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Technology and Long-run Economic Growth in Korea

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Technology and Long-run Economic Growth in Asia

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Technology and Long-run Economic Growth in Korea*

September 8, 2005

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CONTENTS

1. Introduction

Korea has recorded one of the highest growth rates (6.60 %) of GDP in constant 2000 prices among all national economies during the post-war period of 1953-2003. It had recorded negative growth in 1980 (-1.56 %) after the second oil crisis and in 1998 (-7.13 %) after the Asian financial crisis. Except these two years, it has succeeded in achieving a remarkably high growth for five decades. The corresponding estimates in Korea's Manufacturing sector during the period of 1953-2003 are the average annual growth rate of labour productivity in Manufacturing (6.15 %); the average annual growth rate of per capita capital in Manufacturing (7.12 %); and the growth rate of total factor productivity in Manufacturing (3.05%).

Lucas (1993) has termed Korea's episode of rapid growth as "economic miracle". He suggested that we need a theory that incorporates the possibility of rapid growth episodes and that such theory should be able to explain why Korea experienced rapid growth since the mid-1960s while the Philippines experienced no such growth; although both economies started from roughly similar socio-economic conditions. Since then multiple theories of new growth have followed but they seem to have emphasized only a particular aspect of complex development and growth process, for example, externality, human capital, learning-by doing or threshold effect.

Even though Lucas (1993) has observed that both the Philippines and South Korea started from "roughly similar socio-economic conditions", the potential initial conditions were quite different between the two economies in the early 1960's. First, while there was an extensive agricultural land reform in Korea on March 25, 1950 five years after its independence from Japan in 1945, there was almost no significant agricultural land reform in the Philippines. While there was almost no large landlord class as a ruling class in Korea, there were large agricultural oligarchies in the Philippines. Second, there existed a significant difference in the state of income distribution between the two economies. According to World Bank, *Social Indicators of Development 1988*, the income received by highest 10 % of households in the Philippines were 40 % (1965) and 39 % (1975), while that in Korea was 28 % (1975). In terms of primary school enrolment rates, two economies were identically over 100 % by 1965. But the enrolment rates of secondary and tertiary schools began to diverge from 1970's. In the Philippines, the secondary school enrolment rate improved from 46 % in 1970 to 73 % in 1990 and the tertiary school enrolment rate

increased from 3 % to 27 %. On the other hand in the Republic of Korea, two rates improved at much faster rates from 42 % to 87 % and from 16 % to 39 % respectively.

Our explanation of a significant episode is based on two keywords: potential initial conditions and structural change and transformation. By potential initial conditions, we mean that we need to identify the state of initial conditions of the country not only by visible and quantifiable indicators but also by often-hidden indicators. These hidden indicators are so-called deep determinants (Rodrik et al., 2002) typically of social, religious and political nature. Among the potential initial conditions, we argue that historical heritages which are often embodied in institutions and commercial practices are the most important determinants of productivity convergence through technological advancement because they ultimately shape policy environments and determine the success or failure of later development programs.

In case of Korea, we can single out three such initial conditions among hundreds of potential list. The first is a colonial heritage that the primary school enrolment ratio was once increased from less than 5 percent to 30 percent level in 1930's. The second is the episode of an early land reform after independence before interest groups could be formed and allied. The third is the expansion of primary education in mid-1950's under the influence of American mass-education system. The first and the third element combined formed the basis of what I define the two-tier system of human capital which is a unique historical heritage of Korea.

The second key element in explaining significant episodes of productivity change and convergence in Korea is the social capacity to transform from agriculture-based economy to manufacturing one at earlier stage and from labor-intensive manufacturing to capital-intensive and technology-intensive manufacturing industries at later stages. Such a social capacity could exist as potential capacity unless some kind of development shock comes through. Naturally, it is this reason why the role of government is important because it can generate domestically a development shock or absorb a foreign shock and internalize it into a domestic one.

The purpose of the paper is to identify and assess the role of technology in the long-run growth of Korea. Following Schumpeter (1942) and Solow (1956), we all know how important the technology is in economic development and growth. But it is very difficult to identify and assess its role in empirical terms because it is not directly observable. Most of times it is embodied in productive inputs or disembodied as neutral technical progress and shifts in total factor productivity. Based on productivity

estimates by industry, we could identify that in the long-run growth of Korea, the technology in Manufacturing has played a key role in lifting up economy-wide productivity.

The development in manufacturing technology has provided inter-industry spill-over effects to the primary and the tertiary industry. There were also intra-industry spill-over effects within manufacturing from higher skill-intensive manufacturing to lower skill-intensive manufacturing, from capital-intensive production to labour-intensive production, and from export-promoted industries to import-substituting industries. We could also hypothesize and identify that most of manufacturing technologies have been embodied in imported machinery and equipments and reverse-migrated scientists and engineers. The learning-by-doing effect in Manufacturing seems to have played a crucial role in technological advancement and productivity convergence in the long-run growth of Korea.

In what follows, we attempt to provide not another new growth theory but rather a significant episode of productivity convergence based on interaction between technological advancement and industrial restructuring and transformation. We attempt to provide a three-sector model with explicit consideration of learning by doing effect in manufacturing with its spill-over within manufacturing and across other sectors and to identify technical progress in three sectors through empirical observations of Korea during last four decades.

This paper is organized as follows. Section 2 explores a theoretical framework for the relationship between technology and productivity convergence and identifies the sectoral growth rates of technical progress by estimating CES production functions. Section 3 briefly reviews the productivity convergence by Korea and its sectoral composition. Section 4 provides some explanations for a rapid productivity convergence through technological advancement. Section 5 summarizes Korea's technology policies in general. Section 6 concludes the paper.

2. A Theoretical Framework and Empirical Identification of Sectoral Technical Progress

Following recent development in growth literature which emphasize sectoral composition associated with economic growth such as Baumol et al. (1989),

Echevarria (1997), and Laitner (2000), we can define a representative consumer's utility maximization as:

$$\text{Max} \sum_{t=0}^{\infty} \beta^t \cdot U(C_{1t}, C_{2t}, C_{3t}) \qquad (1)$$

$$\sum_{t=0}^{\infty} \beta^t \sum_{j=1}^{3} \alpha_j \log C_{jt} - \eta C_{jt}^{-\rho_j}$$

Subject to

1) $K_{t+1} = (1-\delta)K_t + I_t$

2) $C_{1t} = \gamma_1 \cdot \left(\delta_1 K_1^{-\rho_1} + (1-\delta_1) L_1^{-\rho_1}\right)^{-\frac{\nu_1}{\rho_1}} \cdot e^{\eta_1}$

3) $C_{2t} + I_t = \gamma_2 \cdot \left(\delta_2 K_2^{-\rho_2} + (1-\delta_2) L_2^{-\rho_2}\right)^{-\frac{\nu_2}{\rho_2}} \cdot e^{\eta_2}$

4) $C_{3t} = \gamma_3 \cdot \left(\delta_3 K_3^{-\rho_3} + (1-\delta_3) L_3^{-\rho_3}\right)^{-\frac{\nu_3}{\rho_3}} \cdot e^{\eta_3}$

5) $K_t = K_{1t} + K_{2t} + K_{3t}$

6) $1 = L_{1t} + L_{2t} + L_{3t}$

7) $K_0 = \overline{K}$

where C_j denotes the consumption of goods of sector j, K_j denotes the capital input of sector j, and L_j denotes the labor input of sector j and technology and the production side of the economy are represented by the CES production function in order to allow for varying returns to scale and a more flexible pattern of factor substitutions.

In CES specification, the parameter γ is known as the "efficiency parameter", the parameter δ as the "distribution parameter", the parameter ν as the "returns-to-scale parameter", and the parameter ρ as the "substitution parameter" with the following inequality restrictions:

$$\gamma_j > 0, \quad 0 < \delta_j < 1, \quad \nu_j > 0, \text{ and } \quad \rho_j > -1 \qquad (2)$$

By taking logarithms of both sides of CES production function in 2), 3) and 4), we obtain:

$$\log Y_j = \log \gamma_j + \frac{\nu_j}{\rho_j} \log\left[\delta_j K_j^{-\rho_j} + (1-\delta_j) L_j^{-\rho_j}\right] + \eta_j \qquad (3)$$

By using Taylor's series approximation around $\rho = 0$, and dropping the terms involving powers of ρ higher than one, we obtain:

$$\log Y_j = \log \gamma_j + \nu_j \delta_j \log K_j + \nu_j (1-\delta_j) \log L_j - \frac{1}{2} \rho_j \nu_j \delta_j (1-\delta_j) \cdot \left[\log K_j - \log L_j\right]^2 + \eta_j \qquad (4)$$

$$\log Y_{ji} = \beta_{j1} + \beta_{j2} \log K_{ji} + \beta_{j3} \log L_{ji} + \beta_{j4} \left[\log K_{ji} - \log L_{ji}\right]^2 + \eta_{ji} \qquad (5)$$

The parameters of (5) are related to the coefficients of (4) as follows:

$$\gamma_j = e^{\beta_{j1}} \qquad (6)$$

$$\delta_j = \frac{\beta_{j2}}{\beta_{j2} + \beta_{j3}} \qquad (7)$$

$$\nu_j = \beta_{j2} + \beta_{j3} \qquad (8)$$

$$\rho_j = \frac{-2\beta_{j4}(\beta_{j2} + \beta_{j3})}{\beta_{j2}\beta_{j3}} \qquad (9)$$

Then the first order conditions of profit-maximizing firms can be derived as follows:

$$r = q \cdot \frac{Y_j}{K_j} \left[\nu_j \delta_j - \rho_j \nu_j \delta_j (1-\delta_j)\left(\log K_j - \log L_j\right)\right] \qquad (10)$$

$$w_j = q_i \cdot \frac{Y_j}{L_j} \left[\nu_j (1-\delta_j) + \rho_j \nu_j \delta_j (1-\delta_j)\left(\log K_j - \log L_j\right)\right] \qquad (11)$$

Formal proofs of the existence and uniqueness of the steady state for the model with Cobb-Douglas preferences have been presented in Echevarria (1997). The computational method proposed forces the economy with nonhomothetic preferences

to converge to its asymptotic limit, the steady state of the economy with homothetic preferences.

The above model can have an equilibrium given an initial capital, K

$$(C_{1t,}C_{2t},C_{3t},I_t,K_{1t,}K_{2t},K_{3t},L_{1t,}L_{2t},L_{3t}) = x(K_t,K_{t+1})$$

$$F(k_t,k_{t+1},k_{t+2},x(k_t,k_{t+1}),x(k_{t+1},k_{t+2})) = 0 \quad for\ t=0,.....,n\text{-}2$$

$$F(k_{n-1},k_n,k,x(k_{n-1},k_n),x(k_n,k)) = 0 \quad for\ t=n\text{-}1$$

where k_t refers to the transformed value of the stock of capital at period t and k the transformed stock of capital of the steady state.

Empirical Identification of Technological Progress

We have estimated the above sectoral CES production functions by adding time variable to estimate the rate of technical progress in each sector using Korean data from data base of Pyo (2001) and Pyo (2003) . The results are as follows:

Table 3 Estimates of CES Production Function

	Whole economy	Primary	Manufacturing	Service
Constant	-136.2380 (51.1878)	-44.7535 (16.2222)	-70.8019 (12.1615)	-8.7452 (17.7559)
β_2	0.5607 (0.1751)	0.0434 (0.0782)	0.4679 (0.1224)	0.6933 (0.0981)
β_3	0.2152 (0.2714)	0.1747 (0.2166)	0.3491 (0.1831)	0.0469 (0.2037)
β_4	-0.1001 (0.0446)	-0.0164 (0.0184)	-0.0028 (0.0194)	-0.0282 (0.0173)
time	0.0705 (0.0259)	0.0267 (0.0092)	0.0369 (0.0064)	0.0060 (0.0096)
R^2	0.9995	0.9813	0.9994	0.9985
DW statistic	2.0202	1.9551	0.8835	0.4157

*Standard errors in parenthesis

Estimated rates of technical progress are 7.1 % (whole economy), 2.7 % (primary), 3.7 % (manufacturing) and 0.6 % (service) respectively and statistically significant

except the service sector. The technical progress in manufacturing seems to have generated economy-wide technical progress in a more accelerated fashion.

From estimates of linearized CES production functions, we have calculated the CES parameters using the equations (6)~(9) as follows:

Table 4. Estimates of Parameters of CES Production Function

	Whole economy	Primary	Manufacturing	Service
Rate of Technical progress	0.0705	0.0267	0.0369	0.0060
δ (distribution)	0.7226	0.1990	0.5727	0.9367
ν (returns to scale)	0.7759	0.2181	0.8169	0.7402
ρ (substitution)	1.2870	0.9407	0.0280	1.2837

As shown in above table, the hypothesis of constant returns to scale is rejected all of four specifications. The estimated substitution parameters are quite different among three sectors and the unitary elasticity of substitution implied in Cobb-Douglas specification is accepted in only the primary sector.

3. Technology and Productivity Convergence in Korea: A Growth Accounting

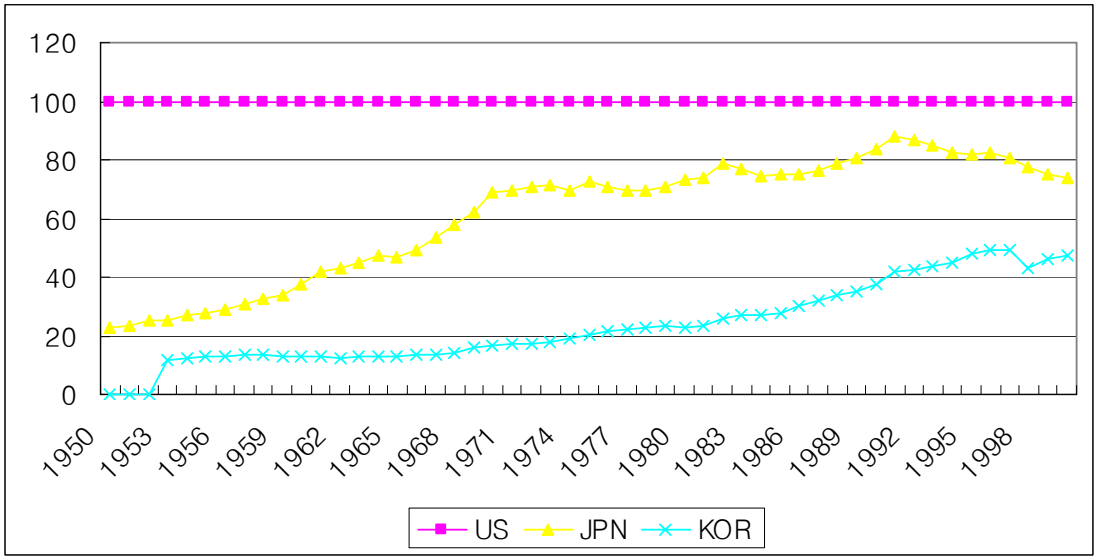
The Productivity Convergence

The World Penn-Table data indicates the following convergence of Korea's labor productivity relative to US:

Korea's Labor Productivity relative to US 1953: 11.70
Korea's Labor Productivity relative to US 2000: 47.70

It provides an episode of rapid productivity convergence: Korea's per-capita income in 1961 was about 11.70 percent of US' per-capita income but it reached to the level of 47.7 percent of US' per-capita income over four decades.

Figure 1 GDP per capita of Korea and Japan (US=100)



The Aggregate Productivity Growth

According to our growth accounting, the overall productivity performance of Korea during the period of 1953-2003 can be summarized in terms of average annual growth rates in 2000 constant price as follows:

GDP growth (DY) = 6.60 %	Capital deepening (DKL) =7.08 %
Labor productivity growth (DLP) = 3.60 %	TFP growth (DTFP) = -0.26 %

In order to carry out a growth accounting, we need to estimate shares of factor income. The share of labor income in the aggregate economy estimated by the Bank of Korea shows an increasing trend from 1953 (0.24) to 1960 (0.36), 1980 (0.49) and 2000 (0.60).

Since the Bank of Korea did not publish the labor income shares by industry before 1970, we have estimated those using the following equations:

$$(5.1)\ \alpha_i = const + \beta_1 \cdot time + \varepsilon_{it}$$

$$(5.2)\ \alpha_i = const + \beta_1 \cdot time + \beta_2 \cdot \frac{K_i}{L_i} + \varepsilon_{it}$$

$$(5.3)\ \alpha_i = const + \beta_1 \cdot time + \beta_3 \cdot \alpha_T + \varepsilon_{it}$$

$$(5.4)\ \alpha_i = const + \beta_1 \cdot time + \beta_2 \cdot \frac{K_i}{L_i} + \beta_3 \cdot \alpha_T + \varepsilon_{it}$$

As the figures 1,2, and 3 show, all the estimates reflect the similar time trend, but the estimates using the labor share in the whole economy(α_T) as independent variable(equations 5.3 and 5.4) seem to reflect the fluctuations in labor shares well during the period of 1970-2003. Therefore, we have used the equation (5.4).

Figure 1. Estimates of Labor Share in Primary Sector

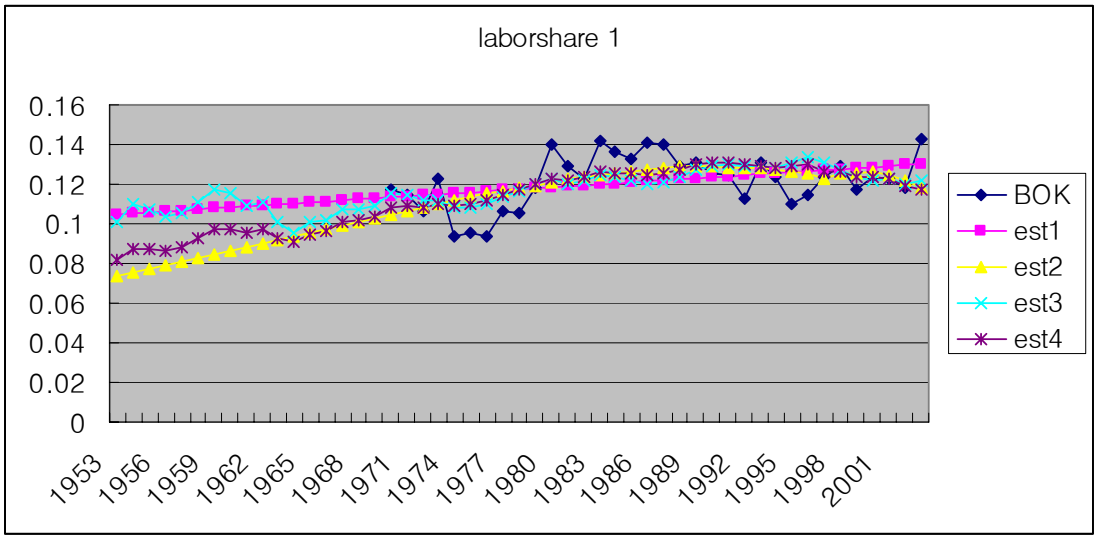


Figure 2. Estimates of Labor Share in Manufacturing Sector

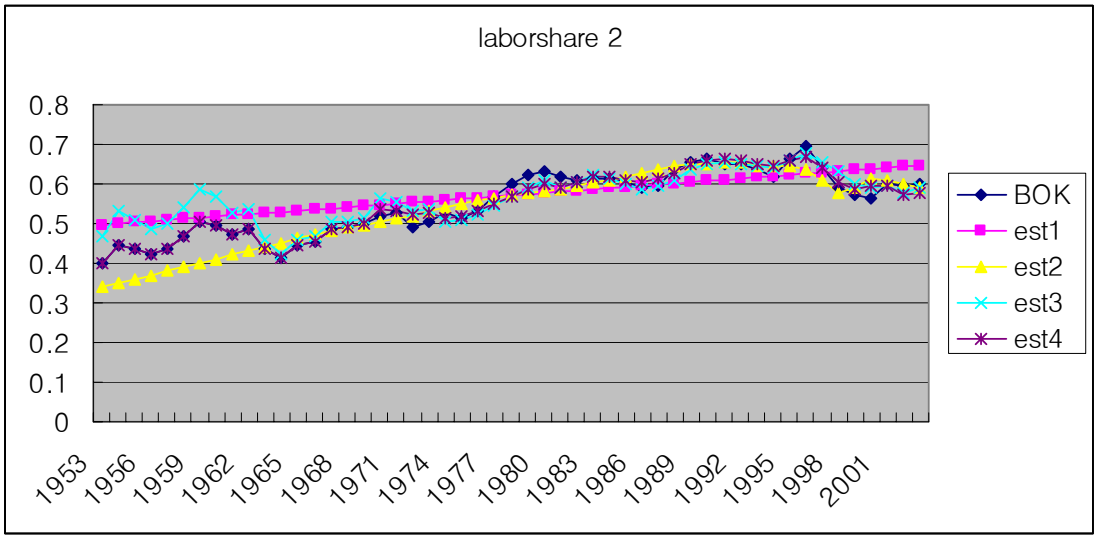
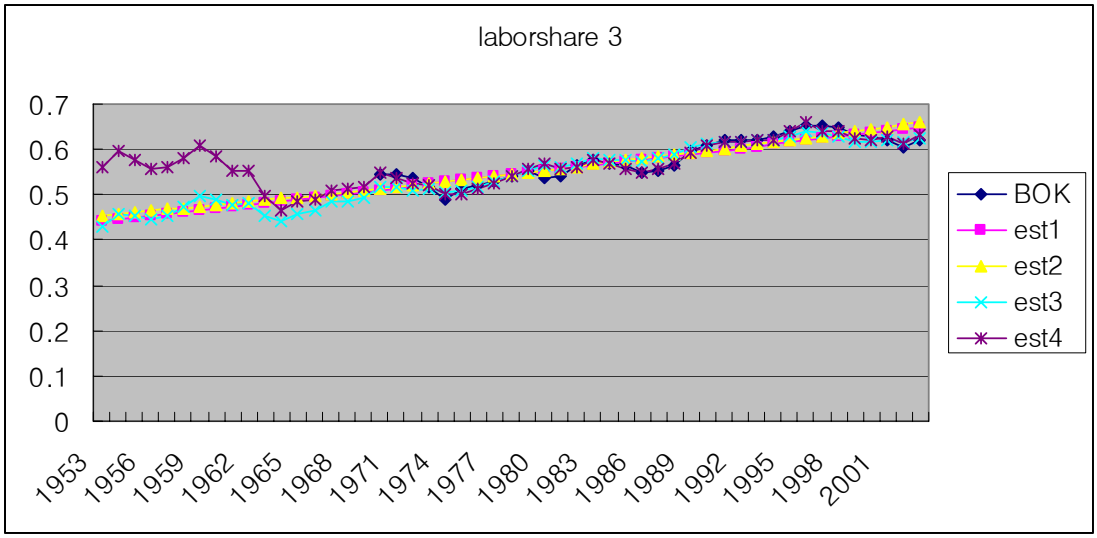


Figure 3. Estimates of Labor Share in Service Sector



Our estimate of labor income share in manufacturing shows also a steady upward trend but with some fluctuation from 1953 (0.39) to 1960 (0.50), 1980 (0.63), 1996 (0.69) and 2003 (0.60). The reduction of labor income share from 1996 to 2000 reflects the impact of the financial crisis in 1997 and is consistent with the worsened Gini coefficient of urban wage earners' Household income. At the same time, it is a manifestation of factor price equalization theorem in the long-run that as a relatively labor-abundant country engages in free trade, the wage increases relative to price of capital; the free trade benefits the relatively abundant factor of the trading country.

The decomposition of economy-wide aggregate growth accounting in per-capita terms can be made as follows:

$$DLP\ (3.60\ \%) = SK \times DKL\ (7.08\ \%) + DTFP\ (-0.26\ \%) \qquad (1)$$

where SK is the average share of capital income in total GDP which is generated from (1 - share of employees' compensation).

Alternatively, the decomposition of GDP growth can be made as follows:

$$DY\ (6.60\ \%) = SK \times DK\ (10.11\ \%) + SL \times DL\ (2.99\ \%) + DTFP\ (-0.26\ \%) \qquad (2)$$

where DK is the average growth rate of capital input, SL is the average share of labor income in total GDP and DL is the average growth rate of labor input.

Manufacturing Productivity Growth

On the other hand, we have estimated corresponding estimates in Korea's Manufacturing sector during the period of 1953-2003 as follows:

$$DLPM\ (6.15\ \%) = SKM \times DKLM\ (7.11\ \%) + DTFPM\ (3.05\ \%) \quad (3)$$

where DLPM is the average annual growth rate of labor productivity in Manufacturing; SKM is the share of capital income in Manufacturing GDP; DKLM is the average annual growth rate of per capita capital in Manufacturing; and DTFPM is the growth rate of total factor productivity in Manufacturing.

$$DYM(10.98\%) = SKM \times DKM(12.11\%) + SLM \times DLM(4.66\%) + DTFPM(3.05\%) \quad (4)$$

where DYM is the average annual growth rate of real Manufacturing GDP; DKM is the growth rate of capital stock in Manufacturing; SLM is the average share of labor income in Manufacturing; and DLM is the growth rate of labor input in Manufacturing.

The comparison of growth accounting between economy-wide aggregate one and Manufacturing sector reveals several characteristics in Korea's productivity performance as follows:

1) The growth accounting at the economy-wide aggregate level over the period of 1953-2003 in Korea has exhibited a capital-input driven growth rather than TFP-led growth confirming the Krugman(1994) proposition. The relative contribution of TFP growth to total GDP growth was slightly negative. It also confirms Nadiri's (1972) proposition that relative contribution of TFP to output growth is small in developing economies as compared to its critical importance in industrialized economies.
2) The manufacturing sector in Korea has accumulated capital at a faster rate (12.11 %) than the aggregate economy (10.11 %) and has increased employment too at a faster rate (4.66 %) than the aggregate economy (2.99 %). Its growth

rate in capital deepening (7.11 %) is almost the same as the economy-wide growth rate (7.08 %). But the relative contribution of TFP in manufacturing (27.8 %) is much more significant than that at the aggregate economy-wide level. Therefore, Korea's rapid growth was manufacturing-led growth and the significant contribution of its TFP seemed to have exercised a spill-over effect into other sectors such as the primary sector and the service sector mitigating their lower TFP.

3) The generated average share of labor income in manufacturing (0.55) was higher than that in the aggregate economy (0.45) due to higher rates of growth in employment even though the average wage rate in manufacturing was lower than the rest of sectors. According to Korea National Statistical Office, the industrial differences in wages are as follows in 1980 and 2000 where index of Manufacturing wage is treated as base index (100):

Therefore, we conclude:

1) The growth accounting at the economy-wide aggregate level over the period of 1953-2003 in Korea has exhibited a capital-input driven growth rather than TFP-led growth confirming the Krugman (1994) proposition. The relative contribution of TFP growth to total GDP growth during the period was slightly negative. It also confirms Nadiri's (1972) proposition that relative contribution of TFP to output growth is small in developing economies as compared to its critical importance in industrialized economies.

2) The manufacturing sector in Korea has accumulated capital at a faster rate (12.11 %) than the aggregate economy (10.11 %) and has increased employment too at a faster rate (6.10 %) than the aggregate economy (3.75 %). Its growth rate in capital deepening (7.12 %) is almost the same as the economy-wide growth rate (7.08 %). But the relative contribution of TFP in manufacturing (27.8 %) is much more significant than that at the aggregate economy-wide level.

3)Therefore, Korea's rapid growth was manufacturing-led growth and the significant contribution of its TFP seemed to have exercised a spill-over effect into other sectors such as the primary sector and the service sector mitigating their lower TFP. The generated average share of labor income[1] in manufacturing (0.55) was higher than

[1] Since we have used employee compensation as labor income, it does not contain

that in the aggregate economy (0.45) due to higher rates of growth in employment in earlier years even though the average wage rate in manufacturing was lower than the rest of sectors.

Table 1 Growth Accounting Results (1953 ~2003)

Year		Total	I	II	III
1953-2003	Total Factor Productivity	-0.26	-6.72	3.05	-0.64
	GDP	6.60	2.13	10.98	6.68
	Labor Input	2.99	-1.24	4.66	5.31
	Capital Input	10.11	9.75	12.11	9.74
	Total Factor Input	6.86	8.85	7.92	7.33
1953-1980	Total Factor Productivity	-1.70	-7.88	1.93	-1.34
	GDP	6.51	2.40	13.21	6.80
	Labor Input	3.77	1.04	7.75	6.22
	Capital Input	10.75	10.67	14.85	9.92
	Total Factor Input	8.21	10.28	11.28	8.14
1981-2003	Total Factor Productivity	1.07	-6.65	4.09	-0.11
	GDP	6.35	0.70	7.99	6.38
	Labor Input	2.01	-3.88	0.91	4.38
	Capital Input	9.45	8.86	9.01	9.62
	Total Factor Input	5.29	7.36	3.89	6.49

Table 2. Index of Industrial Differences in Wages

	1980	2000
Agriculture, Forestry and Fishery	138.4	110.8
Mining	145.4	106.7
Manufacturing	100.0	100.0
Electricity, Gas and Water	179.5	153.9
Construction	197.2	108.1
Wholesale, Retail, Restaurants and Hotels	139.1	95.7
Transport, Storage and Communication	136.9	111.8
Finance, Insurance, Real Estate and Business Service	170.6	121.7
Community, Social and Personal services	187.4	105.3

Sources: Korea National Statistical Office*, Social Indicators in Korea*, 2001

The wage differential between Manufacturing and Non-Manufacturing had been reduced from 1980 (100: 161.8) to 2000 (100: 114.2). There was a significant catch-up of Manufacturing wages to Non-Manufacturing wages level due to the changes into productivity-based compensation policy, strong union activity in Manufacturing and increase in skill-intensity in Manufacturing labor.

The overall productivity trends at both the aggregate economy-wide level and Manufacturing level seem to suggest the growth of TFP may not seem significant in the aggregate sense but it played a crucial role indirectly through lifting up productivity of manufacturing sector.

In summary, we can argue that in case of Korea, the growth of TFP may not seem significant in the aggregate sense but it played a crucial role indirectly through lifting up productivity of manufacturing sector. In particular, the growth in technical efficiency and technical change in manufacturing sector must have worked in two directions to lift up productivity in the rest of sectors: one is a direct effect to manufactures-user industries and the other is indirect effect of spillover and learning-by-doing. For example, computer manufacturing and assembly causes lifting up the productivity of computer-using service industries and the computer manufacturing itself generates spillover effect and induces learning-by-doing to other industries' manpower.

4. Explanation of Rapid Productivity Convergence through Technological Advancement

As pointed out by Lucas (1993), we need a growth theory that incorporates the possibility of rapid growth episodes and productivity convergence. No single theory could explain this episode because it involves more than growth of an aggregate economy; it should deal with complex story of development with late industrialization. It would be tempting to say that everything the Korean Government had done was appropriate and timely and that the interaction between government and market in Korea was well-coordinated. However, a careful examination of the past development history of Korea reveals that there had been pros and cons and ups and downs and that the episode of fast growth had been far from being smooth. The Korean economy had to go through very turbulent periods as witnessed in 1980-1981 following the second oil

crisis and the assassination of President Park and 1997-1998 in the middle of Asian financial crisis.

We can explain the Korean experience of rapid productivity convergence through three stages. During the First stage (1962-1976) of economic development, the Park government adopted a vent-for-surplus type development strategy. The First Five-Year Development period (1962-1966) can be characterized as a period of explosive export growth. Export amount in current US dollars increased from 54.8 million dollars in 1962 to 253.7 million dollars by about five times. Helped by extraordinary export performance, the annual average GDP growth rate increased at 8.5 percent exceeding the target rate (7.1 %). In general, it was a period when nationalistic movement was very high. The foreign direct investments did not receive much credit due to strong anti-Japanese sentiment and therefore, the Park government opted for inducing project loans from Asian Development Bank and World Bank and using them for basic industries such as steel and cement and social infrastructure such as highways and railroads and power plants etc. Most of private projects were awarded to private firms usually to qualified conglomerates through Korea Development Bank, Korea Export Import Bank, Korea Medium and Small Enterprise Bank and other commercial banks through syndicated loans or government-subsidized policy loans. For getting next-round loans, one of the most important criteria was export performance by the loan-awarded companies.

Both the government and banks were monitoring the company's performance. This criterion of export-performance had exercised a constant pressure on private firms and their owners and entrepreneurs so that they were almost obsessed with how to sell their products in overseas market. Even though there must have been a lot of distortion effect, the explicit criterion of export priority had reduced the arbitrariness by bureaucrats and bankers and had made the monitoring system relatively more transparent than that under import substitution system.

Entering the second stage (1977-1986), Korean economy experienced the second oil crisis in early 1980's and had to go through restructuring the past investments in heavy and chemical industries made during late 1970's. But it was this period when major conglomerates such as Samsung, Lucky Goldstar (LG) and Hyundai started investing in semi-conductor industries because they anticipated the technology frontier in that industry and the government wanted to promote

competition in the industry. During this period Korean government has moved from direct industrial support policy to indirect support policy. For example, they tried to shift the paradigm of industrial promotion from directly subsidizing an industry such as steel or automobile to indirectly promoting investments in energy saving, preserving environments and introducing new technologies through enhanced R&D programs. It was also a period in which trade liberalization before capital market opening was seriously deliberated as a backdrop against rising wages and unionism.

The Third stage (1987-2003) is characterized by turbulent transition from authoritarian regime to a more democratic one. It is a period in which Korea had pursued import liberalization and capital market opening by joining WTO and OECD. It was a period when Korean conglomerates engaged in excess competition in a pattern of monopolistic competition across industries. Many of them had invested in pre-emptive investment projects in non-tradable sectors to stay alive against increasing foreign and domestic competition. The monitoring system by both government and banks became less transparent and a lax financial supervision created a vast network of moral hazard. It was also the period of rapidly declining rates of return on capital in Korea as observed. As Independent Evaluation Office of IMF had described it, the Korean financial crisis of 1997 was a twin crisis; foreign exchange crisis and domestic credit crunch. During the post-crisis IMF programs, there were both corporate and financial restructuring and about two-thirds of top-30 conglomerates went bankrupt. But toward the end of this stage, Korean economy was affected by New Economy and IT revolution. There was substitution of investments from conventional non-IT sectors to IT sectors but the employment absorption by IT sectors was rather weak and once IT boom was over by 1999, the investment became quite stagnant casting doubt on new sources of sustainable growth for Korean economy as analyzed in Pyo and Ha (2004) (2005).

In summary, the episode of rapid productivity convergence in Korea was made possible by successful adoption of development strategy based on incremental comparative advantage and industrial restructuring by the government initiative. It was a consequence of interaction between market forces and government intervention.

Major Determinants of Productivity and Technological Advancement

Our explanation of significant episode of rapid productivity convergence by Korea is based on two keywords: potential initial conditions and structural change and

transformation. By potential initial conditions, I mean that we need to identify the state of initial conditions of the country not only by visible and quantifiable indicators but also by often-hidden indicators. These hidden indicators are so-called deep determinants (Rodrik et al., 2002) typically of social, religious and political nature. Among the potential initial conditions, I argue that historical heritages which are often embodied in institutions and commercial practices are the most important determinant because they ultimately shape policy environments and determine the success or failure of later development programs.

In case of Korea, we can single out three such initial conditions among hundreds of potential list. The first is a colonial heritage that the primary school enrollment ratio was once increased from less than 5 percent to 30 percent level in 1930's. The second is the episode of an early land reform after independence before interest groups could be formed and allied. The third is the expansion of primary education in mid-1950's under the influence of American mass-education system. The first and the third element combined formed the basis of what I define the two-tier system of human capital which is a unique historical heritage of Korea.

Among numerous determinants which must have mutually interacted, I would rate human capital determined by historical precondition as the most important determinant without hesitation. The enlargement of primary education and upward mobility in education system are the key elements in improving nation's stock of human capital. The human capital enhances knowledge, absorptive capacity, indigenous R&D efforts, and institutional environments.

Even though Lucas (1993) has observed that both the Philippines and South Korea started from "roughly similar socio-economic conditions", the potential initial conditions were quite different between the two economies in the early 1960's. First, while there was an extensive agricultural land reform in Korea on March 25, 1950 five years after its independence from Japan in 1945, there was almost no significant agricultural land reform in the Philippines. While there was almost no large landlord class as a ruling class in Korea, there were large agricultural oligarchies in the Philippines. Second, there existed a significant difference in the state of income distribution between the two economies. According to World Bank, *Social Indicators of Development 1988*, the income received by highest 10 % of households in the Philippines were 40 % (1965) and 39 % (1975), while that in Korea was 28 % (1975). In terms of primary school enrollment rates, two economies were identically near

100 % by 1965. But the enrollment rates of secondary and tertiary schools began to diverge from 1970's. In the Philippines, the secondary school enrollment rate improved from 46 % in 1970 to 73 % in 1990 and the tertiary school enrollment rate increased from 3 % to 27 %. On the other hand in the Republic of Korea, two rates improved at much faster rates from 42 % to 87 % and from 16 % to 39 % respectively.

The second key element in explaining significant episodes of productivity change and convergence in Korea is the social capacity to transform from agriculture-based economy to manufacturing one at earlier stage and from labor-intensive manufacturing to capital-intensive and technology-intensive manufacturing industries at later stages. Such a social capacity could exist as just a potential capacity and could never materialize in many developing countries unless some kind of development shock comes through. Naturally, it is this reason why the role of government is important because it can generate domestically a development shock or absorb a foreign shock and internalize it into a domestic one. For example, on May 16, 1961, a military *coup* staged by President Park had generated a domestic development shock because the military group had to build their own legitimacy by providing the public with blueprints of economic development. On the other hand the sudden reduction of US aid in early 1960s had caused economic hardship but had generated an external shock to make the Korean people aware of the fact that they cannot live on foreign aids forever and therefore, they need their own indigenous effort of rebuilding national economy.

(1) Adoption of New Technology

As in many developing countries, Korea relied on imported foreign technology to carry out construction and operation of major manufacturing facilities. At the beginning stage, the imported technology came in the form of machineries and equipments mostly from the United States and Japan. The operation manuals by the Japanese producers could be well-interpreted because there were many senior engineers who were trained in the colonial period. One of the reasons why the Japanese machines and equipments were popular at the beginning stage of development is this familiarity with the system and know-how. Another reason is easy access to after-service because of the proximity to Japan. As the engineers and scientists trained in late 1950's and 1960's from the United States started returning home in late 1960's and 1970's, their familiarity with US machines and equipments

has slowly substituted Japanese machines and equipments for US machines and equipments.

The R&D and technology imports are two important windows of technology adoption in many developing countries. But the success of late industrialization ultimately depends on the country's indigenous technological capacity to absorb new technologies at the right time. In general, technology buyers in developing countries are given multiple choices of different technologies by technology sellers in advanced countries for a given plant construction or processing know-how. Usually the choice of the right technology at the right price and at the right timing is the most crucial part to the success of the project. And without indigenous technological capacity, industries in developing countries can not make optimal choice of technology.

In case of Korea, this role of choosing the right technology at the right time was left to entrepreneurs and engineers not to bureaucrats. Most of engineers have been foreign-educated and consulted domestic R&D centers to acquire knowledge on technology in question. In other words, the indigenous technological capacity itself was a human capital.

Even though it is difficult to identify statistically the growth of indigenous technological capacity, the patent statistics can provide us with one source of indicators. According to statistics compiled by Korea Patent Office, the number of patent applications increased exponentially from 1948 (169 cases) to 1960 (611 cases), 1980 (5,070 cases) and 2003 (118,652 cases) as shown in Table 4. The composition by applicant's nationality is as follows: 1948 (Korean 100%), 1960 (Korean 89.2 %, USA 2.7 %, West Germany 1.6 %), 1980 (Korean 24.5%, USA 22.7 %, Japan 32.0 %) and 1997 (Korean 72.6 %, USA 7.9 %, Japan 12.0 %, Germany 2.5 %). In summary, Japan and United States have been two dominant foreign patent applicants but Korean share which was once declined to the level of 24.5 % in 1980 has been kept up at over 70 % level in mid-1990's. It is one indication of indigenous technology build-up.

Table 4. Number of Patent Applications by Year

Classification	Patents	Utility Models	Subtotal	Designs	Trade-marks	Total
1947	236	237	473	23		496
1948	169	166	335	38		373
1949	233	229	462	46		508
1950	126	123	249	30	599	878
1951	30	29	59	3	40	102
1952	91	69	160	19	151	330
1953	76	152	228	62	229	519
1954	132	175	307	76	375	758
1955	156	281	437	216	465	1118
1956	287	494	781	179	1087	2047
1957	469	758	1227	276	1469	2972
1958	555	1105	1660	358	1439	3457
1959	703	1395	2098	362	1307	3767
1960	611	1207	1818	329	1209	3356
1961	858	1683	2541	470	1665	4676
1962	782	1793	2575	570	1890	5035
1963	771	1790	2561	729	1295	4585
1964	908	2244	3152	804	1845	5801
1965	1018	2849	3867	825	2053	6745
1966	1060	3252	4312	1338	2752	8402
1967	1177	3594	4771	1919	3228	9918
1968	1463	5129	6592	3277	6619	16488
1969	1701	5573	7274	4536	9111	20921
1970	1846	6167	8013	4522	5124	17659
1971	1906	6810	8716	5348	5816	19880
1972	1995	7747	9742	5991	6878	22611
1973	2398	7561	9959	6333	9562	25854
1974	4455	6833	11288	6220	9053	26561
1975	2914	7290	10204	6707	9476	26387
1976	3261	8378	11639	6018	11037	28694
1977	3139	7601	10740	5520	9415	25675
1978	4015	6645	10660	6265	12040	28965
1979	4722	7957	12679	8371	13789	34839
1980	5070	8558	13628	10075	13558	37261
1981	5303	9064	14367	10394	15755	40516
1982	5924	10669	16593	11902	19537	48032
1983	6394	11485	17879	13947	23982	55808
1984	8633	14765	23398	15870	24764	64032
1985	10587	18548	29135	18949	26069	74153
1986	12759	22401	35160	18731	28031	81922
1987	17062	24773	41835	20231	30762	92828
1988	20051	22677	42728	18162	34681	95571
1989	23315	21530	44845	18196	39832	102873

1990	25820	22654	48474	18769	46826	114069
1991	28132	25895	54027	20097	46612	120736
1992	31073	28665	59738	22948	45124	127810
1993	36491	32218	68709	27568	59593	155870
1994	45712	39806	85518	29033	72581	187132
1995	78499	59866	138365	29978	71852	240195
1996	90326	68822	159148	29859	85062	274069
1997	92734	45809	138543	28491	87065	254099
1998	75188	28896	104084	23732	57393	185209
1999	80642	30650	111292	32404	87332	231028
2000	102010	37163	139173	33841	110073	283087
2001	104612	40804	145416	36867	107137	289420
2002	106136	39193	145329	37587	107876	290792
2003	118652	40825	159477	37607	108917	306001
Total	1175388	813052	1988440	643018	1481432	4112890

Source: The Korean Intellectual Property Office

There are two additional indicators for the development of indigenous technological capacity. One is the status of national technical certificates and the other is the status of vocational training. According to Ministry of Labor‘s Yearbook of Labor Statistics, total national technical certificate holders increased from 122,833 persons in 1978 to 541,544 persons in 2000. The composition by kinds of national certificates was Craftsman (54.8 %), Industrial Engineer (24.6 %), Assistant Craftsman (11.9 %), Engineer (8.5 %) and Professional Engineer (0.3 %) in 1978. It changed in 2000 to Craftsman (78.0 %), Industrial Engineer (10.2 %), Assistant Craftsman (2.2 %), Engineer (9.0 %), Professional Engineer (0.4 %) and Master Craftsman (0.1 %). It indicates while professional engineers and engineers certificate holders did not increase much in recent years because the market demand for their service is limited, the supply of craftsman certificate holders increased significantly both in numbers and in shares.

(2) Research and Development

It is well-known that increased spending on R&D can lead to discovery of new technologies or development of new products that contribute to higher productivity. But in many developing countries, R&D can be wasted because of lack in infrastructure of R&D and motivation for indigenous R&D effort. Korea was no exception. It was only after experiencing two-rounds of oil crisis and the first year of

negative real GDP growth(-2.1%) in 1980, the new government of the post-Park regime had realized the limitation of extensive growth based on factor accumulation and capacity expansion under the so-called " Heavy and Chemical Industrialization Policy " and started to seek for new sources of growth. According to MCI, the policy targets announced in February 1982 included export promotion with enhanced value-added, the upgrading and rationalizing of industrial structure and enhancement of industrial competitiveness through maintaining balanced growth among different sectors.

Most of R&D policies were formulated by Ministry of Science and Technology (MOST) in consultation with Economic Planning Board (EPB) and Ministry of Commerce and Industry (MCI) so that there was check and balance among ministries on R&D expenditure. By the end of March 1982, MOST has selected a total of 108 Special R&D Projects which will be carried out by 80 private firms (a total of 7.2 million US dollars) and 28 government research institutions or enterprises (a total of 18.7 million US dollars).

In June 1982, MOST has announced Five-Year R&D Plan for Fine Chemical Industries selecting 200 projects in five areas of specialization (a total of 62.8 million US dollars of private funds and 77.5 million US dollars of government funds). In February 1984, the government announced a plan to promote basic R&D to co-fund with the private sector a total of 100 million US dollars by 1988. In March of the same year, Ministry of Finance had announced to provide R&D Funds to not only hardware manufacturers but also software manufacturers. In September, the Bank of Korea announced to increase financial support to Small and Medium Industries (SMI) who adopt technology innovation plans and new technology development.

In January 1985, Ministry of Finance announced an ambitious plan of mobilizing a total of 243.7 million US dollars as R&D funds from five financial institutions for technology development including Korea Development Bank (KDB) and National Investment Fund (NIF). In August 1986, MCI announced a plan to support software industries by funding through Industrial Development Fund (IDF) as infant industries in order to prepare for import liberalization and intellectual property rights issue. On the other hand, MOST announced a plan to spend a total of 126.2 million US dollars as Special R&D Expenditure in three representative technology-intensive frontier industries: Fine Chemical, Semi-Conductor and New Material Industries.

In November 1986, MCI selected a total of 219 manufacturing processes which are in need of urgent R&D projects (837 cases) and announced to support those selected R&D projects to be completed in two years by 1988.

One of the maintained hypotheses that I would propose is that the main R&D activities in Korea were pioneered by the first generation of scientists and engineers who have been educated and trained from the United States and Europe. They include the founding members of KAIST and Korea Defense Research Institute etc. Since at that time, private firms R&D facilities were fragile and often lacked the right equipment and facilities and financial compensations were also low. Therefore, the bulk of major scientists and engineers preferred the government think-tanks. It was only in the 1990s when the prestigious private R&D centers run by major conglomerates could offer better salaries and non-salary remunerations.

R&D activities at both government and private sector level needs to be assessed. In general, R&D expenditure can be decomposed into two categories; public R&D and private R&D. In case of Korea, the role of public R&D was dominant at the beginning of its development plan in 1960s. However, public R&D could not satisfy technology and engineering demand by private firms as the industrial structure is transformed from light industries to heavy and chemical industries during 1970's. The private R&D which was motivated by various tax incentives by the government had been oriented toward more application and adaptation technologies and engineering know-how. Therefore, there seem to have been a complementary relationship between public R&D and private R&D during 1960s and 1970s in Korea.

On the other hand, the role of private R&D started to dominate public R&D in Korea from mid-1980's when Korea's industrial policy shifted from direct industry-specific support policy to indirect functional support policy. It was also the time when major Korean conglomerates started investing semi-conductors, higher-value added steel and metal products, and machinery and equipments including automobiles. In the 1990's, the public R&D played an important role in telecommunication industries. For example, ETRI (Electronic Telecommunication Research Institute) and KISDI (Korean Information Society Development Institute) are representative examples. And public R&D and private R&D started having not only complementary elements but also competitive elements.

The differential role of public R&D and private R&D in the evolution of Korea's R&D policy needs to be carefully examined and its relationship with

productivity performance in key sectors should be evaluated. For example, according to Ministry of Science and Technology and Electronics and Telecommunications Research Institute, the R&D expenditure on Information and Telecommunication has occupied 20 percent of total R&D expenditure and 0.39 percent of GDP in 1991 but increased by 2000 to 49.2 percent and 1.32 percent level respectively. The sector's R&D expenditure was decomposed between public and private by the ratio of 18 percent and 82 percent respectively in 1991 but changed to the ratio of 10 percent and 90 percent in 2000.

The overall trend in R&D expenditure shows a remarkable upward trend both in terms of absolute amount being put in and the relative share to GDP as shown in appendix Table. The total expenditure increased from 1.2 billion Won (0.24 % of GDP) in 1963 to 13,848 billion Won (2.67 % of GDP) in 2000. The sustained productivity growth was made possible by building up its own indigenous technological capacity through division of work between public R&D and private R&D.

The number of R&D institutes increased from 72 in 1963 to 2,856 in 1996 and R&D manpower increased from 1,750 persons to 132,023 persons during the same period. In 1996, 11.7 percent of R&D manpower was with research institutes, 34.3 percent was with universities and the remaining 54 percent was with private firms. The decomposition of R&D expenditure by function shows: basic R&D (18.2 %), applied R&D (28.9 %) and product development (53.0 %) in 1983 and basic R&D (12.6 %), applied R&D (24.3 %) and product development (63.1 %) in 2000 as shown in Appendix Table. The relative weight of R&D expenditure in product development became larger than basic or applied R&D expenditure in recent years. It indicates the private R&D expenditure has become more important than public R&D and Korea's R&D has become more commercially oriented expenditure.

(3) Technology Transfer

Regarding technology import policy, Korea has adopted the promotion of R&D and technology import as a prime policy to enhance productivity increase which can be linked to a good export performance. Korea's development strategy from the very beginning of 1960's aimed at inducing syndicate loans from World Bank, Asian Development Bank, and commercial banks and then, reallocated them to project-qualified companies through government controlled banks such as Korea

Development Bank, Korea Small and Medium Enterprise Bank, Korea Export and Import Bank, etc. Therefore, the role of direct foreign investment was relatively insignificant, which was different from the development strategies of Singapore, Hong Kong, and Taiwan.

Under the system, the project-awarded qualified companies had to meet the government standard of export performance and cost-benefit requirements by substantially improving productivity performance. They have had relatively little time for endogenous R&D effort and had to rely on imported technology. Most of imported technology had been in the form of imported know-how and manuals which come with the purchase of imported machinery and equipments. Later on most of imported technologies were in the form of purchased licensing agreements and intellectual property rights. But most of firms had to invest in minimum R&D in order to build their own technology-adoption capacity typically by building their own laboratories and sending their engineers abroad for further training. Indigenous R&D came much later as most of firms have accumulated enough level of adoption technology. Therefore, the government policy aiming at promotion of R&D and liberal technology import policy must have affected positively on the productivity performance of project-awarded firms.

According to Science and Technology Yearbook by the Ministry of Science and Technology, the number of technology import cases reported was 285 cases during 1967-1971: Electrical & Electronics (65 cases), Refinery & Chemical (59 cases) and Machinery (58 cases) among other industries. The number increased sharply during the period of Korea's investment in heavy and chemical industries (1972-1976) to a total of 434 cases: Machinery (116 cases), Refinery and Chemical (85 cases) and Electrical & Electronics (84 cases). However, as the Korean economy started to increase investment for technology intensive sectors such as semi-conductors and IT sectors from mid-1980's the industrial composition also changed. The total number of technology import cases (5,830 cases) during the period of 1985-1996 is decomposed as Electrical and Electronics (2,016 cases, 34.6 %), Machinery (1,714 cases, 29.4 %) and Refinery & Chemical (979 cases, 16.8 %).

In terms of statistics on technology licensing payments by countries, the United States was dominant donor country during 1962-1966 with 0.5 million US$ (71.4 %) out of a total of 0.7 million US$. After the diplomatic relationship with Japan was restored in mid-1960's, Japan became the second largest technology supplier: During

1967-1972, a total of 26.6 million US$ was paid as technology fee to the United States (11.0 million US$, 41.4 %) and Japan (10.5 million US$, 39.5 %). In 1996 just before the financial crisis of 1997, the total technology fee payment reached a record high level of 2,297.2 million US$ with the decomposition by the United States (1,160.0 million US$, 50.5 %) and Japan (723.9 million US$, 31.5 %). So the United States and Japan continued to be two dominant suppliers of technology to Korean industries.

Three Channels of Technological Advancement

(1) Human Capital

In terms of human capital accumulation, we should note a remarkable feature in the history of modern Korea. That is the introduction of mass-education in primary schools at unprecedented rates and at the time of starvation and political unrest. According to Kimura (1986), the overall primary enrolment ratio for boys in 1911 was 15.2-19.1 percent at the end of Yi Dynasty. And a survey of national illiteracy conducted by the colonial government as part of population census in 1930 showed the overall illiteracy rates of 50.4 percent for males and 89.8 percent for females.

The primary school enrolment ratio, which has been frequently used as a proxy for human capital in recent growth literature, had been lifted up twice remarkably in modern history of Korea. The first jump occurred during 1930's after the Colonial Government of Imperial Japan had adopted a conciliatory policy to integrate Koreans into mainland Japanese. They started introducing the Japanese system of education in place of traditional apprenticeship-like Korean system called *Seodang*. By 1940, the primary school enrolment ratio ascended to about 60 percent and 30 percent for boys and girls respectively. But a survey conducted by the post-colonial government in 1945 found that 77 percent of adults over 13 years old still did not have the skills of reading and writing in Korean language, *Hangul.* The US military government and the succeeding Rhee government had to make intensive efforts to eradicate adult illiteracy. The second jump occurred around 1957 when the Rhee government started introducing American system of mass education and the primary school enrollment ratio had ascended to 70 % level without too much differential between boys and girls.

By 1960, the primary school enrolment ratio had reached 99.8 percent level as shown in Appendix Table. However, the composition of population by educational attainment (25 years old and over) in 1966 shows that 79.6 percent of population were

primary school graduates or under and only 3.7 percent were college graduates and over. Thus the initial condition of educational attainment in Korea in 1960's can be summarized as the vast expansion of primary education with very limited higher education. On the other hand, Korea has adopted education policy in which public education plays greater role in primary and secondary education than in tertiary education. The college-level education was left for competition between public and private colleges and universities.

The hypothesis that I put forward here is that the beneficiaries of mass education in the 1930's have become manager classes and those of mass education in the 1950's have become major force of production and office workers in the later development periods of 1960's and 1970's. This seemingly two-tier system of human capital has been the core of Korea's success in late industrialization, which distinguishes itself from other developing countries.

As shown in Appendix Table A4, the composition of population of 25 years old and over by educational attainment show: Primary School Graduates and under (79.6%), Middle School Graduates (11.1 %), High School Graduates (5.6 %) and college Graduates and over (3.7 %) in 1966 and the corresponding rates became 23.0 %, 13.3 %, 39.4 % and 24.3 % in 2000. So the fast and large-scale expansion of primary school education in the late 1950's has been instrumental to developing indigenous R&D capacity, enhancing technology adoption skills and building up human capital through advances into higher education.

As I have shown in Pyo (1998), the role of human capital in Korea in its earlier development stage was as a productive input rather than as accumulated knowledge to provide externality. The growth miracle of South Korea is not a miracle but the result of sustained accumulation and use of human capital.

Another stylized fact to be observed is that the ratios of human capital (H) and physical capital (K) in Japan and Korea have increased over time but have not reached yet the level of United States which had been maintained at the range of .95-1.0 during 1947-1969 according to Kendrick (1976). Estimates by Pyo and Jin (2000) showed that the ratio of Japan had peaked in 1990 at .65 but started to decline to the level of .62 by 1996. The estimate by Pyo (1993) showed that the ratio of Korea had peaked in 1976 but declined to the level of .40 by 1990. If we regard the ratio of United States as a benchmark ratio of human capital and physical capital which

Azariadis and Drazen (1990) defines as a threshold point beyond which human capital can exhibit threshold externalities implied in endogenous growth theory.

The consideration of human capital in addition to physical capital would be especially meaningful if we regard the costs associated with the installation and the demolition of capital as important determinants for a long-run growth path. As Barro and Sala-i-Martin (2004) outlines, the adjustment costs would be especially important for increase in human capital through the process of education because the learning experience fundamentally takes time and attempts to accelerate the educational process are likely to encounter rapidly diminishing rates of return.

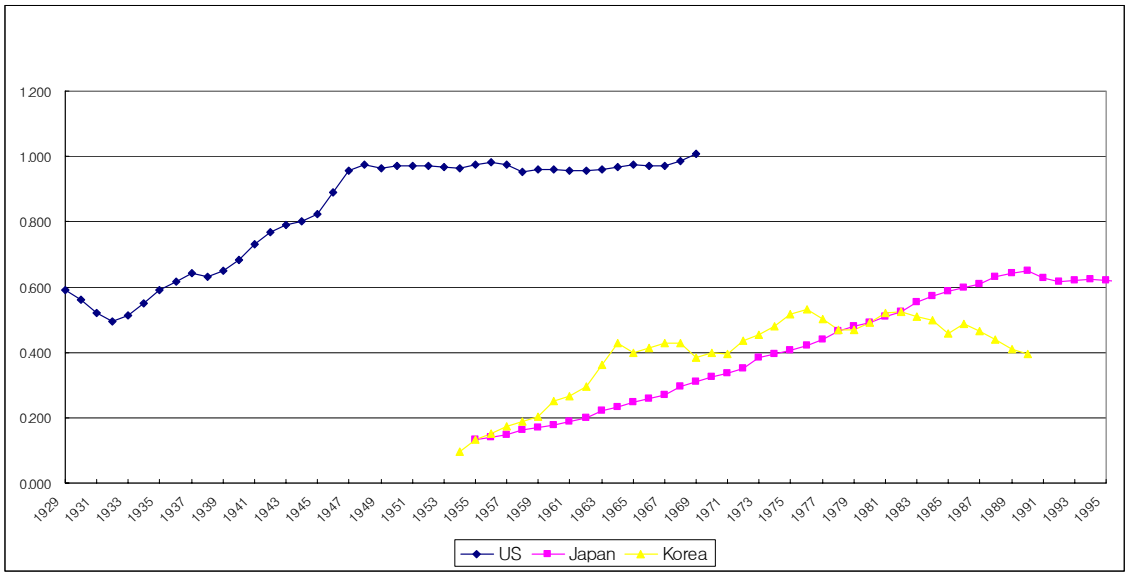
The consideration of human capital in addition to physical capital provides us with important implications on the speed of productivity convergence. In the course of economic development, per-capita human capital stock can be relatively high at the outset if the economies were particularly endowed with rich tradition of educational investment and historical infra-structure. But the fall in the ratio of human capital to physical capital over time would ultimately cause diminishing returns to per-capita physical capital to set in faster than otherwise. Therefore, the speed of convergence would be greater in the economy which enjoyed the higher shadow price of human capital than in the economy which did not enjoy the higher shadow price of human capital. I suppose that the East Asian economies may belong to the former category so that the current stagnation may reflect the phenomenon of diminishing returns to physical capital as the accumulation of human capital did not catch up.

(2) Labor Supply

Considering the unfavorable initial conditions such as lack of natural resources, high population density, existing twin gaps and war-devastated socio-economic infrastructures by early 1960's, Korean government had to rely on relatively abundant labor force to start up its engine for late development from 1962.

Other than educational indicators, the initial conditions in Korea around early 1960's were far from being favorable. The unemployment rate was high (8.1 %) in 1963 and the dominant portion (63.0 %) of population were still left at Agriculture, Forestry and Fishing. Since the primary sector's production share in 1963 GDP was only 43.4 percent, the economy was being dominated by a low-productivity primary sector.

Figure 5 The Comparison of H/K Ratio in US, Japan, Korea



Sources: Pyo and Jin (2000)

The employment statistic by industry shows a typical pattern of rural-urban migration and primary-manufacturing shift during the period of 1960-1974. As the economy passed the Lewisian turning point and the period of unlimited supply of labor was over around 1974, the unemployment rate was reduced from 8.1 percent in 1963 to 5 percent level in 1974. The proportion of employed persons in the primary sector declined very fast from 63 percent in 1963 to 34.0 percent in 1980 and 10.9 percent in 2000 while that of manufacturing increased fast between 1963 and 1980 from 7.9 percent to 21.6 percent but remained flat until 2000 (20.2 %).

The shift in labor supply from the primary sector to the secondary sector was made possible by various tax and subsidy incentives provided to manufacturing export industries. For example, there were tax incentives and at times subsidies in the construction of dormitory housing for plant workers and in the supply of wages-in-kind such as free or low-cost meals and clothing etc. Many elementary workers particularly women employees found the dormitory life safer and more convenient with modern facilities such as TV sets and refrigerators. Of course, the primary motivation of the labor shift came from higher wages and salaries in manufacturing and the job security. In the primary sector of agriculture and fishery, there were wide-spread disguised unemployment and the employment in the sector was very much cyclical and seasonal so that rural workers started dreaming of obtaining secured

employment in urban setting. A various OJT programs offered by firms eliminated the fear of urban employment by migrated workers from rural area.

In summary, the pattern of labor supply in Korea during last four decades can be characterized as follows. At the first stage (1960-1974), the vent-for-surplus type quantity of labor supply helped by the rapid expansion of primary education has dominated the scene. Also at this stage, the shift from the primary sector to the secondary sector was made being helped by rural-urban migration. Then in the second stage (1975-1987) there was major intra-industrial labor shift within manufacturing from labor intensive manufacturing to heavy and chemical manufacturing as shown in Row 8 of the Appendix Table. In the third stage (1988-2000), as the Korean economy moved into a more information and technology intensive structure and service-oriented economy, quality of labor rather than quantity of labor became more important than before.

(3) Physical Capital

The rate of growth in physical capital in Korea during last four decades is truly an unprecedented one. UNIDO estimate of 11.21 percent is quite similar to my own estimate of 11.39 percent even though the method of estimation is different. I have used the polynomial benchmark equation method linking four benchmark years' data rather than perpetual estimation method assuming 13.3 percent depreciation rate. My estimates of economic depreciation rate for the aggregate capital stock were lower than 13.3 percent; 9.4 percent during 1977-1987 and 7.8 percent during 1987-1997.

The growth rate in Korea was higher than the growth rate (10.3 %) of gross capital stock in Japan in its high growth period (1964-1985) and that of net stock in Taiwan(1960-1987) as I noted in Pyo (1996, Table 4). Such a rapid accumulation of physical capital can be made possible under the two conditions. One is a sustained continuation of high rates of return and the other is a continued rise in savings rate in particular private savings rate. As observed in Pyo and Nam (1999), Korea's before-tax gross rate of return (gross operating surplus/ gross capital stock) was as high as 33.7 % in 1971 higher than Japan's gross rate of return (31.2 %), which led Harberger to term two economies as "outliers". At the same time, two economies had maintained higher than OECD average savings rate. Even though both Japan and Korea experienced the rapid decline of rate of return from 1975 and from 1985 respectively

and their rates ultimately converged to OECD average level by early 1990's, they had met these two conditions for the rapid accumulation of physical capital.

The high rates of return in Korea during the 1970's and the1980's was made possible by the combination of two factors. One factor was the relative suppression on labor movement and wage increase and the continued incentive for internal corporate retained earnings through low-dividend policy. The other factor was households' preference for higher savings and lower consumption for educational purpose and investment in housing to guard themselves from hyper-inflation.

The expansion of primary education during late 1950's had opened up the possibility of moving up the ladder of higher education for many beneficiaries of primary education. They had been taught about the virtue of savings for higher education and for securing housing. The private savings rate in 1960 was only 5 percent but has more than doubled within a decade and more than tripled within two decades. The gross savings rate increased from 9.0 percent level in 1960 to 18 percent level in 1970, 24.4 percent in 1980 and 32.4 percent in 2000. The domestic gross investment ratio started off at 10.0 percent level in 1960 but increased fast to the level of 36.2 percent in 1980 exceeding gross domestic savings rate but reduced to the level of 28.3 percent in 2000. The sustainable productivity growth over four decades since 1960 in Korea was made possible by the sustained growth of gross domestic savings particularly private domestic savings, which were channeled into sustained domestic investment. Otherwise, Korea might have experienced foreign debt problem as many Latin American countries in the 1980's.

According to Economic Planning Board's Main Economic Indicators (1980), out of total gross domestic capital formation (100%) the share of government savings declined from 37.8 percent in 1960 to 19.4 percent in 1979 while the share of households' and non-profit organizations' savings increased from – 16.9 percent to 29.2 percent. Williamson (1977) pointed out that Korean households' financial savings were low because of low interest rate policy by the government and high inflation rates thus making real interest rate low. However, they saved in the form of housing without mortgage loans and other forms of savings in non-financial intermediaries.

The allocation of capital through credit control and policy loan schemes in earlier period and more liberalized financial system in later period must have

contributed to the accumulation of physical capital because the waste of capital was closely monitored by both government and banks controlled by government.

5. Technology Policy in Korea

The fruits of knowledge which is frequently hidden and intangible by its nature have been important determinant in Korea's productivity growth. The stock of knowledge at the beginning stage of development plans was very shallow such that it did not reach to the threshold level where externality can be put into effect.

The policy direction by the Korean government during the period of 1953-1961 was the promotion of import-substituting manufacturing by means of allocation of foreign exchange earned through foreign aid. Therefore, there was very little aspect of direct productivity-enhancing policies during the period of 1953-1961.

The trend continued even after the formal launching of Five-Year Economic Development Plan in 1962. From 1962 to 1981, most of productivity-enhancing policies were of the second type: targeting strategic export-promoting sector, designating certain areas as Export Processing Zone (EPZ), and series of trade policies designed to promote export industries. There was very little policy attempt to improve R&D facilities and technology adoption until the early 1980's.

As reviewed before, Korea was basically an agricultural economy by early 1960's.According to my long-run data base of Korea (Pyo, 2001), the share of the primary sector (Agriculture, Fishery and Forestry) in total value added has changed: 62.6 % (1911), 47.1 % (1938), 40.4 % (1953) and 41.1 % (1961). The share of the primary sector in total employment is estimated to have changed: 87.4 % (1911), 82.5 % (1938), 70.4 % (1953) and 64.2 % (1961).

The episode of productivity change has begun by a concerted effort of government and private sector. After the Rhee government was toppled by student demonstration on April 19, 1960, a weak cabinet government was formed but economic and political instability followed until President Park consolidated power through a military *coup* on May 16, 1961. The Park government was very weak in legitimacy and therefore, had to establish themselves by solving nation's economic hardship and eliminating poverty. They announced a series of economic stabilization measures including Freezing of High-interest Loans to farmers and fishery households on May 25, 1961. By the measure, farmers and fishers were supposed to pay back their loans to National Agricultural Cooperative Federation (public bank) at reduced

annual interest rate (12 %) over extended period of time (5 years). In turn, National Agricultural Cooperative Federation issued Agriculture Finance Bond to lenders which were supposed to be paid back at 20 % annual interest rate over 4 year-period after a one-year grace period. Under the measure, a total of 53.7 billion Hwan was registered as high-interest loans and 29.6 billion Hwan was ruled as eligible loans and 23.7 billion Hwan was paid back through the bond. Since at the time farmers and fishers were trapped by high-interest (at times over 40 %) curb-market loans which they had incurred as operating expense and child education fees etc., the measure was taken as a significant relief to them and became instrumental in their mobility to manufacturing sector.

The Economic Planning Board (EPB) was established in July 1961 as up-scaled Ministry independent of Ministry of Finance specializing in drafting and administering economic development plans and it was also given budgeting power and supervising role of public enterprises. The Deputy Prime Minister was appointed to head EPB and the planning and implementation of economic development plan was centralized. EPB drafted the First Five-year Economic Development Plan (FEDP) by end of 1961 and announced on January 5, 1962. Under the plan, two-types of industries were chosen as strategic industries. One is labor-intensive manufacturing sector such as plywood, wigs, simple assembly of home electronics and textile & apparel which have best potential for exports. The other is so-called basic industries for constructing infrastructure and providing basic materials for other industries such as steel & iron, cement, and electric power plants etc. which are import-substitutes.

During the First (1962-1966) and Second Five-year Economic Development Plan (1967-1971), the industrial restructuring has taken the form of inter-industry transformation mostly migration from Agriculture, Forestry and Fishery to Mining and Manufacturing and Services. When the first oil crisis shocked the country in 1974, the Korean government started realizing that exports of simple assembled manufactures may become no longer viable. In addition to material and intermediate product cost-inflation due to quadrupled oil prices, there was a substantial wage increase as the Korean economy passed Lewisian turning point around 1975 ending a period of unlimited labor supply.

According to Nurkse (1961), if the source of growth of an economy lies in the growth of a factor, one of the most important tasks is to allocate the factor to the industries with “incremental comparative advantage”. Nurkse (1961, P.308) made

distinction between "established" and "incremental" comparative advantage, which becomes necessary as soon as we apply the central concept of international trade theory to the problem of economic growth. After distinguishing between two types of industrialization, export promotion of manufactured goods to industrial countries and production for domestic markets, he then argued:

> *"It is to make use of growing resources which cannot with comparative advantage be absorbed by expansion in the traditional sectors that industrialization becomes really necessary. We therefore envisage industrial activities, whether for export or for home use, as being set up on top of the existing export sectors, so long as in these sectors a country still enjoys a high "established" comparative advantage even though, as a consequence of sluggish expansion of external demand, its "incremental " comparative advantage in these lines may be low."*

In other words, it is necessary to view comparative advantage in a dynamic setting for development strategy based on export promotion through industrialization. In case of Korea, the inter-industry transformation in the form of migration from traditional sector to Manufacturing has taken place during the period of 1962-1974. Then it was substituted by intra-manufacturing transformation and restructuring during the period of 1975-1979 from unskilled labor-intensive industries to skilled-labor intensive industries and more capital-intensive industries. This restructuring was provoked by the first oil crisis in 1973-74.

The second restructuring was carried out mainly during 1980's in order to rectify some of the investments which were ill-conceived or mismanaged. After President Park was assassinated in October 1979, there was a brief period of political instability and also the second oil crisis in 1980 followed. The growth rate of real GDP dropped from 9.3 percent in 1978 and 6.8 percent in 1979 to – 1.5 percent in 1980. The regime of President Chun coming from military background also had to seek a political legitimacy by improving economic conditions. One of the policy doctrines by President Chun was to follow President Park's principle of keeping economic policies independent of political and military influence. Most of major economic policy decisions were left to expert bureaucrats who had decided that there was a need to carry out a major industrial restructuring and reduce foreign debt.

During the period of 1975-79, some of the conglomerates carried out pre-emptive investments in heavy and chemical industries such as automobile, shipbuilding, cement, iron and steel, and refinery and petrochemical industries

following the Government policy direction to restructure economy from light industries to heavy and chemical industries. Many of such projects had become white-elephants in early 1980's and no longer viable. Some of the major conglomerates had to give up several projects and consolidation of excessive investment had become inevitable. The government initiated restructuring through government-controlled banks such as Korea Development Bank which had provided loans to major heavy and chemical industries projects.

During the period of 1980's there were some important policy shifts to help restructuring economy. The first shift was to promote technology-intensive industries after learning lessons from over-investing in heavy and chemical capital-intensive industries. From early 1980's Samsung entered into semi-conductor investments and Lucky-Goldstar (LG) and Hyundai followed Samsung. The second shift was made by Ministry of Commerce and Industry (MCI) which changed industrial support policy from direct support system to indirect support system. For example, in the 1970's MCI tried to identify so-called strategic export sector and promoted the industry by providing various incentive tax-cum subsidy system and easy access to loans by government controlled banks. But in the 1980's the direct support system was slowly replaced by indirect support system. For example, there was R&D support system and investment tax credit system for investments in energy-saving machinery and equipments and facilities. The third shift was to move toward import liberalization in commodity markets as documented in Pyo (1990). The trade liberalization effort in the 1980's had provided a significant incentive for industrial restructuring by reducing inflationary pressure and therefore, reducing financial distortion which existed in the form of the gap between official bank lending rate and unofficial curb-market rate.

The third industrial restructuring was made as a consequence of IMF bail-out measure after the December 1977 financial crisis. As documented in IMF (2003), it was a basically twin-crisis: a combination of domestic banking crisis and foreign exchange crisis. Under the system of IMF mandated bail-out, Korean industries had to go through a massive restructuring. As I have outlined in Pyo (2004), in 1997 there were thirteen *Chaebols* out of top-thirty *Chaebols* that went under court-supervised restructuring. The fundamental cause of the 1997 crisis in Korea was pre-emptive over-investments by major conglomerates while there was a significant reduction in rates of return. As I defined in Pyo (2000), it was the failure of excess competition

model as a consequence of unchecked financial liberalization and lax bank supervision.

The excess competition occurred not because *chaebols* were not interested in profits but because they began to realize that their protected market and regulatory regime was being threatened by the change in political economy between the government and *chaebols* and by increased foreign competition through full-scale trade and financial liberalization by Korea's accession to WTO and OECD. The change in political economy was inevitable because Korea was going through a very turbulent period of democratization in transition from quasi-military authoritarian regimes of Presidents Chun(1981-1987) and Roh (1988-1992) to a truly civilian government of President Kim (1993-1997). The transition implies a transformation from a strong government with more control power to a weaker government with less control power. In other words the alliance between the government and big business through exchange of political contribution and favoritism has been weakened creating an environment where *chaebols* are no longer well-protected in their respective markets. And the impending foreign competition had accentuated this trend and had made many conglomerates impatient and nervous and caused them to over-react or over-invest recklessly.

The industrial restructuring after 1998 has taken form of M&A and big-deals among troubled major conglomerates. In addition, as IT boom followed after the financial crisis, Korean industries have invested in IT sector and venture capital. But the investment stagnation was followed and therefore, the long-run prospect of productivity growth is quite uncertain at this point. After a massive restructuring in the form of cuts in employment and working hours, the labor productivity has improved but the overall gain in total factor productivity is not observed yet. But the recovery after the crisis was made possible by some productivity gain through industrial restructuring under IMF- mandated programs.

In summary, the episode of rapid productivity convergence in Korea was made possible by successful adoption of development strategy based on incremental comparative advantage and industrial restructuring by the government initiative. It was a consequence of interaction between market forces and government intervention.

Technology Policy and Competitive Environment

Korea has maintained a competitive environment in social mobility through education. It has also pursued egalitarian social and economic policies which may have helped the productivity growth.

The constant inflow of scientists and engineers from abroad was made possible as Korea's economic development passed the Lewisian turning-point in mid-1970s and since then followed the sustainable long-term high-growth. In the background of such constant inflow lies the mass-education but a very competitive education system. In such a social environment, promoting one's human capital was commensurate with promoting one's physical and financial wealth.

On the other hand in terms of industrial policy, the government has deliberately introduced limited competition by lowering entry barriers over time and by monitoring market failures by major conglomerates in order to maximize efficiency of limited resources as I have outlined in Pyo (2000). In other words, the government has played the role of competition promoter and supervisor through government-controlled banks which are part of quasi-internal organization. In this regard, the system has promoted monopolistic competition across industries. That is why one observes in Korea a larger number of automobile manufacturers, telecommunication equipment producers, mobile phone companies and so on than those normally observed in many developing countries or smaller advanced countries. For example, in automobiles there were at least three producers and in electronics there were always more than three competitors. In case of semiconductor industry, Samsung entered to the market in the early 1980's following the Japanese semiconductor manufacturers. But then the Korean government allowed market entry by Lucky-Gold Star (LG) and Hyundai to promote the competition. Such an example is not limited to export industries. The monopoly of Korean Airline Group in airline business was broken when government allowed the second airline's (Asiana) market entry in mid 1980's. In case of mobile telecommunication, the government tried to break the monopoly of SK in cellular phone service by issuing another license to a cellular operator called Shinsegi and then introduced further competition issuing licenses to three PCS service providers. The bureaucrats wanted to avoid such blame that they are bribed or lobbied by a certain business conglomerate.

Together with abundant reserve labor force with minimum education level, the social environment in a relatively egalitarian state seems to have interacted

positively toward gearing up launching an economic development plan. As outlined in Pyo (1996), the ruling class in the colonial period was discredited after gaining independence from Japan and most of land owners lost power after the land reform in 1949 and the subsequent Korean War. The social environment in early 1960's of Korea was pretty much a classless society in which average household regarded a better education for their children as best investment for upward social mobility. The Confucian tradition in favor of education must have acted positively too but it should be noted that the household's choice of educational investment was a rational economic choice rather than a cultural or religious one. The parents have expected higher rates of return on education of their children because in a classless society, upward social mobility is determined by education.

While there was a strong notion that Korea started off in the early 1960's as a relatively egalitarian society, the rapid accumulation of capital after the launching of development plan could have made income distribution worse than before. There are no reliable statistics of income distribution in 1970's and early 1980's. The Family Income and Expenditure Survey by National Statistical Office provide index of concentration (Gini Coefficient) starting from 1985 and Urban Wage Earners' Households Income from 1993. These two sources of income distribution statistics show a conflicting pattern. The former Gini coefficient has improved from 0.345 in 1985 to 0.295 in 1996 just before Korea's financial crisis of 1997 as shown in Appendix Table. On the other hand, the latter Gini coefficient has deteriorated from 0.281 in 1993 to 0.291 in 1996 and 0.317 in 2000. The latter Gini coefficient seems more reliable because it reflects the impact of a financial crisis on income distribution: in general, a financial crisis worsens income distribution because of increase in unemployment and high interest policy ensuing after the crisis which makes the rich richer and the poor poorer because the former has financial assets while the latter has financial debts.

Korea-specific factors such as historic legacy coming from the Japanese Colonial Period (1910-1945) and the division of the Korean peninsula and the resulting national preoccupation with security issues should be addressed. Political environment and security issues should be added to provide broader picture of Korea's unique development history.

Defense budget in Korean government expenditure occupied 53.7 percent in 1953, 35.0 percent in 1960, 20.0 percent in 1990 and 11.2 percent in 1999. At the

time of launching Economic Development Plan in early 1960's, the defense budget was an overhang to the economy. At times, the constant confrontation with North Korea was used as a means of political suppression by authoritarian regimes and suppression on union movements. However, the security issue has had some positive aspects in lifting up overall productivity of the economy. For example, national conscription system might have deprived from Korean youths of their opportunity to advance the next ladder of learning and training but it also provided them a minimum general education to read and write and most of all a discipline as workforce.

The vent-for-surplus type supply of labor force has been the cornerstone of Korea's rapid industrialization. But it was only a part of necessary conditions. There must have been interaction in a market economy between government and entrepreneurs. The government established after a military coup by President Park in 1961 lacked the legitimacy as a democratically elected government. Therefore, they sought for restoring the popularity of their regime by carrying out economic development plans successfully. In other words, their political stability depended on economic prosperity and most of all they had to create jobs for the urban unemployed and the vast disguised unemployed in the rural sector.

The experience of the second oil shock and the first negative growth in 1980 in the political instability followed after the assassination of President Park had made the entire HCI plans reevaluated. The turning point in Korea's industrial policy came in 1983 when the government switched from direct industrial promotion to indirect and functional support system. In other words, the new industrial support system was designed to avoid sector-specific industrial promotion and targeting strategy and to introduce more competition through import liberalization. Under the new paradigm of industrial policy, for example instead of supporting specific industries such as cement and steel manufacturing, the government supported investments in energy-saving machinery and equipments by a variety of financial-incentive and tax-incentive system. At the same time, the relative importance in industrial targeting was switched from capital-intensive industries to technology-intensive industries. Samsung started investing semi-conductor manufacturing in order to catch up Japanese firms and the Korean government allowed LG and Hyundai to enter into semi-conductor market to

promote competition. There was also active support into software industries to promote technology-intensive industries.

As a conclusion on the link between government policy and productivity enhancement, the episode of Korea provides us with clear evidence on the positive role of government in promoting productivity through both direct policies such as public R&D expenditure and indirect policies based upon subsidies and other incentive systems. But the set of government policies aimed at promoting productivity needs to be coordinated in terms of timing and internal check and balance. The implementation of such policies at the right timing is one of the most important aspects. For example, high educational capacity can be a necessary condition but not a sufficient condition for large-scale public R&D expenditure. At the beginning of industrial development, technological diffusion rather than technological innovation could be more important and practical so that large-scale public R&D can be launched at a later stage of development when R&D infrastructure is built and there arises genuine motivation for indigenous R&D effort as Korea waited until early 1980's.

The Political Economy and Institutional Aspects of Technology Policy

In order to promote competition among big firms, the Fair Trade Act was introduced in October 1971. In 1981, Fair Trade Commission designated a total of 666 firms in 14 industries as restricted from forming cartels. In June 1985, the government required C*haebols* to register their cartels in order to avoid their excessive concentration power. At the present time, Fair Trade Commission remains as a powerful watchdog to large conglomerates and *Chaebols.*

The transition from authoritarian or semi-authoritarian regime to a democratic one was far from being smooth. At times Korea had to go through a very turbulent period both politically and economically. As I observed in Pyo (2000), a distinguishing feature of export-led growth in Korea was its unique industrial structure. The government policy protected bureaucrats from accusations of being linked to one or two conglomerates' interest but, at the same time, provided big conglomerates with irresistible incentives for horizontal diversification. The phenomenon of 'too big to be failed' set in because big conglomerates themselves were stockholders of many financial institutions and the moral hazard in financial institutions started eroding their competitiveness. The top 30 conglomerates were

producing over half of Korea's GNP and the top five conglomerates' share was as much as one-third of the country's total production.

The business groups called *'chaebol'* in Korea many look quite similar to the Japanese 'zaibatsu', but they are different in many respects. First, Korean *chaebols* had to rely on developing the export market more intensively than the Japanese firms because their domestic market size was less than 5 per cent of the Japanese domestic market size in 1975 (US$20.9 billion, as against US$499 billion, in term of GNP) and less than 9 per cent in 1995 (US$ 453 billion, as against $5156 billion, in terms of GNP). As a result, there could coexist in Japan two types of zaibatsu: one is a highly specialized technology leader in multinational markets (for example, Toyota, Sony and Toshiba) and the other is a business group of horizontally diversified firms (for example, Mitsubishi group, Mitsui group, Sumitomo group and Fuji group). But, in Korea, only the latter type (for example, Samsung, Hyundai and Lucky-Goldstar) could be established because specialization was riskier than diversification under the oligopolistic setting with the government regulation on entry and exit. In addition, diversification through cross-shareholding could generate higher economies of scale in a limited domestic market.

Second, the way the business groups are governed in Korea is quite different from that in Japan. As a result of dissolution of zaibatsu under the MacArthur administration, there were few dominant family groups which could own and manage zaibatsu. The corporate ownership structure in Japan is a more diversified one than that in Korea and the role of institutional investors is much more important in Japan than in Korea. As a result, the decision-making process and the corporate governance in Japan are much more consensus-based than those in Korea. Such a difference in ownership structure and governing pattern could make a substantial difference to the outcome of the excess competition because a more consensus-based system can survive better than an authoritarian owner-management system at the time of policy failure and can protect itself from overextension through a built-in system of checks and balances.

6. Concluding Remarks

Since the early 1990's the model of monopolistic competition across industries in Korea has been subject to change both domestically and internationally. First of all, the so-called 'Lipset phenomenon' has arrived on the sociopolitical scene of Korea, as

outlined in Pyo (1993). The country's success in export-led growth had brought about increasing demands for democracy and the transition from an authoritarian regime to a democratic one has been turbulent rather than smooth. The increasing demand for higher wages and benefits by organized labor through, at times, violent disputes and strikes had placed an extra burden on firms' efforts at restructuring and 'downsizing'. But most important of all, in the face of increasing domestic and foreign competition, some monopolistic competitors had carried out a series of ill-fated pre-emptive strategic investments. As anticipated in Pyo et al, (1996), the potential impacts of the World Trade Organization (WTO) in a general equilibrium context had become much greater than those in a partial equilibrium context. One typical manifestation of such impacts was over-investment in non-tradable sectors and pre-emptive investment in some tradable sectors.

Considering the current market trend towards deregulation and privatization, it was difficult for the government to discourage the entry. Even though it did not materialize owing to the objections by the government and the subsequent financial turmoil, we could have seen another pattern of oligopolistic competition in the steel industry, too. Many Korean firms in the automobile industry and the semiconductor industry tried to put themselves in strategic positions in the global market. They seemed to take the view that there was increasing demand for their products from emerging markets and transition economies. They regarded their products as not necessarily top-quality goods but as reasonably priced, competitive products in such markets.

Their success or failure depended on their income-generating capacities because they had to pay back interests and principals of the loans they had borrowed from domestic and foreign banks. This game of high-yield high-risk in strategic markets was to determine the substantiality of export-led growth in Korea. Such a game could not have been maintained if there was no moral hazard in the financial sector and if the government was strong enough to insulate its bureaucrats from the distributive politics among *chaebols* and other interest groups, including labor unions. But neither condition was met. In addition, the owner-management corporate governance without consensus building and internal checks and balances resulted in over-investment in existing business and caused excessive competition against a background of moral hazard in the financial sector and lax banking supervision by

weak government. In my judgment, this was the most fundamental cause of the financial crisis in Korea.

A recent report by the Independent Evaluation Office (IEO) of the IMF (2003) has characterized the financial crisis of 1997 in East Asia as a new type of balance of payments crisis which has been triggered by a massive capital inflows followed by a sudden capital outflows. In particular, the report has noted that the nature of the crisis in Korea and Indonesia was "twin crises" in which the external crisis coincided with a banking crisis. We can identify South Korea, Indonesia, Malaysia, Thailand, and the Philippines as five Asian-Crisis countries and Japan, Hong Kong, Singapore, Taiwan, and China as other five East Asian non-crisis countries.

The overall assessment on the macroeconomic performance by Asian-Crisis countries is that the rebound of growth over the period of 1999-2000 has slowed down in the subsequent period of 2001-2003 mainly because of stagnant demand for domestic investment across all crisis-inflicted economies. In particular, the domestic investment on Machinery and Equipment has been very disappointing. For example, in case of Korea, its average annual growth rate was 17 percent during the pre-crisis period of 1994-1996 and became negative during the crisis-years in 1997(- 9.6 %) and 1998(- 42.3 %). Then the average annual growth rate has become explosively positive in 1999 (36.8 %) and 2000 (33.6 %) but suddenly has dropped in 2001 (-9.0 %), 2002 (7.5 %) and 2003 (-1.2 %).

There are two main issues at hand in examining the investment trend in the post-recovery period in Asian-Crisis countries. One issue is whether the stagnation in investment is a permanent phenomenon and, therefore, the period of "East Asian Miracle" is over. The other issue is why the volatility of investment is so large during the post-crisis period of 1999-2003.

Economic development and late industrialization is often a complex interaction between endogenous historical heritages and imported institutional elements. It involves more than mechanical income-growth dynamics. Therefore, we want to go beyond the traditional explanations of the determinants of free market system and search for more cultural and historical aspects. The reason is that without expanding the boundaries of our research, we may not be able explain for the rising sentiments of anti-market movements and pro-socialist policy doctrines under increasingly unwarranted egalitarianism in recent years in Korea.

During the process of rapid economic development, Korean people used to think that the remarkable achievement of growth is mainly due to either government's planning or work-ethics of the ordinary workers, without realizing the role of entrepreneur for finding the business opportunities. They regarded free-enterprise system is basically implanted system and viewed it as free-good in a capitalist society. In recent years, while there are ample evidences of benefits of free enterprise system, some anti-market and anti-business sentiments have been growing among civil activists, intellectuals, and union leaders. We have begun to realize that free enterprise system is not free.

The free enterprise system and entrepreneurship is like two sides of coin: without one, the other cannot survive. As I argued before, one of the main reasons why Korea could grow so fast under dictatorship is because the dictatorship was relatively less-corrupted and it pursued export promotion maintaining a certain degree of transparency in who gets what and how. Through this system the entrepreneurship in Korea could be nurtured making one of the most successful story of late industrialization.

The current situation would become worse, as many international consulting organizations ascribe the poor performance in national competitiveness to environment and institutions hostile to business activities. This hostile environment inside Korea is a fatal problem for further growth, as international economies become more integrated: Korean firms tend to stop investing domestically and foreign investments do not flow into Korea.

In order to resume sustainable growth and renew the productivity convergence Korea needs to find a new paradigm of technological advancement and growth-oriented system under drastically changed social and political landscapes. The Korean economy has been struggling in finding such a path under a non-authoritarian regime. It may take much longer time than expected because under the current mode of globalization, relying on market mechanism seems to be the only solution for a small open economy like Korea.

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Appendix

Table A1 Major Social and Economic Indicators of Korea (1960-2000)

Social and Economic Indicators	1953	1960	1980	2000
1. Population Trend (In thousand persons)				
Census Enumeration		24,989	37,436	46,136
Household (In thousand)		4,371	7,969	
Average number of member (In persons)		5.6	4.5	
Estimates of midyear population	20,527[2]	25,012	38,124	47,008
Male	10,083[1]	12,551	19,236	23,667
Female	10,443[1]	12,462	18,888	23,341
Sex ratio (per 100 female)	96.6[1]	100.7	101.8	101.4
Population density (persons per sq.Km)	208.5[1]	254.1	385.1	472.6
2. Summary of Economically Active Population				
Population 15-year old and over		14,551[3]	24,463	36,139
Economically active population		8,230[2]	14,431	21,950
Employed		7,563[2]	13,683	21,061
Unemployed		667[2]	748	889
Non-economically active population		6,321[2]	10,032	14,189
Unemployment rate (%)		8.1[2]	5.2	4.1
3. Employed Persons by Industry (%)				
Agriculture, Forestry and Fishing		63.0[4]	34.0	10.86
Mining and Manufacturing		8.7[3]	22.5	20.23
Manufacturing		7.9[3]	21.6	20.15
Social overhead capital and other services		28.3[3]	43.5	68.91
Construction		2.5[3]	6.2	7.5
Wholesale & retail trade, restaurants & hotels			19.2	27.2
Transport, storage & communication			4.5	6.0
Finance, Insurance, Real estate & Business, service			2.4	9.9
4. National Income (At current prices)				
GNI (Billion US $)	1.4[5]	1.9	60.9	635.4
GDP (Billion US $)	1.3	2.0	62.2	457.4
Per Capita GNI (US $)	67[6]	79	1,598	9,628
5. Growth rate by kind of economic activities [7](%)				
GNI	5.1[8]	1.1[9]	-5.3	3.6
GDP	5.6[7]	1.2[8]	-2.1	9.3
Agriculture, Forestry and Fishing	8.0[7]	-2.1[8]	-20.0	2.0
Mining and Manufacturing	11.5[7]	10.9[8]	-1.2	15.7
Manufacturing	18.1[7]	8.2[8]	-1.6	15.9
Electricity, gas and water	22.7[7]	-0.0[8]	-0.5	14.0
Services	1.2[7]	2.6[8]	2.2	9.5
Producers of government and non-profit services			4.4	0.3
Social and Economic Indicators	**1953**	**1960**	**1980**	**2000**
6. Production Structure (% at current price)				

[2] 1952
[3] 1963
[4] 1963
[5] Gross National Products
[6] Per Capita GNP
[7] Series at 1995 constant prices
[8] 1954
[9] Gross National Products

Agriculture, Forestry and Fishing	47.3	36.8	14.7	4.7
Mining and Manufacturing	10.1	15.9	29.7	31.6
Manufacturing	9.0	13.8	28.2	31.3
Electricity, gas and water	2.6	4.1	10.1	10.8
Services	40.0	43.2	36.0	43.1
Producers of government and non-profit services			9.5	9.8
Industrial Structure				
Light Industries	78.9	76.6	46.4	22.3
Heavy and Chemical Industries	21.1	23.4	53.6	77.7
7. Gross Output and Value-added of Manufacturing (In billion Won, %)				
Gross Output				
Manufacturing	25.3[10]	59.7	36,279.0	564,834.1
Food products, beverages and Tobacco	6.7[9]	12.7	4,979.4	41,129.3
(Composition ratio)	(26.48)	(21.27)	(13.73)	(7.28)
Textiles, Wearing apparel and Leather	9.0[9]	18.1	6,495.4	40,998.6
(Composition ratio)	(35.57)	(30.32)	(17.90)	(7.26)
Wood and products of wood & cork	1.7[9]	4.3	883.8	3,171.7
(Composition ratio)	(6.72)	(7.20)	(2.44)	(0.56)
Pulp, paper products, printing and publishing	1.5[9]	3.7	1,401.6	23,214.3
(Composition ratio)	(5.93)	(6.20)	(3.86)	(4.11)
Chemical products, refined petroleum products, Coke, Rubber and plastic products	2.7[9]	9.3	10,068.4	117,660.4
(Composition ratio)	(10.67)	(15.58)	(27.75)	(20.83)
Non-metallic mineral products	0.8[9]	3.6	1,601.6	16,983.3
(Composition ratio)	(3.16)	(6.03)	(4.41)	(3.01)
Basic metals	0.6[9]	1.8	3,387.3	44,590.8
(Composition ratio)	(2.37)	(3.02)	(9.34)	(7.89)
Fabricated metal products Machinery and equipment n.e.c.	1.9[9]	5.3	6,960.8	267,816.0
(Composition ratio)	(7.51)	(8.88)	(19.19)	(47.41)
Others	0.5[9]	0.9	500.7	9,269.6
(Composition ratio)	(1.98)	(1.51)	(1.38)	(1.64)
Value-added				
Manufacturing		21.9	11,856.60	219,424.60
Food products, beverages and Tobacco		4.2	1,968.30	18,117.70
(Composition ratio)		(7.04)	(5.43)	(3.21)
Textiles, Wearing apparel and Leather		6.4	2,311.20	17,561.10
(Composition ratio)		(10.72)	(6.37)	(3.11)
Wood and products of wood & cork		1.4	205.9	1,285.90
(Composition ratio)		(2.35)	(0.57)	(0.23)
Pulp, paper products, printing and publishing		1.7	526.6	10,558.20
(Composition ratio)		(2.85)	(1.45)	(1.87)
Chemical products, refined petroleum products, Coke, Rubber and plastic products		2.9	2,427.40	35,441.10
(Composition ratio)		(4.86)	(6.69)	(6.27)
Non-metallic mineral products		2.0	682.6	8,423.50
(Composition ratio)		(3.35)	(1.88)	(1.49)
Basic metals		0.5	924.1	13,917.40
(Composition ratio)		(0.84)	(2.55)	(2.46)
Fabricated metal products Machinery and equipment n.e.c.		2.3	2,587.70	110,190.70
(Composition ratio)		(3.85)	(7.13)	(19.51)
Others		0.4	222.8	3,927.90
(Composition ratio)		(0.67)	(0.61)	(0.70)
Social and Economic Indicators	**1953**	**1960**	**1980**	**2000**
8. Savings ratio and Investment ratio (%)				
Gross savings ratio	13.1	9.0	24.4	32.4
Private	11.1	5.0	19.1	19.3
Domestic gross investment ratio	14.7	10.0	36.2	28.3
Domestic gross fixed investment ratio	6.9	9.9	34.0	28.5
Ratio of Investment to abroad	-1.6	0.4	-8.5	
Ratio of Exports and Imports to GNI	11.7	16.0	80.3	90.3
Exports	3.2	4.1	34.6	46.4

[10] 1955

Imports	9.8	12.7	45.8	43.9
9. Electric Power (In GWh, %)				
Total power generated	736	1,697	37,239	266,400
Hydro	395	580	1,984	5,610
(Composition ratio)	(53.7)	(34.2)	(5.3)	(2.1)
Thermal	130	1,117	31,778	151,826
(Composition ratio)	(17.7)	(65.8)	(85.3)	(57.0)
Nuclear			3,477	108,964
(Composition ratio)			(9.3)	(40.9)
Power sold		1,154	32,734	239,535
Consumption per capita (Kwh)		46	859	5,067
10. Number of Registered Motor Vehicles (In thousand)				
Total	12.8	30.8	527.7	12,059.30
Passenger cars	3.7	128	249.1	8,083.90
(Composition ratio)	(28.6)	(41.5)	(47.2)	
Private	1.6	4.2	178.5	7,798.5
Truck	6.8	13.4	226.9	2,511.0
(Composition ratio)	(53.3)	(43.7)	(43.0)	
Buses	2.2	4.2	42.5	1,427.2
Special car	0.2	0.4	9.2	37.1
Number of Licensed Drivers			1,860.7	18,697.3
11. Communication System and Number of subscribers				
Number of communication systems (In thousand)	26	108	2,835	23,841[11]
Analog	26	108	2,815	
Digital			20	23,841[10]
Number of telephone subscribers (In thousand)	23	87	2,705	21,932
Business			971	
Households			1,734	
Telephone subscribers per 100 people (%)		0.3	7.1	47.5
Number of public telephone (In Each)		609	58,017	539,983
12. Overseas Direct Investments (In million US$)				
Total permitted			250.7[12]	
Total invested			145.2[11]	3,668.2
South-east Asia			52.9[11]	829.7
North America			32.7[11]	1,159.4
Europe			5.2[11]	142.1
Liquidation etc.			18.2[11]	191.3
Net invested			127.0[11]	3,476.9
Investment outstanding			127.0[11]	25,816.3
13. Investments from abroad (In million US$)				
Total		47.4[13]	143.1	15,696.7
U.S.A.		25.0[12]	70.6	2,922.3
Japan		8.3[12]	42.5	2,448.2
Hong Kong		2.8[12]	0.5	123.5
Germany		0.2[12]	8.6	1,599.4
United Kingdom		10.5[12]	2.3	84.3
France				607.2
Netherlands			1.8	1,768.4
Social and Economic Indicators	**1953**	**1960**	**1980**	**2000**
14. Elementary School				
Number of School	4,033	4,496	6,487	5,267
Number of Students	2,259,313	3,622,685	5,658,002	4,019,991
Female students (%)			48.5	
Enrollment ratio		99.8	102.9	98.7
Number of Teachers	35,059	61,605	119,064	140,000
Female teachers (%)		22.0	36.8	
Number of Students per teacher	64.4	58.8	47.5	28.7
Number of Students in a class	57.6	57.0	51.5	35.8
15. Advance Rate of Graduates to Higher School Level (%)				

[11] 1997
[12] 1968~1980
[13] 1962~1966

Advance Rate of primary school Graduates to middle school			95.8	99.9
Male			97.4	99.9
Female			94.1	99.9
Advance Rate of middle school Graduates to high school		70.2[14]	84.5	99.6
Male			87.5	99.6
Female			80.8	99.6
Advance Rate of high school Graduates to higher education		29.8[13]	23.7	68.0
Male			24.5	
Female			22.5	
16. Composition of Population by Education Attainment (25 Years Old & Over, %)				
Primary School Graduates and Under	91.8[15]	79.6[16]	55.3	23.0
Male	86.0[14]	68.9[15]	42.8	15.1
Female	97.1[14]	89.5[15]	67.0	30.4
Middle school Graduates	5.3[14]	11.1[15]	18.1	13.3
Male	8.9[14]	15.9[15]	19.8	12.3
Female	2.0[14]	6.6[15]	16.5	14.3
High school Graduates	1.7[14]	5.6[15]	18.9	39.4
Male	2.7[14]	8.5[15]	25.4	41.6
Female	0.7[14]	2.9[15]	12.9	37.3
College, University Graduates and Over	1.3[14]	3.7[15]	7.7	24.3
Male	2.4[14]	6.7[15]	12.0	31.0
Female	0.3[14]	1.0[15]	3.6	18.0
17. Private Institutes (In each, person)				
Institutes		1,136[17]	5,023	57,935
Liberal arts & sciences course		214[16]	381	14,043
Art course		193[16]	1,485	26,160
Management business field		92[16]	1,367	11,029
Attendants		52,009[16]	411,162	7,772,909
Liberal arts & sciences course			117,618	1,388,333
Art course			52,808	987,610
Management business field			123,922	565,350
Instructors			13,332	135,637
Social and Economic Indicators	**1953**	**1960**	**1980**	**2000**
18. Public Education Cost per capita (In thousand won)				
Elementary Schools		4.7[18]	118.5	2,023
Middle Schools		9.5[17]	157.2	2,690
High Schools		19.7[17]	149.7	2,841
Junior colleges		53.0[17]	708.0	3,095
National & Public		50.4[17]	893.3	2,471.0[19]
Teacher's College		44.2[17]	1,114.0	6,449
College & university		68.3[17]	1,036.3	5,526
National & Public		93.3[17]	1,198.2	4,673.8[18]
19. Institutions and Personnel Engaged in R&D				
Research activity performance Institutions		72[20]	647	4,635
Research Institutes			124	173
University & College			202	268
Companies			321	4,194
Researchers		1,750[19]	18,434	159,973

[14] 1962
[15] 1955
[16] 1966
[17] 1965
[18] 1967
[19] 1997
[20] 1963

Research Institutes			4,598	
University & College			8,695	50,155
Companies			5,141	70,431
Researchers per 10,000		0.6[19]	4.8	
20. R&D Expenditures character of work (In billion won)				
Total		1.2[21]	621.7[22]	13,848.5
Ratio to GDP (%)		0.24[20]	0.97[21]	2.67
Basic research			113[21]	1,746.1
(Composition ratio, %)			(18.2)	(12.61)
Applied research			179.4[21]	3,370.1
(Composition ratio, %)			(28.9)	(24.34)
Experimental development			329.4[21]	8,732.3
(Composition ratio, %)			(53.0)	(63.06)
21. Water supply				
Water supply (In thousand)	3,451[23]	4,210	20,809	41,774
Water supply ratio (%)		16.8	54.6	87.1
Capacity (In thousand ton per day)	240[22]	517	6,756	26,980
Water supply per person a day (litter)	65[22]	99	256	380
Number of Regions with Water Supply (In each)	50[22]	58	243	861
22. Distribution of Income (Gini Coefficient)				
Family and Expenditure Survey			0.345	0.295
Urban Wage Earners' Households			0.291	0.317
23. Labor Union				
Number of Unit unions			2,141	5,698
Union Members (1,000 persons)			967	1,527
Union Membership Rate (%)			20.8	12.0
Number of Labor Dispute Cases			1,873	250
Working Days Lost(Days)			5,400,837	1,893,563

Sources: Korea National Statistical Office, Social Indicators in Korea (2001), Korea Statistical Yearbook (2001), and Changes in Social and Economic Life in Korea during last Five Decades (1998)

[21] 1963
[22] 1983
[23] 1954