in take. By 1990 this ratio had risen to 39.2 percent [Lim (1995)].[4]

[3]In South Korea this has taken the form of obtaining un-packaged technology components from many sources and assembling mainly in technology packages owned by large manufacturing firms (the chaebels) to suit local requirements.

[4]Separate figures on management specialists are not available. These are included in the social science category in the data prepared by the ministry of education.

Table 3

Proportion of Educated Workers Acquiring Employment in South Korea, 1977–1993

	Whole Industry	Elementary School Graduates	Middle School Graduates	High School Graduates	Junior College Graduates	College Graduates
1973	100	44	35	16	0.9	4.1
1974	100	41	36	18	1.1	4.3
1975	100	36	40	19	1.1	4.4
1976	100	32	42	19	1.2	5.2
1977	100	30	40	22	1.3	5.9
1978	100	28.1	42.7	22.1	1.3	5.7
1980	100	22.6	46.4	23.0	1.7	6.0
1981	100	18.8	45.1	26.5	1.9	7.6
1982	100	16.9	44.4	31.1	2.5	5.0
1983	100	13.5	44.4	34.1	2.8	5.1
1984	100	12.2	43.3	37.1	2.8	4.5
1985	100	10.7	42	39.5	2.9	5.0
1986	100	8.9	37.2	35.4	3.2	5.2
1987	100	8.5	34.4	47.6	3.6	5.7
1988	100	7.3	32.3	50.1	3.9	6.3
1989	100	7.2	28.3	50.9	4.8	8.7
1990	100	7.6	25.4	52.7	5.5	8.6
1991	100	7.6	22.2	53.9	6.4	9.6
1992	100	7.2	20.5	56.3	6.3	9.5

Source: Korea Statistical Yearbook (annual 1977–1993).

Heavy investment in physical and human capital has been accompanied by growth in total productivity. Lim (1995) estimates total factor productivity growth rates for 19 manufacturing branches for the period 1960 – 1985 (divided into four sub periods). Total factor productivity grew at an annual average rate of 5.8 percent per annum during the entire period (an impressive rate of growth but significantly lower than the rate of growth of the physical and human capital stock). TPF growth was highest during 1966 – 1970 averaging 15.3 percent per annum. TPF growth has averaged about 5 percent during 1975–1985 and was negative during 1970–1975 when South Korea was severely affected by the oil crises. It is interesting to note that there is no systematic association between physical investment growth and the growth of TPF across industries. Spearman's rank correlation coefficient for industrial branches ranked according to physical capital growth on the one hand and TPF growth on the other is only 0.41 in 1985. Intermediate and consumer goods branches such as chemicals, rubber, furniture, tobacco and printing which had low physical investment growth had relatively high TPF growth during 1965–1985. Moreover, Lim's evidence shows a decline in TPF growth in several capital goods branches during 1980–1985 compared to the earlier five year periods. Branches experiencing TPF growth decline include metal products, electrical and non electrical machinery and transport equipment. On the other hand, consumer branches such as leather, wood, furniture, paper and printing have experienced strong TPF growth during 1970–1985.

Kim and Cho (1989) have presented estimates of R and D “Capital stock” in South Korean manufacturing during 1977-1986. This was estimated on the basis of expenditure on machinery and equipment, rates and land service charges and payments of research personnel. They show that:

1. During the 10-year period, the total R and D capital stock in the manufacturing sector grew over 5 fold (or approximately at an annual average growth rate of 17.5 percent). The growth rate for machinery and equipment sectors (ISIC 38) dominated with an 8-fold increase and also in terms of absolute volume. The chemicals and plastics sector followed in terms of growth rate and absolute amount.
2. Domestic R and D expenditure exceeded spending on technology imports by a factor of 2. This seems to suggest that although the core technology unavailable at home has been imported, efforts were made to minimise imported content of the total technology package. Domestic R and D efforts supplemented technology import s as much as possible. The proportion of domestic R and D shows even a greater dominance in the traditional sectors such as the food-processing sector, with 90 percent in 1986 and the textile and clothing sector with 83.7 percent. Presumably, the latter sectors seem to have achieved technological capabilities close to the best practice abroad by the end of the period.

The overall picture that emerges shows:

1. Capability building took place at an unusually rapid rate in South Korea in terms of both physical and human capital. Physical capital growth was mainly concentrated in the non-intermediate heavy industries. R and D expenditure also grew rapidly and was increasingly financed by large private sector conglomerates moving into the capital goods branches.
2. Human capital growth probably outpaced the growth of physical capital. South Korea began her industrialisation era with a high ratio of human to capital expenditure and human skills were continuously upgraded so that the level of skills in industrial employment rose continuously during the period. Demand of skilled labour also grew rapidly and graduate unemployment had effectively been eliminated by 1985.
3. Technology capability building in South Korea has been achieved primarily by the growth of the physical and human capital stock. The rate of total factor productivity growth has been significantly lower than that of

the stock of (physical and human) capital stock. There is no evidence that manufacturing branches in which investment growth has been concentrated have enjoyed above average TPF growth. Nor is there evidence of across the board TPF growth acceleration during the 1980s.

4. While R and D expenditure and technological accumulation, remains high technological dependence on imports has been reduced mainly in the consumer goods branches. In the capital goods branches technological import as a proportion of R and D capital stock have not declined significantly. Indeed Kim and Cho (1989) show that the ratio of imported technology to R and D stock rose in the Machine and Equipment branch (ISIC 38) from 24 percent in 1977 to 33 percent in 1986. This suggest that domestic substitution of technological imports has become increasing difficulty over the years.

II. GOVERNMENT POLICIES FOR CAPACITY BUILDING

The South Korean government has sought to enhance technological capacity building by influencing both demand and supply related factors. Demand side policy creates market needs for technological upgrading. Major instruments used for this purpose were (a) export policy and (b) imposed crises on the corporate sector.

Export policy centred on the annual setting of very ambitious export targets at a branch and firm level. Firms had to constantly undergo a life and death struggle to regularly meet these targets and the acquisition of efficient technologies became necessary for firm survival. Exporters had to make large lump sum investments for capacity building far more than local market size. Exploiting economies of scale and scope was thus structured into the investment strategies of Korean firms which were focussed on expending shares in international markets. Korean firms also had to build close relationship with international buyer groups. Marketing of Korean manufacture products was effectively monopolised by foreign buyer groups, which developed a stake in Korean export successes. These foreign buyer groups provided invaluable help to Koran firms in acquiring technological capabilities through interactive tutorial processes and allowed Korean firms to focus their efforts primarily on acquiring productive capability [Chio (1994)]. The buyer groups had however a relatively short time horizon and did not encourage innovation and basic research in South Korea.

Early on in the industrialisation process the government recognised the need to encourage the growth of large industrial conglomerates the famous *chaebols* many of which owe their existence to acquiring on very favourable terms Japanese property seized by the Korean government in the late 1940s. Many *chaebols* have now developed into multinationals and they have played a crucial role in technology acquisition and upgrading. Up to the late 1970s the *chaebols* remained heavily dependent on Japanese SMEs for components production specially in the electronics and automobile branches but since 1979 the government began actively promoting technology based Korean SMEs. These efforts have however not been particularly successful and the Korean SME sector lags significantly behind those of Taiwan and Japan. Process innovation has been seriously hampered by this lack of depth in the Korean industrial sector.

Deliberate crisis imposition on the corporate sector has not remained confined to the setting of export targets. A crises was imposed on the corporate sector when $ 12.7 billion were invested during 1973 –1979 for the creation of heavy and chemical industries (HCI) primarily for the purpose of creating a self-reliant national defence capability.[5] The steel, petrochemical, heavy machinery, shipbuilding, industrial electronics and non ferrous metals industries were built up on a crash programme and by the late 1990s most of these industries had matured and showed significant improvements in EPRs and comparative cost indices [Lee (1997)] enabling Korean firms to make a breakthrough in many technology intensive international markets.

The rapid growth of HCI created crises of technological learning for the *chaebols*. Lacking capability initially they had to rapidly upgrade technology assimilation capacity in the areas of plant construction and commissioning. Technological learning became essential for survival. The automobile industry was forced by the government to shift rapidly from knocked down assembly of foreign cars to the development of totally locally designed cars. [Kim (1998).]

In the electronics industry, the Korean government released an ambitious Long-term Electronic Industry Promotion Plan. The government was determined to promote the industry as a leading exporter. In 1969, when the industry was still exporting at the level of a mere $ 42 million, the government set the goal for exports at $ 400 million for 1976 (the last year of the Plant). The government's export drive not only set specific export goals and directives that forced local firms to be competitive in both price and quality in the international markets, it also provided incentives that compelled local firms to acquire technological capability quickly. In 1976, exports exceeded $ 1 billion, indicating the rapid learning in production and product design that the industry accomplished.

Overall it took only fifteen years for the ratio of value added in light industries over HCVIs to fall from four one in Korea; whereas, the same shift took twenty-five years in Japan and fifty years in the U.S. [Watnabe (1985)]. This rapid growth of technological capability was also sustained by several supply side measures and policies. The share of education in the budget rose from 2.5 percent in 1951 to over 17 percent by 1966. Government expenditures, however, accounted for only one-third of the total expenditures in education, the remainder being borne by the private sector, reflecting the high commitment for education within Korean society. Out of eight industrialised countries and two NICs, this commitment was the strongest in

[5]The South Korean government became acutely conscious of the need for this in the wake of American military defeats in Cambodia, Laos and Vietnam during 1968–1975.

Korea [Porter (1990)]. Enrolment at the various levels of the formal education system increased rapidly from 1953 and reached the level of the advanced counties by 1980. As a result, the illiteracy rate dropped from 78 percent in 1945 to 27.9 percent by 1960, to 10.6 percent by 1970 and to an insignificant level by 1980 [McGuin (1980)].

South Korea suffered from a very serious problem of brain drain during the 1950s and 1960s. As of 1967, 96.7 percent of Korean scientists and 87.7 percent of engineers educated abroad remained there, mainly in the U.S., compared with the corresponding comparisons of 35 and 30.2 percent for all counties [Kim (1997)], they, however, became important sources of an overseas technical network and a high calibre manpower pool for Korea's subsequent development.

The first systematic government efforts to repatriate Korean scientists and engineers from abroad began in 1966 when the government established the Korean Institute of Science and Technology (KIST) as the first government research institute (GRI). The nature of state involvement was "directive" rather than "promotional" in orientation. The government vigorously pursued the repatriation of experienced scientists and engineers with a highly attractive compensation package, a significant departure from the administrative culture of Korea where the literate-bureaucrats historically exerted power over technicians [Yoon (1992)]. The state-led repatriation programme was quite successful, as few returnees went back to advanced countries. The programme also served as a model for the private sector.[6]

Throughout the period, the government actively discouraged the use of foreign licensing and foreign direct investment as means for technology acquisition. It forced firms to acquire unpakged technology from several sources and assimilate it in local production processes [Kim (1985)]. This allowed Korean firms to maintain management and technological independence of individual multinationals at least during the early stages of industrial development.[7]

Technological upgrading has been facilitated by the proliferation and later amalgamation of government research institutes (GREs).[8] The government has made these institutes the major instruments in various National R and D programmes. The most ambitious national R and D programme was the Highly Advanced National (HAN) R and D project, also known as the G-7 project, which was aimed at lifting Korea's technological capability to the level of the G-7 countries by the year 2020. The main concern of the government has been to enhance research and technology

[6]As noted above graduate over supply was eliminated only to the mid 1980s.

[7]Tight control of FDI is reflected in the fact that Korea's stock of FDI in 1983 was only 7 percent of that in Brazil, 23 percent of that in Singapore, and less than a half of that in Taiwan, and Hong Kong. The proportion of FDI to total external borrowing was only 6.1 percent in Korea compared with 91.9 percent in Singapore, 45 percent in Taiwan, and 21.8 percent in Brazil [KEB (1987)]. FDI's contribution to the growth of GNP in Korea in the 1972–1980 period amounted only to 1.3 percent, while its contribution to total and manufacturing value added was only 1.1 percent and 4.8 percent respectively in 1971 and 4.5 percent and 14.2 percent, respectively, in 1980 [Cha (1983)].

[8]South Korean universities are mainly teaching bodies and not research oriented.

development by the chaebols and generous incentives and preferential financing[9] has been provided for this purpose. The private sector's share in national R and D expenditure has gone up from 2 percent in 1963 to 81 percent by 1995. Total R and D expenditure is now about 3 percent of South Korea's GNP [Kim (1997)].

The rapid speed of technological accumulation seems consistent with the dominant themes of industrialisation policies during the past three decades. First, "the growth first" objective, coupled with the goal of achieving competitiveness in international markets, compelled private enterprises to learn to develop new products, new production processes etc. the government encouraged them to import "state of the art" technologies rather than second-hand, labour intensive, "appropriate" technologies, and also to reach the maximum engineering-determined output capacity in the shortest time of learning and mastering rather than maximising short run profit. This strategy was applied to all investment projects launched under the Heavy and Chemical Industry Development Programme during the 1970s. This strategy stems from the logic of "learning by doing by imitating, by training" rather than from the logic of achieving the static, allocative equilibrium paradigm.[10] But the emphases on rapid output expansion inevitably led to a downgrading of process innovation and basic research.[11]

Second, besides the encouragement provided by various forms of incentive schemes, the fierce competition among *chaebol* groups, must be noted. This competitive nature created a rivalry for technological progress. Broadly speaking, Korean *chaebols* imitated the behaviour of Zaibatsus in Japan. It cannot be over-emphasised that competition has been a critical driving force for rapid growth, based on learning of new technology in Korea.

Policy initiatives thus played an important role in technological upgrading in South Korea. The government has used institutional, trade, fiscal, credit and capacity building measures carefully targeted at national champion firms which have been induced and enabled gradually to take over the government's technology building role.[12] But has the technological accumulation that occurred been sufficient to ensure the sustainability of Korea's development process?

III. THE ISSUE OF SUSTAINABILITY

The recent upheavals in the East Asian currency and capital markets have shown that South Korea too is vulnerable to international shocks. In terms of GDP growth, South Korea's performance was superior to most other East Asian countries

[9]Preferential financing amounted to W. 671.6 billion in 1987 accounting for 94.3 percent of total cooperate R and D financing funded by the government. In contrast, direct R and D subsidies by the government accounted for only 4 percent of the total R and D expenditure and direct investment through venture capital firms accounted for 1.7 percent. The impact of concessional financing, however, may be overstated. With rates on preferential loans ranging between 6.5 percent and 15 percent, they conferred little advantage over financing available in the international market [KITA (1994)].

[10]During the same period net capital stock grew by about 3 times.

[11]Sec Kim (1998).

[12]As noted above private investments are financing over 80 percent of R and D expenditure in South Korea.

during the 1970s and 1980s except China. In 1990–96, Korea ranked behind China and Hong Kong in terms of annual average rates of GDP growth. In terms of export performance South Korea lead during the 1960s and 1970s and was second only to Hong Kong in the 1980s. In 1990–1996 South Korean exports grew at an annual average rate of over 11 percent but China, Hong Kong and Singapore enjoyed significantly higher export growth. (UNIDO data based).

South Korea grew at the rate of 6.8 percent during 1996 and was then expected to register 6 percent GDP growth rate during 1997. Inflation during 1997 ran at about 3 percent and international reserves were stable at $34 billion during most of 1996 and 1997 [FER (1997)]. The South Korean economy was the 11th largest economy in the world in terms of GDP in 1995 and the country was the 12th largest trader [World Bank (1997)].[13] Exports have grown by 6 percent during 1996–1997 and the current account deficit to GDP ratio was below 3 percent.[14] The debt servicing to GDP ratio was estimated at about 5.3 percent in mid 1997.[15] South Korean fundamentals thus looked sound from a medium term perspective in early 1997.

Nevertheless South Korea has been seriously affected by the financial crisis in East and South East Asia. The trade GDP ratio stands at over sixty percent reflecting a high degree of exposure to international shocks [World Bank (1997)]. As in East Europe the experience with policy, liberalisation has been unsavoury leading to increased financial vulnerability. A series of corporate failures during 1996 and 1997 created severe problems for the banking sector. Foreign portfolio investors who during 1997 accounted for about 10 percent of shares on the Seoul Stock Exchange are estimated to have withdrawn over a billion dollars during the second half of 1997. The won depreciated by about 50 percent during 1996–97.[16] Major industrial conglomerates were heavily leveraged and the corporate sector had to service between $60 to $70 billion worth of external debt every year. The collapse of major chaebol groups have created bad debts of between 25 to 30 trillion won for the Korean banks.[17] External borrowing has become extremely expensive and credit ratings of major Korean financial institutions and debt instruments have been downgraded.[18] Domestic interest rates have gone up as have bank portfolio infection

[13]These rankings are likely to have been significantly affected by the major devaluation of the Won during 1997.

[14]As compared to 4.6 percent at end 1996.

[15]Again this might be an under-estimate due to the rapid devaluation of the Won.

[16]The fixed exchange regime was abandoned in 1990 and a managed float introduced. The foreign exchange market was still controlled in 1997. All onshore trading of the Won had to be backed by real economic transactions like settlements of import bills, and offshore trading was effectively nonexistent.

[17]Major Chaebol groups which have gone bankrupt in 1997 including Hambo, Sammi, Jinro, Dianong, Sacngbongwood, Kia, Tael Media and New Cor.

[18]To hold Korea Development Banks' global bonds, which have the same credit rating as Korean government debt, New York traders were in late 1997 demanding US. Treaty yields, plus 350 points (3.5 percentage points) or more, treating them basically as junk bonds. And Exim Bank in 1997 shelved a $350 million Eurobond issue when investors demanded Libor (the London interbank offered rate) plus 250 basis points. The inflated spreads reflect an "Asia premium" on top of a "Korea premium".

ratios.[19]

Several authors have over the years identified an important weakness of South Korean industrial structure. Manufactured sector growth in South Korea—as in the other Asian tiger economics—has been primarily a consequence of factor accumulation—rise in labour participation, improvement in educational levels and rapid physical accumulation of capital stock. Total factor productivity growth has been surprisingly low. According to Young's (1994) estimates annual total factor productivity growth during 1960–85 averaged 1.4 percent for South Korea.[20] Lau and Kim (1992) using a significantly more sophisticated econometric model found that productivity growth in the East Asian economies, including South Korea during 1968–1986 was not significantly different from zero. Young's own subsequent econometric work using primary data sources and much more rigorous procedures produced total factor productivity growth rates of 1.6 percent per annum for South Korean manufacturing during 1966–1980 [Young (1994b)]. Labour productivity growth has been significantly higher in South Korea than in other developing countries[21]—but this is not due to increase in labour efficiency but to an increase in the physical capital to labour ratio. This has been made possible by very heavy borrowing of Korean *chaebols* from international markets.[22]

High international indebtedness (particularly of the corporate sector) and low total factor productivity growth are two important structural weaknesses of South Korean industry. This has led Krugman (1994) to stress the similarities between East European and East Asian industrialisation processes in a much-quoted paper. Krugman's main argument is that growth based on expansion of inputs (rather than growth in output per unit of input) is unsustainable in the long run—there are insurmountable upper limits to increases in investment to GDP ratios, labour participation rates and in the share of highly qualified employees in the total labour

[19]Authors' interviews in May 1997.

[20]Young's (1994) estimates of total factor productivity growth rare crude. He uses data for 118 countries provided by Summers and Heston (1990) cumulating investment flows for ten years (1960–1969). Using a 6 percent depreciation rate provides a benchmark capital stock for each economy in 1970; which can then be extended to 1985 using the investment date for 1970–1985. Using the Summers and Heston data on output and number of workers then allows for a cross-sectional regression of the growth of output per worker (1970–1985) on a constant and the growth of capital per worker (1970–1985).

$$Qi – Li = –0.2140.45\ (Ki – Li) + Ei$$

Where *Ei*, the residual for each economy, represents a measure of the growth of total factor productivity (over and above the world average) in that economy. Clearly, this procedure is fraught with error. In particular, since technical change induces capital accumulation the coefficient on capital per worker will tend to overstate the elasticity of output with respect to capital input. Recall that Lim (1985) estimated an annual average TPF growth rate of 5.8 percent for Korean manufacturing during 1960–1985.

[21]Labour productivity measured in terms of output per worker in the manufacturing sector grew at the rate of 7.3 percent annum in South Korea during 1970–90, as against a corresponding rate of growth of 4.1 percent in Taiwan 2.8 percent in Singapore, 5 percent in Thailand and 2.6 percent in India [Young (1994a) Table 4].

[22]As noted above corporate debt now exceeds $60 million.

force—the Soviet Union reached these limits in the mid 1960s, South Korea may be reaching them now. On the other hand, in countries such as China and the United States where productivity growth (and not increase in inputs) is the main source of output growth these limits are irrelevant. Growth is self-sustaining in the sense that limits to efficiency growth are as yet undiscovered. Moreover environmental constraints are likely to be more significant in the case of input sourced growth—productivity led growth is often of a physical resource conserving character.

It would of course be unrealistic to make a direct comparison between the experience of East Europe and East Asian countries Lau (1992), find no apparent convergence between the technologies employed in East Asia and in the West. This data relates however to an earlier period and since then (1985) Korean technological capabilities may have significantly increased as evidenced by the changing commodity composition of its exports. Lee (1997) has produced estimates of changes in effective protection rates and in comparative cost indices[23] for 23 manufacturing sectors over the period 1970 to 1990 and shows that all high technology manufacturing branches with the sole exception of transport equipment had matured or were tending to maturity during this period and were becoming internationally competitive.[24] This does not imply of course that the technological dependence of these branches on imports had been reduced.

This is not the place to review the extensive literature on the relative effectiveness of industrial policies produced in Korea in the wake of the World Bank's "miracle" report (1993)[25] since its focus is on macroeconomic impact and competitiveness and not on technological learning. The Heavy and Chemical Industry (HCI) development initiative in response to the 1973 crisis is regarded by most Korean economic analysts as decisive in achieving technological transformation[26] reflected in a major shift in the composition of Korea's manufactured exports. Will the government be able to take a similar initiative to reverse policy liberalisation and achieve technological upgrading through creating another "crisis of learning" at the level of the firm? Or has "globalisation" in the words of Dani Rodrik "gone too far" and the South Korean state like the Russian

[23]Defined as

$$Ci(t) = (1 + ERPi(t))/(1 + ERPa(t))$$

Where

Ci(t) = comparative cost index of industry *i* at year *t*,
$ERPi$(t) = effective rate of protection for industry *i* at year *t*,
$ERPa$(t) = effective rate of protection for the whole (traded goods) industry.
I = 1,2,-,-,-,29 (industrial branches).

Ci(*t*) measure the relative departure of value added in domestic market prices from value added in world market prices between an industry and the whole (traded goods) sector. The smaller *Ci*(*t*) is, the stronger the comparative advantage, and if larger than one, there is comparative disadvantage.

[24]See also Lee (1996).

[25]For a good review see Kwon (1994) and Wade (1995).

[26]See e.g. Kim (1998) Kim (1995).

Federation—and the USSR under Gorbachev—now become subservient to international capital? If that is, the case Korea's permanent relegation from the first division of world industrial powers cannot be ruled out.

The policy capability of the state is measured by its ability to tax capital. In an incisive analysis Rodrik (1997) has shown that an increase in openness (which Rodrik measures by a proxy for the cost of moving capital abroad L) makes capital more responsive to changes in international prices and correspondingly magnifies macro economic fluctuations at home. Increased openness reflects a fall in the cost of moving capital abroad—a declining. L Past a certain threshold, value of L the government loses its ability to effectively tax capital. When this happens the fiscal and monetary policies of the concerned country may no longer be regarded as autonomously determined—they are endogenised within the systems that generate "globalised" factor and product prices. In the World Bank's favoured phrase, the economic policies of such a country are effectively "locked in".

It is clear that the December 1997 agreement with the IMF has committed Korea to increasing capital mobility (reducing L) but has the critical L threshold been reached and the Korean State effectively subordinated to international financial markets? If this is the case—and there are some pointers in this direction[27]—one may expect a slowing down of the growth of technological learning. This will be an effect of (a) a switch of investment from high to low technology intensive branches in which Korea has a higher comparative advantage (b) an abandonment of long term ambitious investments by the chaebols (c) reduction in government spending and (d) a dismantling of the sector and firm specific incentives and policy initiatives which sustained technological learning in the past.

While the unfolding of such a scenario is not inevitable it seems increasingly likely. What are the lessons to be learnt from these episodes by developing countries?

IV. LESSONS FOR PAKISTAN

In March 1998, an important study on *Building Pakistan's Technological Competence* was prepared for the Pakistan 2010, long term perspective project. The study discussed South Korea's technological development in some detail with a view to assessing its relevance for Pakistan.

The analysis of the Korean case (P 18-21.34) does not discuss the limitation of the Korean technology strategy—it regards it as an unqualified success. This is attributed to.

[27]The autonomy of the South Korea State had been underwritten by its military alliance with the United States since 1953. Today relations are increasingly strained as the US peruses a dialogue with North Korea and seeks to use trade measures to restrict South Korean exports to American markets. The tolerance America displayed for Korean state interventionist policies my well now be a thing of the post see Cha (1997).

i. Creating large trading companies at an early stage of development.
ii. Targeting key lists of imported components for domestic production.
iii. Application of strict licensing tax and credit polices.
iv. Maintenance of close liaison between the public and private sectors.
v. Promoting industrial concentration in high technology sectors.
vi. Implementation of large national projects.
vii. Reliance on multinationals for technology imports.

According to the Report "the government has maintained its ability to guide the private sector by successfully operating its own research labs" (p. 34). The success of this strategy is reflected in the assessment of the report to the effect that "this powerhouse economy (of) East Asian show(ed) that the catching up process (with the West) can be more rapid than anyone imagined (p. 11).

But in its policy recommendations for Pakistan almost all these features of the Korean experience are ignored. Instead the focus is on market orientation. Suggested implementation mechanisms are specifically designed to by pass the existing bureaucracy (p. 1). The proposed cluster councils are to be dominated by the private sector and are to account for a larger and larger proportion of the national technology budget (p. 2). Pakistani firms are to become more sophisticated consumers of internationally available technologies. Pakistani firms and research institutes cannot afford the "luxury of basic research (for) science does not create wealth. It occurs far from market forces" (p. 5). Technology acquisition must be market driven.

The report rejects the standard dictionary definition of innovation which is "to bring in new methods and ideas" It restricts "innovation" to the "successful application of technology the opening absorbing and diffusion of technology by an organisation" (p. 5) International technology is seen as "footloose" (p. 7) and Pakistani firms should be part of the international procurement system. Market incentives should not be displaced by government directives (p. 10) MNC subsidiaries are seen as important sources for technology development and university based centres of excellence should be linked to MNC subsidiaries.

The report does not recognise the deceleration of world out put and trade growth during the 1990s. [UNIDO (1997)] (it says "world trade has attained new heights") (p. 15) nor the slowdown in technology transfer created by the implementation of TRIPS and TRIMS. It advocates rapid compliance with TRIPS and other WTO regulation (p. 101). It advocates an incrementalist approach towards technologies upgrading and explicitly rejects a "big push" approach and the undertaking of large national projects (p. 114). There is in this perspective certainly no room for genuine technological innovation (defined as the development of new methods and techniques) Pakistani firms and research institutes are "expected to play a role not in developing but in the selection and implementation of appropriate technologies" (p. 114) Pakistani firms should rely on foreign consultants because "they cannot afford to have their own R and D departments "(p. 114) research institutes should become market oriented and competitive (p. 116) Cluster councils should be based on existing successful groupings such as surgical instruments, textiles, leather and establish operational priorities of the Research Institutes (p. 117). Focus should be on clusters which increase exports. Technology development should be driven by the need to raise export competitiveness (p. 119) Net working with international firms should be improved (p. 121).

South Korean technological development was not market driven but it did rely on acquisition from foreign sources with the primary concern being the development of export competitiveness.

South Korean technological progress had suffered from three major weaknesses.

(i) Neglect of innovating (as against imitation and adoption).
(ii) Accepting subordination to the marketing strategies of international buyer groups.
(iii) Lack of interaction between the Chaebels and small and medium enterprises.

The Korean strategy of relying exclusively on technology repackaging meant that R and D effort was concentrated exclusively on process replication and imitation. While as pointed out above, this is a cost effective approach at the early stages of industrial development capacity must also be created for fostering basic research and product and process innovation. Pakistan must therefore complement the technology upgrading efforts of profit oriented enterprises by establishment of centres of technological excellence specialising in innovation and basic research in key area. This is necessary to reduce technological dependence of the type that developed in South Korea.

Equally important is the need to develop an independent market capacity in both domestic and intentional markets. Export orientedness especially if dependence on the market strategy of major buyer groups is institutionalised creates a bais against undertaking long term research and process innovation. An independent marketing strategy targeting major market is thus important.

Finally, technological sustainability requires the creation of industrial depth. This requires vertical integration of production, technology transfer and marketing structures of large and small enterprises an area in which very limited progress was made in South Korea sustainable technological development strategy requires that special emphasis be laid on strengthening organisational linkages between large and small enterprises especially in the manufacturing sector.

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