# 23. ESTIMATES OF LABOR AND TOTAL FACTOR PRODUCTIVITY BY 72 INDUSTRIES IN KOREA (1970–2003)

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## Introduction

In recent years, especially since the 1997 economic crisis in the East Asian countries including Korea, considerable changes have taken place in the Korean economy, such as investment stagnation (see e.g. Pyo (2006) Pyo and Ha (2005)), changes in production input patterns, and so on. One of the most important changes is the demand for high productivity, which would compensate the recent slowdowns of growth rates in capital and labor inputs. As Krugman (1994), Young (1994), and Lau and Kim (1994) showed, the East Asian economic miracle may be summarized as `input-led' growth. Korea was no exception in this respect of growth pattern.

However, both the stagnation in investment and the decrease in average working hours require a productivity surge for long-term growth in Korea. In addition, a sharp decrease in the fertility rate in Korea necessitates productivity increase in order to improve the present income level and facilitate the support of the large elderly population by the small numbers of working age adults. For these reasons, `productivity-driven' growth is indispensable for Korea. According to Lewis (2004), the fast economic growth in Korea is the result of both large labor input and capital accumulation. He argues that the average working hours is 40% higher than that of the U.S., and almost a third of GDP has been allocated to investment, while GDP per capita in Korea is about half of the U.S. GDP per capita. The focus is changing from how much inputs are put into production to how well those are organized.

The purpose of this paper is to explain the data structure of Korea for the estimation of productivities by industry in KLEMS model and present preliminary estimates of labor productivity and total factor productivity (TFP) at reasonably detailed industry level. We have used 72-sector industrial classification following the guidelines of EU KLEMS project for the future comparability with EU member countries, the United States, and Japan. Therefore, an analysis based on detailed industrial classification gives us better views on productivity and growth, which is difficult to grasp in broader industrial classifications. Industries in an economy

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have shown different productivity trends and growth patterns according to their characteristics of production, competition policies, and other economic and non-economic circumstances.

KLEMS model is a kind of gross output growth accounting in which output is measured by gross output and inputs are decomposed by capital (K), labor (L), energy (E), material (M), and service (S). Since this methodology is basically based on gross output, it has the advantage of eliminating effects of intermediate inputs from other industries on productivity, therefore allowing productivities by industry to be more accurate. Moreover, the assumption on real value-added production function (separability assumption) is not usually guaranteed[344], which also gives legitimacy to gross output growth accounting. However, gross output growth accounting requires more information on intermediate inputs than value-added growth accounting. Therefore, the data structure for estimating productivity has to be consistent with not only national income accounts but also input-output tables, Use and Make Matrix etc. and the estimation methodology for unavailable data should be examined more carefully.

We have found that Korea's catch-up process with industrial nations in its late industrialization has been predominantly input-led and manufacturing based. We have also found that TFP growth has been positively affected by the growth of labor productivity and output growth. However, since its financial crisis in December 1997, the sources of growth seem to have switched to TFP-growth based and IT-intensive Service based. But lower productivity in service industries due to regulations and lack of competition seems to work against finding renewed sustainable growth path.

This paper is organized as follows. Section 2 examines data structure including the methodology of measuring gross output by industry from Input-Output Tables and National Accounts published by the Bank of Korea and input measurements. Section 3 presents the estimates of labor productivity and TFP by 72-industry and examines the relations between labor productivity and TFP and between output growth and TFP growth by periods. Section 4 concludes the paper.

## Data Structure

### *Gross Output Data*

National Accounts by the Bank of Korea (1999, 2004) report annual series (1970–2002) of nominal gross outputs at basic prices, both nominal and real value-added at basic prices, nominal compensation of employees, and operating surplus at current prices of 21 industries including 9 manufacturing industries. Those data can be extended to the year 2005 from ECOS (Economic Statistics System) in the Bank of Korea website[345]. National Accounts (1987, 1994, 1999, 2004) also reports annual series (1985–2002) of both nominal and real Make Tables (V-Tables) and real Use Tables (U-Tables).

344 See Berndt and Christensen (1973,1974), Berndt and Wood (1975), Denny and Fuss (1977), and Yuhn (1991) for the U.S., and Pyo and Ha (2005) for Korea

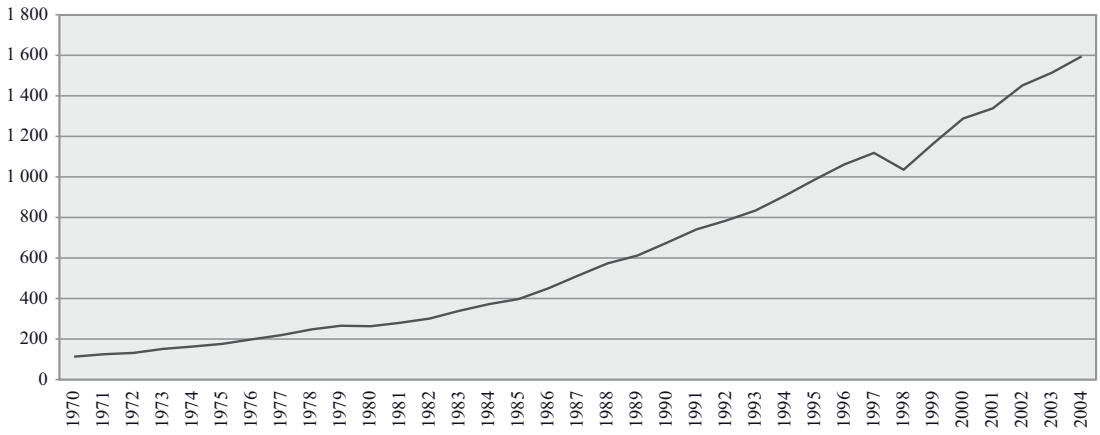
345 http://www.bok.or.kr

In addition to nominal gross output and both nominal and real value-added, real gross output at basic prices and real intermediate inputs at purchase prices can be obtained from Use Tables. However, since Make Tables and Use Tables for the years 1970–1984 and 2003–2004 are unavailable, we have generated them through RAS method using annual data from National Accounts and Input-Output Tables, and benchmark tables of 1985 and 2000, respectively. As the published Use Tables of National Accounts in Korea present the Domestic and Import Use Tables combined, we have not been able to isolate them into two separate tables. In the case of Use Tables before 1995, all the intermediate commodity inputs by industry are measured at purchase prices. Since 1995, those inputs have been measured at incomplete basic prices in the sense that those inputs include trade and transportation margins but isolate net production tax to the last row of intermediate input matrix. Because we have no information for transformation of the Use Tables from purchase prices to basic prices before 1995 and the Use Tables after 1995 have been measured at incomplete basic prices, we have changed the Use Tables at basic price after 1995 into Use Tables at purchase price allocating net production tax to each commodity proportional to each volume.

The trend of gross output has been shown in graph 23–1. There was no real break in gross output growth in Korea's economy-wide economic performance except in the year 1998 after the financial crisis in December 1997. Even during the years of first oil crisis of 1974–1975 and the second oil crisis of 1980–1981, the Korean economy's real gross output continued to grow without major setbacks. After the economic crisis of December 1997, Korean economy had to go through IMF-mandated adjustment and restructuring program as documented in Pyo (2004). We observe that even though economy-wide labor productivity continues to grow, the disparity between labor productivity in Manufacturing and that in Service has been widening. As the IMF-mandated restructuring in Manufacturing sector has improved on labor productivity gain through cut-back of unnecessary manpower, the restructuring in most of Service sectors except a few IT-related finance and communication sectors has been lagging behind.

**Trend of Real Gross Output**
(2000 prices)

**G 23–1**



### *Measurement of Capital Input*

The success of late industrialization by newly industrializing economies could not have been made possible if both the rapid accumulation of capital and its changing distribution among sectors were not realized in their development process. However, it is difficult to identify these factors empirically because the time series data of capital stocks in fast-developing economies by both types of assets and by industries are not readily available. The lack of investment data for a sufficiently long period of time to apply the perpetual inventory estimation method was the main cause of the problem. However, the National Statistical Office of the Republic of Korea has conducted nation-wide national wealth survey four times since 1968. Korea is one of a few countries which have conducted economy-wide national wealth surveys at a regular interval. Since the first National Wealth Survey (NWS) was conducted in 1968, the subsequent surveys were made in every ten years in 1977, 1987, and 1997, respectively. Since such regular surveys with nation-wide coverage are very rare in both developed and developing countries, an analysis on the dynamic profile of national wealth seems warranted to examine how national wealth in a fast growing economy is accumulated and distributed among different sectors.

The estimation of national wealth by types of assets and by industries was made by Pyo (2003) by modified perpetual inventory method and polynomial benchmark year estimation method using four benchmark-year estimates. We have extended his estimates to the year 2004, and changed the base year from 1995 to 2000. Since the database of Pyo (2003) covers 10 broad categories of industrial sector together with 28 sub-sectors of Manufacturing, it has been reclassified and reconciled with 72 industry classification using other sources such as Mining & Manufacturing Census and Surveys, Wholesale and Retail Surveys, and so on. We have classified assets into five categories; residential building, non-residential building, other construction, transportation vehicles, and machinery, while excluding large animals & plants, household durables, and inventory stocks. We have used estimated depreciation rates in Pyo as shown in table 23–1.

**T 23 – 1 Estimated Depreciation Rates of Assets (%)**

| | 1968–1977 | 1977–1987 | 1987–1997 |
|---|---|---|---|
| Total | 5.1 | 5.7 | 4.6 |
| Residential Building | 5.5 | 1.2 | 3.3 |
| Non-residential Building | -6.7 | -1.3 | 3.0 |
| Other Construction | 9.7 | 8.4 | 1.0 |
| Transportation Vehicles | 49.3 | 28.7 | 16.9 |
| Machinery | 1.1 | 11.4 | 9.2 |

Source: Pyo(2003)

In order to derive capital service inputs from capital stocks, we have followed the method of Jorgenson, Ho, and Stiroh (2005) except the adjustment for a rapid IT asset price decline. The capital service flows for each asset have been estimated from the capital stocks, and have

been aggregated over all the assets assuming that the flow of capital service is proportional to the average of current and one-year lagged capital stocks, which means that currently installed capital stock is available in the midpoint of the installed period. We have estimated the price of capital service through the user cost of capital formula. This methodology derives the cost of capital by the equality between two alternative investments: earning a nominal rate of return and investing in asset earning a rental fee and selling the depreciated asset. We have used yields of corporate bonds for nominal rates of return and Pyo's (2003) results for depreciation rates as shown in table 23–1. We did not consider tax effects in estimating cost of capital for the unavailability of data.

### *Measurement of Labor Input*

In order to measure labor input for KLEMS model, we have to obtain both quantity data of labor input such as employment by industries and hours worked and quality factors such as sex, education and age. Both availability and reliability of labor statistics in Korea have improved since 1980. But the measurement of labor input by industries cannot be readily made because the statistics of employment by industries are not detailed enough to cover 72 sectors. Therefore, we have used other sources for breaking down the labor data. More detailed classifications of employment will have to rely on Employment Table, which is published as a supporting table to Input-Output Table. But it is available only every five year when main Input-Output Tables are published. Mining and Manufacturing Census and Survey by National Statistical Office also report employment statistics but it is limited to mining and manufacturing only.

Economically Active Population Yearbook by National Statistical Office reports the number of employment, unemployment, not-economically-active population and economically active population. Report on Monthly Labor Survey by Ministry of Labor publishes monthly earnings and working days of regular employees. Survey Report on Wage Structure by the same ministry reports wages. Nominal wages are also available from this survey. For the present study, we have obtained the raw data file of Survey Report on Wage Structure from the Ministry of Labor and Economically Active Population Survey from National Statistical Office for the period of 1980–2003. The data are classified by two types of gender (Male and Female), three types of age (below 30, 30–49, and 50 above), and four types of education (middle school and under, high school, college, and university above) and, therefore, there is a total of 24 categories of labor as shown table 23–2.

Since the raw-data file of the Survey Report on Wage Structure contains more detailed industrial classification than that of the Economically Active Population Survey, we have calculated the quantity of labor from the Economically Active Population Survey and the quality of labor from the Survey Report on Wage Structure. This enables us to include self-employed labor as well as to use more detailed data. However, since the Survey Report on Wage Structure does not include Agriculture and Government sectors, we had to use the average value of the entire economy for the quality measure of these two sectors. In order to make quality adjustments to the employment data, we have taken the method of Jorgenson, Gollop, and Fraumeni (1987).

**T 23 – 2 Classification of Labor Input**

| Categories | |
|---|---|
| Gender | (1) male (2) female |
| Age | (1) below 30 (2) 30–49 (3) above 50 |
| Education | (1) middle school and under |
| | (2) high school |
| | (3) college |
| | (4) university or above |

### *Energy, Material, and Service and Input Shares*

In order to decompose intermediate inputs into energy (E), material (M), and service (S) inputs, we have identified coal and lignite, crude petroleum and natural gas, uranium and thorium ores, metal ores, coke, refined petroleum products and nuclear fuel, gas, water, and electricity commodities as energy inputs, both primary commodities and remaining manufacturing commodities as material inputs, and remaining service inputs as service inputs.

Regarding shares of inputs, we have used compensation of employees as shares of labor inputs and remaining value-added as shares of capital inputs. This method may underestimate the shares of labor input by allocating the compensation of self-employed to the shares of capital input, and this gap would be especially large in primary industry. There are some adjustment processes to correct underestimation of labor share as attempted by, for example Harberger (1987), but we have not applied it in order to avoid arbitrary adjustments. This can be improved in future studies. As for energy, material, and service inputs, we have used nominal inputs for their own shares.

## Estimates of Labor Productivity and TFP by 72-industry

### *Trend of Labor Productivity Level and Growth Rates by Sector*

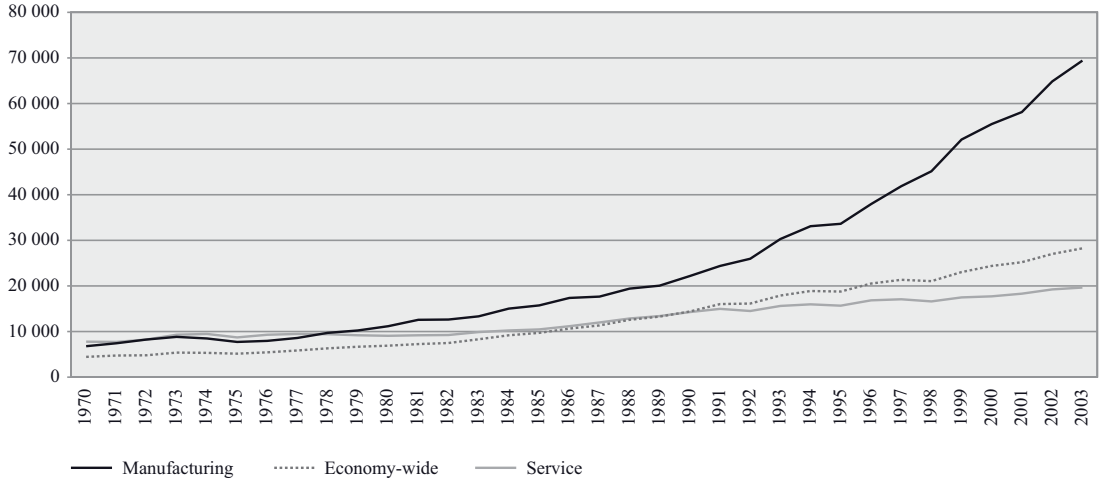
**(1) The Level and Trend of Labor Productivity**

As shown in graph 23–2, the general trend of labor productivity reveals a rising trend but with a remarkable difference between Manufacturing and Service. While the labor productivity level in Manufacturing measured as the ratio of real price output to working hours increased sharply, the level in Service increased very slowly. The role of productivity gain in Manufacturing in the catch-up process of Korea has been well-documented by Timmer (1999) and Pyo (2001). As observed in Pyo and Ha (2005), the labor productivity level was not reduced during the years (1997–1998) of the Asian Financial Crisis because of IMF-mandated industrial restructuring: the reduced output was matched by reduced employment leaving labor productivity level unaffected.

The relatively sluggish productivity gain in Service sector has been pointed out by IMF in their recent consultation with the Korean authorities as a bottleneck of sustainable growth for Korea. Inklaar, Timmer and van Ark (2006) also pointed out the slower productivity gain of service industries in Europe relative to those in the United States. A more detailed decomposition of labor productivity by sector and by sub-period is presented in Table 4. According to Kim(2006), while the share of Service sector in Korean economy has increased sharply reaching 56 percent level of GDP and 65 percent of total employment in 2005, the Service productivity is not only low in level terms compared to industrial nations' levels but also lags behind in terms of growth rate. She also points out that Korea's inter-industry linkage effect between Manufacturing and Service is also only about half the size of industrial nations.

**Trend of Labor Productivity Level**
<gross output per hour (won)>

**G 23–2**




**(2) The growth rates of labor productivity by Sector**

The growth rates of labor productivity as summarized in table 23–3 confirm the remarkable difference between Manufacturing and Service sector. Throughout the entire period of 1972–2003, the economy-wide labor productivity has grown at the average rate of 5.59 percent but with the sectoral difference between Manufacturing (6.99 %) and Service (2.91 %). The difference did not shrink but rather has expanded as the process of industrialization continued. For example, the difference in the 1990's (9.55 % vs. 2.64 %) has been more than doubled since 1970's (4.01 % vs. 2.15 %).

The observed difference in both levels and growth rates of labor productivity between Manufacturing and Service can signal the difference in the degree of foreign competition, the proportion of tradable and non-tradable and the degree of domestic competition due to historically different regulatory environments. For example, the proportion of public enterprises and their subsidiaries in total output of many service industries such as utilities (electricity, water and gas), transportation and communication is a lot greater than their proportion in Manufacturing so that their productivity improvement could have been sluggish over time. In addition, many non-tradable sectors of service industries such as retail trade, real estate and financial services, hotels and restaurants etc. have been subject to all kinds of regulations such as zoning, sanitary standards and segregated financial market services etc.

**T 23–3 Growth Rtaes of Labor Productivity by Sector (%)**

| Period | Economy-wide | Manufacturing | Service |
|---|---|---|---|
| 72–'79 | 4.32 | 4.01 | 2.15 |
| 80–'89 | 6.87 | 6.75 | 3.77 |
| 90–'99 | 5.54 | 9.55 | 2.64 |
| 90–'98 | 5.14 | 9.01 | 2.40 |
| 99–'03 | 5.87 | 8.61 | 3.33 |
| 72–'03 | 5.59 | 6.99 | 2.91 |

### *Gross Output Growth Accounting and TFP Growth*

The growth rate of economy-wide TFP has been estimated as -0.59 percent. The growth rates of TFP in Manufacturing and Service are estimated as 0.48 percent and -0.92 percent respectively throughout the entire period of 1972–2003 as shown in table 23–4. Also the economy-wide TFP growth rate during the pre-crisis period (1990–1998) has been estimated as -0.84 percent**.** And the growth rate during the post-crisis period (1999–2003) has been estimated as 0.86 percent.

**(1) The Level of TFP Growth and its Trend by Sector**

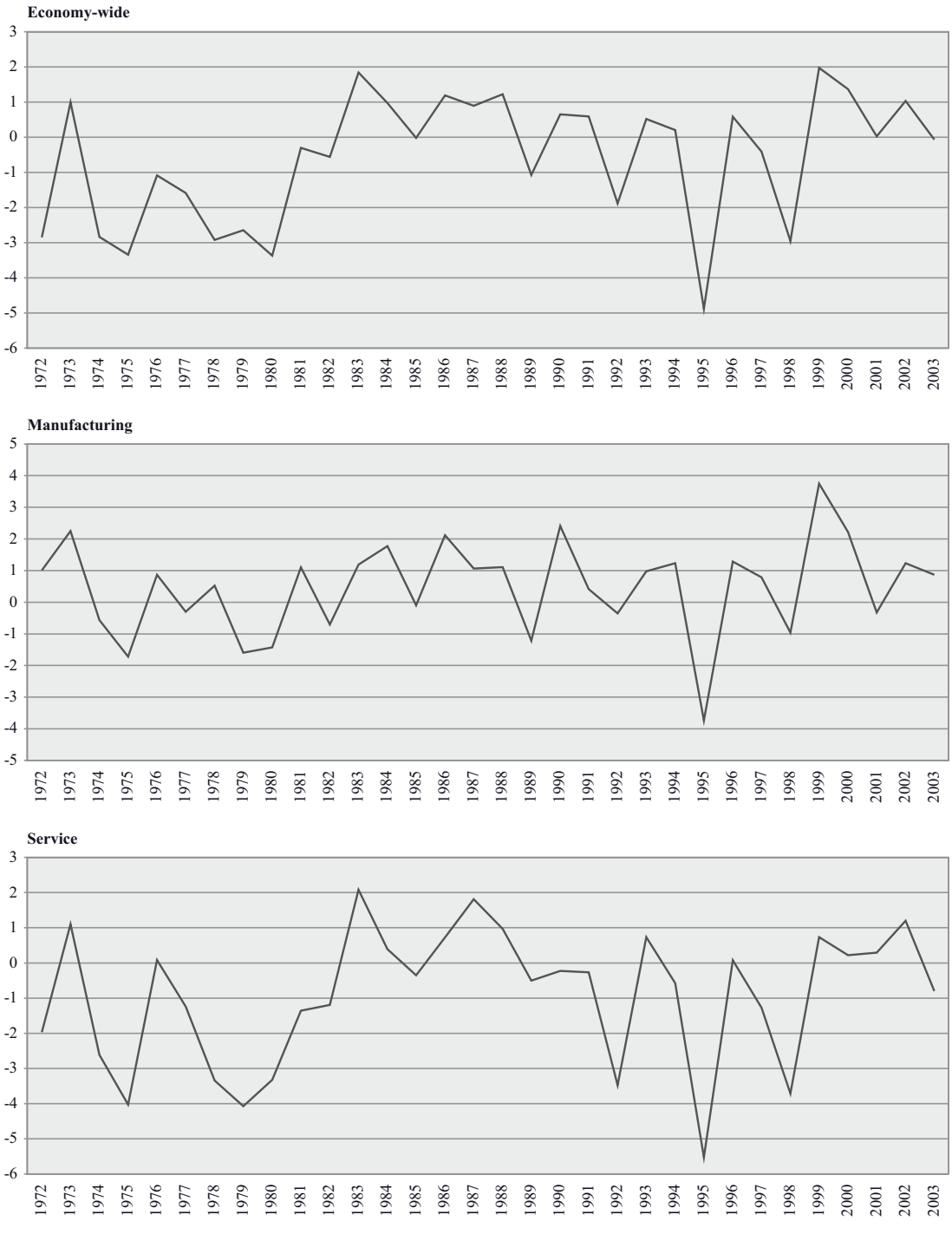
The growth rates of TFP by sector are shown in graph 23–3. Throughout the entire period 1972–2003, Korean economy experienced about 2 break-points: mid-1970s which was the first oil shock and in 1997 which was the financial crisis. The difference between two break points can be summarized as follows. During the second half of 1970's, the growth rate of gross output was not low, but the growth rates of inputs such as capital(4.56%), labor(1.79%), energy(0.69%), intermediate goods(3.34%) especially, were relatively higher. Therefore, the growth rates of TFP have been estimated as negative. In case of late 1990's the negative growth of TFP has been resulted from the shrink of gross output rooted from economic crisis.

In addition we observe that the estimated TFP growth rates in Manufacturing are in general greater than in Service. It maybe due to the fact that innovation processes such as product innovation or process innovation are more sensitive and stronger in manufacturing than in service. Also the R&D investment for innovation is in general more intensive in manufacturing than in service. So the growth rates of TFP in Manufacturing seem to be greater than in Service.

After the economic crisis in 1997–1998, the economy-wide growth rate of gross output has been recovered, at the same time the growth rates of input factors such as capital, labor and service have also been reduced from those during the pre-crisis period. Accordingly, the growth rate of TFP during the post-crisis period has been relatively higher than that during the pre-crisis period. Secondly the contributions of TFP to economy-wide gross output growth during the entire period of 1972–2003 are -7.5 percent, and 4.7 percent in Manufacturing, and -12.8 percent in Service. Then we can examine the relative contribution ratio of the input factors to the output growth. The relative contribution ratios to output growth during the entire period are in order of intermediate goods (52.3 %), capital (15.6 %), energy (11.3 %), service (10.2 %), labor (5.8 %) in Manufacturing. So the innovation or the role of intermediate goods for enhancing productivity is more important in Manufacturing than in Service. And the contribution ratio of TFP to Manufacturing output growth (4.7 %) is of rather insignificant magnitude. On the other hand, in Service the contribution are in order of capital (48.7 %), service (23.9 %), labor(20.1 %), intermediate goods(15.8 % ), energy (4.2 %). Hence we can see the input's role for enhancing productivity is different between Manufacturing and Service.

## The Growth Rates of TFP (%)

G 23–3



Thirdly the total factor productivity growth in gross output growth accounting is lower than that without quality adjustment in input data. The quality of labor has affected the growth of output about 2.4 % in Manufacturing and 3.9 % in Service during the entire period, Also the quantity of labor has affected the growth of output by about 3.4 % in Manufacturing and about 16.3 % in Service during the entire period, Thus the labor input in Service has influenced output growth both in quantity and quality of labor than that in Manufacturing. The quantity of labor input in Manufacturing has been reduced during the pre-crisis period. It reflects a drastic structural adjustment in Korea's labor market after the crisis of 1997–1998. As a consequence, the contribution rate of labor to output growth has become negative in Manufacturing after the crisis. In Service, Post and telecommunication which is related strongly with IT technology has recorded a relatively higher growth rate (4.93 %) of TFP among service sectors.

On the one hand the sectors which were based on IT technology such as i) Office, accounting and computing machinery (1.91 %), ii) Other electrical machinery (2.45 %), iii) Electronic valves and tubes(2.87 %), iv) Telecommunication equipment (2.13 %) in Manufacturing, have shown higher growth rate of TFP during the entire period (1972–2003). But the labor intensive sectors such as i) Leather and foot-wear (-1.25 %), ii) Food products and beverages (-0.73 %), iii) Wearing apparel, dressing and dying of fur (-0.69 %), iv) Printing and reproduction (-0.61 %) have shown negative growth rates of total factor productivity as shown Table A1 in Appendix.

In Service, Post and telecommunication which is related strongly with IT technology has recorded a relatively higher growth rate (4.93 %) of TFP among service sectors. But the social and private sectors such as i) Public administration and defense (-10.36 %), ii) Private households with employed persons (-8.95 %), iii) Other service activities (-8.74 %) have shown negative growth rates of TFP such as i) Public administration and defense (-10.36 %), ii) Private households with employed persons (-8.95 %), iii) Other service activities (-8.74 %) have shown negative growth rates of TFP as shown Table A1 in Appendix. Therefore, we can see that the leading sectors for enhancing productivity growth are related with IT sectors. Korean economy has heavily invested in IT sectors on a full scale since 1995 as shown in Table 5 and recently analyzed in Ha and Pyo (2004).

**T 23 – 4 Gross Output Growth Accounting and TFP Growth**

| Period | Gross output | Capital input | Economy-wide | | | Energy input | <log growth rates(%)> | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Labor input | | | | Inter-mediate input | Service input | TFP |
| | | | Total Labor | Quantity Labor | Quality Labor | | | | |
| 72–79 | 9.48 | 4.56 | 1.79 | 1.03 | 0.76 | 0.69 | 3.34 | 1.13 | -2.03 |
| 80–'89 | 8.36 | 3.05 | 0.62 | 0.28 | 0.34 | 0.45 | 3.18 | 0.98 | 0.08 |
| 90–'99 | 6.43 | 2.40 | 0.49 | 0.19 | 0.31 | 0.70 | 1.64 | 1.76 | -0.56 |
| 90–'98 | 5.84 | 2.54 | 0.49 | 0.15 | 0.34 | 0.63 | 1.30 | 1.71 | -0.84 |
| 99–'03 | 7.61 | 1.11 | 0.48 | 0.33 | 0.14 | 0.75 | 2.78 | 1.62 | 0.86 |
| 72–'03 | 7.81 | 2.98 | 0.85 | 0.44 | 0.41 | 0.61 | 2.63 | 1.32 | -0.59 |

**contribution to output growth**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 72–79 | 100.0 | 48.1 | 18.9 | 10.9 | 8.1 | 7.3 | 35.3 | 11.9 | -21.5 |
| 80–'89 | 100.0 | 36.5 | 7.4 | 3.4 | 4.0 | 5.3 | 38.0 | 11.8 | 0.9 |
| 90–'99 | 100.0 | 37.3 | 7.7 | 2.9 | 4.8 | 10.9 | 25.6 | 27.3 | -8.7 |
| 90–'98 | 100.0 | 43.5 | 8.4 | 2.5 | 5.8 | 10.8 | 22.4 | 29.4 | -14.4 |
| 99–'03 | 100.0 | 14.6 | 6.3 | 4.4 | 1.9 | 9.9 | 36.6 | 21.3 | 11.4 |
| 72–'03 | 100.0 | 38.2 | 10.9 | 5.6 | 5.3 | 7.8 | 33.7 | 17.0 | -7.5 |

| Period | Gross output | Capital input | Manufacturing | | | Energy input | Inter-mediate input | Service input | TFP |
|---|---|---|---|---|---|---|---|---|---|
| | | | Labor input | | | | | | |
| | | | Total Labor | Quantity Labor | Quality Labor | | | | |
| 72–79 | 15.30 | 2.41 | 1.72 | 1.28 | 0.43 | 1.66 | 8.29 | 1.17 | 0.06 |
| 80–'89 | 10.27 | 1.68 | 0.59 | 0.40 | 0.19 | 0.88 | 5.83 | 0.80 | 0.49 |
| 90–'99 | 6.94 | 1.20 | -0.14 | -0.34 | 0.20 | 1.19 | 2.94 | 1.17 | 0.58 |
| 90–'98 | 5.56 | 1.26 | -0.22 | -0.44 | 0.22 | 1.08 | 2.17 | 1.04 | 0.23 |
| 99–'03 | 10.11 | 0.70 | 0.26 | 0.16 | 0.09 | 1.02 | 5.26 | 1.32 | 1.55 |
| 72–'03 | 10.18 | 1.59 | 0.59 | 0.35 | 0.24 | 1.15 | 5.33 | 1.04 | 0.48 |

**contribution to output growth**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 72–79 | 100.0 | 15.8 | 11.2 | 8.4 | 2.8 | 10.8 | 54.2 | 7.6 | 0.4 |
| 80–'89 | 100.0 | 16.3 | 5.7 | 3.9 | 1.8 | 8.6 | 56.8 | 7.8 | 4.8 |
| 90–'99 | 100.0 | 17.3 | -2.0 | -4.9 | 2.8 | 17.2 | 42.3 | 16.9 | 8.4 |
| 90–'98 | 100.0 | 22.6 | -3.9 | -7.9 | 4.0 | 19.5 | 39.0 | 18.7 | 4.1 |
| 99–'03 | 100.0 | 6.9 | 2.5 | 1.6 | 0.9 | 10.1 | 52.1 | 13.0 | 15.3 |
| 72–'03 | 100.0 | 15.6 | 5.8 | 3.4 | 2.4 | 11.3 | 52.3 | 10.2 | 4.7 |

| Period | Gross output | Capital input | Service | | | Energy input | Inter-mediate input | Service input | TFP |
|---|---|---|---|---|---|---|---|---|---|
| | | | Labor input | | | | | | |
| | | | Total Labor | Quantity Labor | Quality Labor | | | | |
| 72–79 | 7.86 | 4.77 | 2.05 | 1.52 | 0.54 | 0.26 | 1.43 | 1.36 | -2.01 |
| 80–'89 | 7.92 | 3.70 | 1.33 | 1.11 | 0.22 | 0.18 | 1.52 | 1.27 | -0.08 |
| 90–'99 | 6.54 | 3.17 | 1.28 | 1.12 | 0.16 | 0.37 | 0.69 | 2.37 | -1.35 |
| 90–'98 | 6.61 | 3.37 | 1.39 | 1.22 | 0.17 | 0.34 | 0.69 | 2.40 | -1.58 |
| 99–'03 | 5.87 | 1.39 | 0.86 | 0.68 | 0.18 | 0.54 | 0.73 | 2.02 | 0.33 |
| 72–'03 | 7.22 | 3.51 | 1.45 | 1.17 | 0.28 | 0.30 | 1.14 | 1.73 | -0.92 |

**contribution to output growth**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 72–79 | 100.0 | 60.7 | 26.1 | 19.3 | 6.8 | 3.3 | 18.1 | 17.3 | -25.6 |
| 80–'89 | 100.0 | 46.6 | 16.8 | 14.0 | 2.8 | 2.3 | 19.2 | 16.0 | -0.9 |
| 90–'99 | 100.0 | 48.5 | 19.6 | 17.2 | 2.5 | 5.7 | 10.6 | 36.3 | -20.7 |
| 90–'98 | 100.0 | 51.1 | 21.0 | 18.4 | 2.6 | 5.1 | 10.5 | 36.4 | -24.0 |
| 99–'03 | 100.0 | 23.6 | 14.7 | 11.6 | 3.1 | 9.3 | 12.4 | 34.4 | 5.6 |
| 72–'03 | 100.0 | 48.7 | 20.1 | 16.3 | 3.9 | 4.2 | 15.8 | 23.9 | -12.8 |

**T 23 – 5 The Investment in IT Sector**
(2000 prices, %)

| Year | IT Investment (billion won) | Growth(%) |
|---|---|---|
| 1995 | 15,125.7 | – |
| 1996 | 17,916.0 | 16.9 |
| 1997 | 19,122.0 | 6.5 |
| 1998 | 17,099.2 | -11.2 |
| 1999 | 23,716.0 | 32.7 |
| 2000 | 32,190.9 | 30.6 |
| 2001 | 31,502.0 | -2.2 |
| 2002 | 33,143.8 | 5.1 |
| 2003 | 31,551.8 | -4.9 |
| 2004 | 31,391.9 | -0.5 |

*Source: Bank of Korea(http://ecos.bok.or.kr)

### *Cumulative Contribution of Sectors to TFP growth*

Following Fukao et. al,(2006), we can examine the sectoral contribution of TFP growth and identify what are the core sectors for enhancing productivity. As shown in graph 23–4, the weight of gross output of the sectors with positive Economy-wide TFP growth is about 52 % while the weight with negative TFP growth is about 48 % during the entire period of 1972–2003.

We can identify sectors that have contributed to the growth of economy-wide TFP positively. Leading sectors in this group include Financial Intermediation and Post and Telecommunications in Service and Basic Metals and Electronic Valves and Tubes in Manufacturing among others. We also identify sectors with negative contribution to Economy-wide TFP growth such as Agriculture, Hotels and Restaurants, Imputation of owner-occupied housing and Media activities etc.

As shown in graph 23–4, the weight of gross output of the sectors with positive TFP growth in Manufacturing is 72.4% while the weight with negative TFP growth is 27.6% during the period of 1972–2003. The sub-sectors with positive TFP growth are basic metals, chemicals, machinery, textiles, rubber and plastic, fabricated metal, wood, other non metallic mineral, motor vehicles and trailers as non IT sectors, and electronic valves and tubes, office, accounting and computing machinery, telecommunications, radio and TV receivers as IT sectors. The sub-sectors with negative TFP growth are leather and footwear, wearing and apparel, coke and refined petroleum etc.

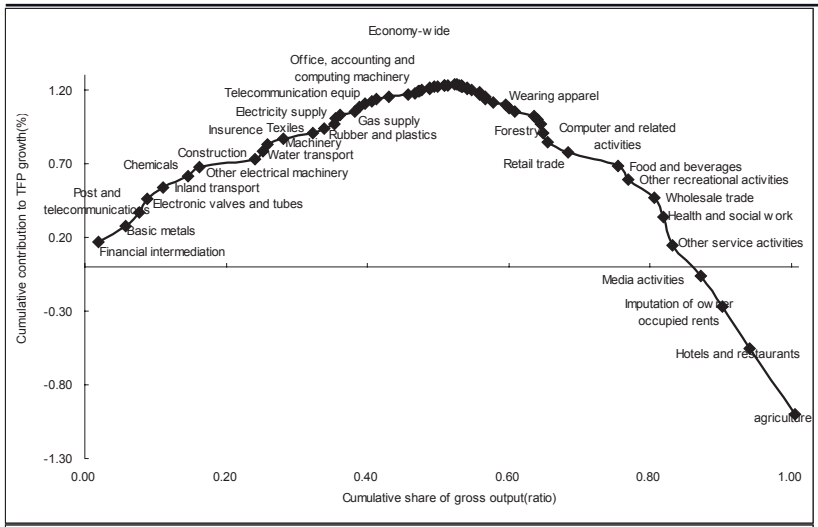
On the other hand, we can look at Service industry separately. As shown in graph 23–4, the weight of gross output of the sectors with positive TFP growth in Service is only about 40 % while the weight with negative TFP growth is 60 % during the period of 1972–2003. The group of service industries with positive TFP growth includes Financial intermediation, Post and communication, Inland Transport, Water Transport, Construction etc. The group with negative TFP growth includes Hotels and Restaurants, Imputation of owner-occupied housing, Media activities and Wholesale trade etc.

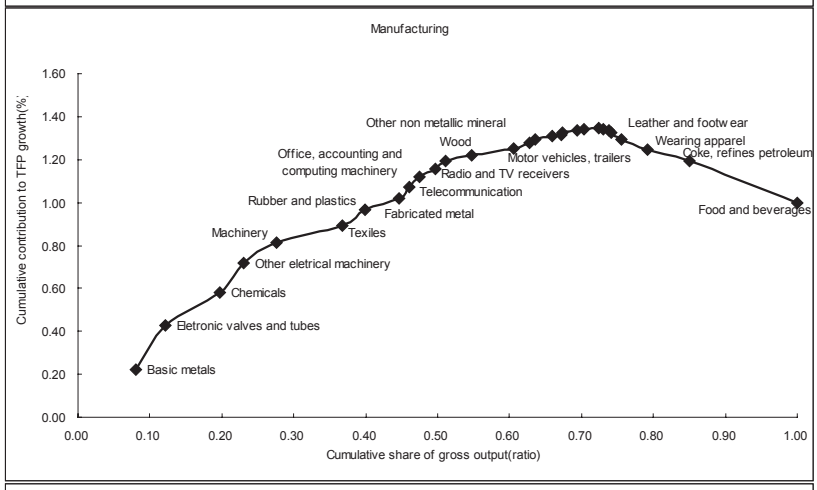
### *Relations of TFP growth with Labor Productivity and Output Growth*

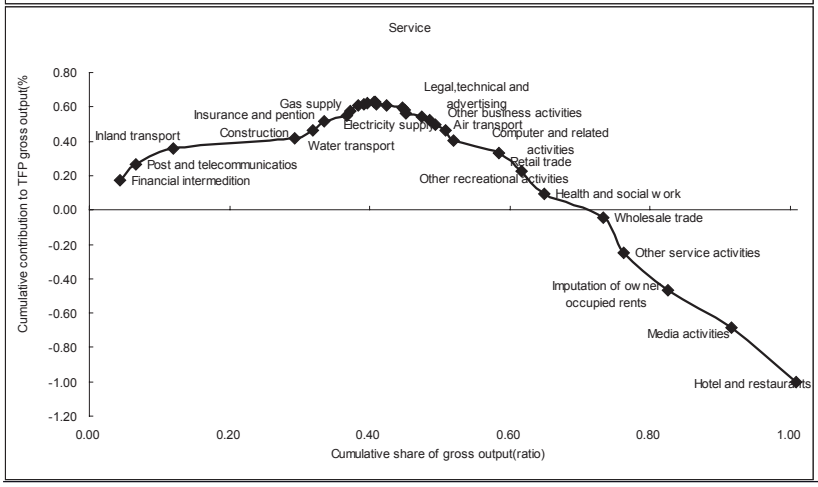
In order to identify the relation between labor productivity growth and TFP growth, we can divide sectors into 4 groups by the average growth rates in Manufacturing and Service. The relations of TFP with labor productivity and output growth can be further examined by looking at the scatter diagrams such as Figure 5 and 6. A visual inspection tells us that TFP growth is positively correlated with both labor productivity growth and output growth and TFP-LP relation is stronger than TFP – Output relation.

## Cumulative Contribution of Sectors to TFP Growth (1972–2003)

G 23-4

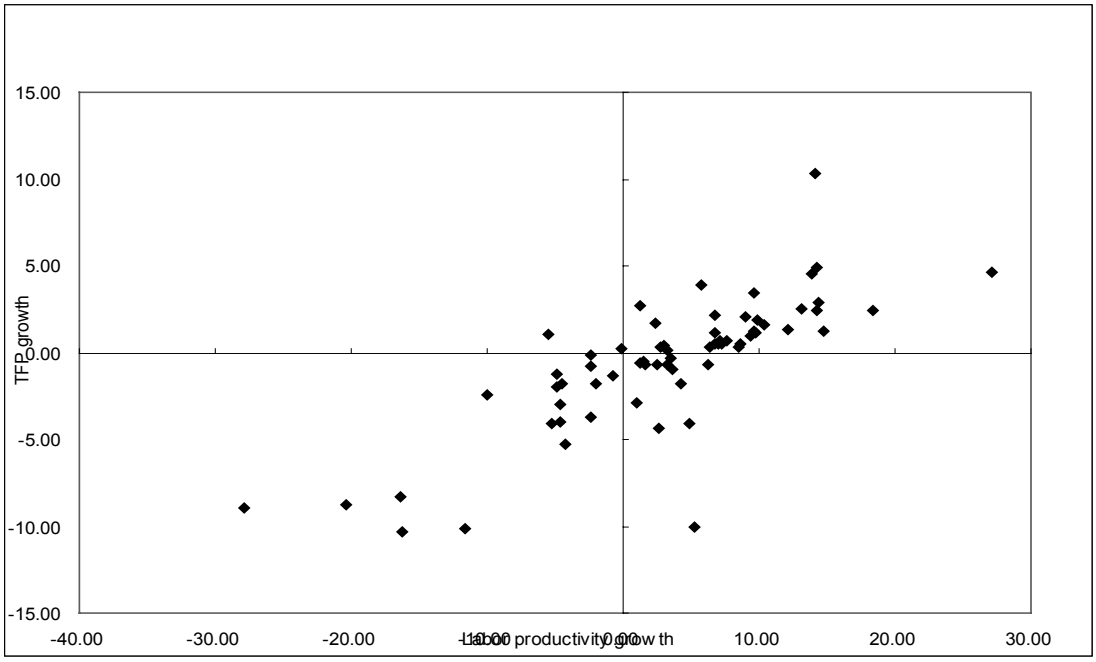


In table 23–6, we have summarized two simple regression results where TFP Growth rate is regressed upon LP and output growth rate. We are adopting implicit hypotheses that higher LP and output growth induces TFP growth through enhanced human capital and economies of scale. In both regressions, the coefficients of LP growth and Output Growth are significant. The TFP-LP regression seems more significant than TFP-Output regression.

**Plotting between TFP Growth and Sectoral Labor Productivity Growth (1972–2003)**
in percent **G 23-5**

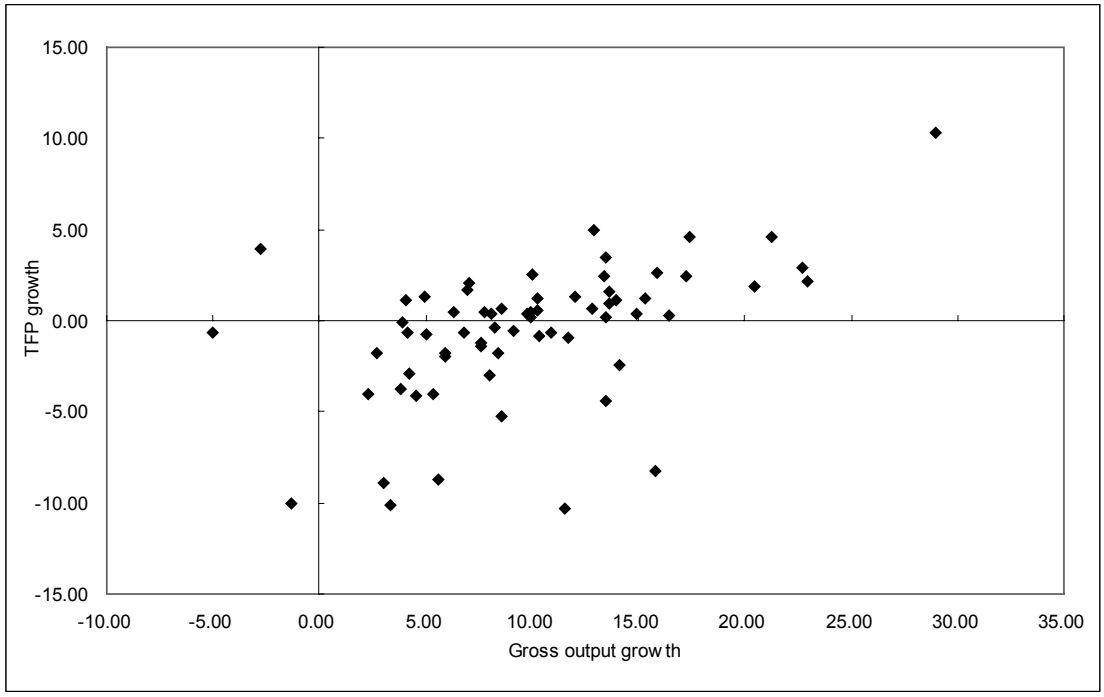



## A Linear Rank Test of Independence

In addition to regression analysis, we have used a type of distribution-free linear rank statistic, a generalization of the Mann-Whitney-Wilcoxon statistic for two Independent samples following Baily, Hulten and Campbell (1992) and Hogg and Craig (1978) and Choi (2003) and Neter et al.(1996).

Let $(X_1, Y_1), (X_2, Y_2), ..., (X_n, Y_n)$ be a random sample from a bivariate distribution of the continuous type. Let $R_i$ be the rank of $X_i$ among $X_1, X_2, ..., X_n$ and $Q_i$ be the rank of $Y_i$ among $Y_1, Y_2, ..., Y_n$ . If X and Y have a large positive correlation coefficient, we would anticipate that $R_i$ and $Q_i$ would tend to be large or small together. In particular, the correlation coefficient of $(R_1, Q_1), (R_2, Q_2), ..., (R_n, Q_n)$, namely the Spearman rank correlation coefficient :

**Plotting between TFP Growth and Sectoral Gross output Growth (1972–2003)**
in percent **G 23-6**




$$r_s = \frac{\sum_{i=1}^{n}(R_i - \bar{R})(Q_i - \bar{Q})}{\sqrt{\sum_{i=1}^{n}(R_i - \bar{R})^2 \sum_{i=1}^{n}(Q_i - \bar{Q})^2}} \tag{1}$$

would tend to be large. Since $R_1, R_2, ..., R_n$ and $Q_1, Q_2, ..., Q_n$ are permutations of 1,2,…,n, this correlation coefficient can be shown to equal :

$$r_s = 1 - \frac{6\sum_{i=1}^{n}(R_i - Q_i)^2}{n(n^2 - 1)} \tag{2}$$

The mean and the variance of $r_s$ under $H_0$ is derived as:

$$\mu_s = 0, \qquad \sigma_s{}^2 = \frac{1}{\sqrt{n-1}} \tag{3}$$

As shown in table 23–7, the computed linear rank statistics reject the null hypotheses that TFP growth is stochastically independent of LP growth and that TFP growth is stochastically independent of output growth at the 1 % significance level.

### T 23 – 6 Regression Results

(2000 prices, %)

**1. Relation between Labor Productivity Growth and TFP Growth**

Model: $\log(TFPt/TFPt\text{-}1)=\alpha+\beta\log(LPt/LPt\text{-}1)+\gamma$

log(TFPt/TFPt-1)=Sectoral avergae TFP growth rate during 1972–2003

log(LPt/LPt-1)=Sectoral avergae labor productivity growth rate during 1972-2003

Number of sectors: 66 sectors(except #5, #6, #33, #39, #66, #72 for data insufficiency)

| Dependent var. | β | S.E. | DW | adj$R^2$ |
|---|---|---|---|---|
| TFP Growth rate | 0.322*** | 0.031 | 1.967 | 0.613 |

***: Pr>t is 1%, **:Pr>t is 5%, *:Pr>t is 10%

1) Data for sector 36 is available only during 1977–2003, and data for sectors of #44, #55, #59 are available only during 1989–2003

**2. Relation between Gross Output Growth and TFP Growth**

Model: $\log(TFPt/TFPt\text{-}1)=\alpha+\beta\log(GOt/GOt\text{-}1)+\gamma$

log(TFPt/TFPt-1)=Sectoral avergae TFP growth rate during 1972–2003

log(GOt/GOt-1)=Sectoral avergae Gross output growth rate during 1972–2003

Number of sectors: 66 sectors(except #5, #6, #33, #39, #66, #72 for data insufficiency)

| Dependent var. | β | S.E. | DW | adj$R^2$ |
|---|---|---|---|---|
| TFP Growth rate | 0.306*** | 0.066 | 1.479 | 0.235 |

***: Pr>t is 1%, **:Pr>t is 5%, *:Pr>t is 10%

*1) Data for sector 36 is available only during 1977–2003, and data for sectors of #44, #55, #59 are available only during 1989–2003*

## Conclusion

The purpose of this paper is to explain how the database of Korea has been constructed for estimating productivities by industry in KLEMS model and how we have estimated 72-industry level labor productivity and TFP. We have also conducted a gross output growth accounting. Throughout the entire period of 1970–2003, the economy-wide labor productivity has grown at the average rate of 5.59 percent but with the sectoral difference between Manufacturing (6.99 %) and Service (2.91 %). The difference did not shrink but rather has expanded as the process of industrialization of the Korean economy continued. For example, the difference in the 1990's (9.55 % vs. 2.64 %) has been more than doubled since 1970's (4.01 % vs. 2.15 %). The observed difference in both levels and growth rates of labor productivity between Manufacturing and Service can signal the difference in the degree of foreign competition, the proportion of tradable goods and non-tradable goods and services and the degree of domestic competition due to historically different regulatory environments.

The growth rate of economy-wide TFP has been estimated as -0.59 percent. The growth rates of TFP in Manufacturing and Service are estimated as 0.48 percent and -0.92 percent respectively throughout the entire period of 1972–2003. Korean economy experienced two major break-points: in 1974 which was the first oil shock and in 1997 which was the financial crisis. The difference between two break points can be summarized as follows. During the second half of 1970's, the growth rate of gross output was not low, but the growth rates of inputs such as capital(4.56%), labor(1.79%), energy(0.69%), intermediate goods(3.34%) especially, were relatively higher. Therefore, the growth rates of TFP have been estimated as negative. In case of late 1990's the negative growth of TFP has been resulted from the shrinkage of gross output rooted from economic crisis.

In addition we observe that the estimated TFP growth rates in Manufacturing are in general greater than in Service. It maybe due to the fact that an innovation process such as product innovation or process innovation is more sensitive and stronger in Manufacturing than in Service. Also the R&D investment for innovation is in general more intensive in Manufacturing than in Service. So the growth rates of TFP in Manufacturing seem to be greater than in Service.

We can identify sectors that have contributed to the growth of economy-wide TFP positively by decomposing relative contribution of each sector to total TFP growth (Y-axis) with each sector's relative weight of output (X-axis). Leading sectors in this group include Financial Intermediation and Post and Telecommunications in Service and Basic Metals and Electronic Valves and Tubes in Manufacturing among others. We also identify sectors with negative contribution to Economy-wide TFP growth such as Agriculture, Hotels and Restaurants, Imputation of owner-occupied housing and Media activities etc.

The relations of TFP with labor productivity and output growth can be examined by looking at the scatter diagrams and a regression analysis. A visual inspection tells us that TFP growth is positively correlated with both labor productivity growth and output growth and TFP-LP relation is stronger than TFP –Output relation. We have adopted an implicit hypothesis that higher LP and output growth induces TFP growth through enhanced human capital and economies of scale. In both regressions, the coefficients of LP growth and Output Growth are significant. The TFP-LP regression seems more significant than TFP-Output regression.

Productivities in an economy are not identical across industries, and productivity differences are also observed when compared with other economies. For example, most industries in Japan exhibit higher productivity in Manufacturing such as Electrical machinery, Motor and other transport vehicles, and Instruments industries resulting in higher productivity in the entire economy. However, total factor productivities of Korea in Construction, Petroleum products, Fabricated machinery, and Finance industries are higher than those of Japan. International comparison of productivity among industries will demonstrate a relative productivity of each industry, illustrating whether the way goods and services are produced is relatively efficient or not and referring to the appropriate policies for improvement such as competition, restriction, R&D policies, and so on. Establishment of dataset with the same standards for productivity measurement will facilitate these inter-industry and international comparisons, and contribute to better understanding of economic growth.

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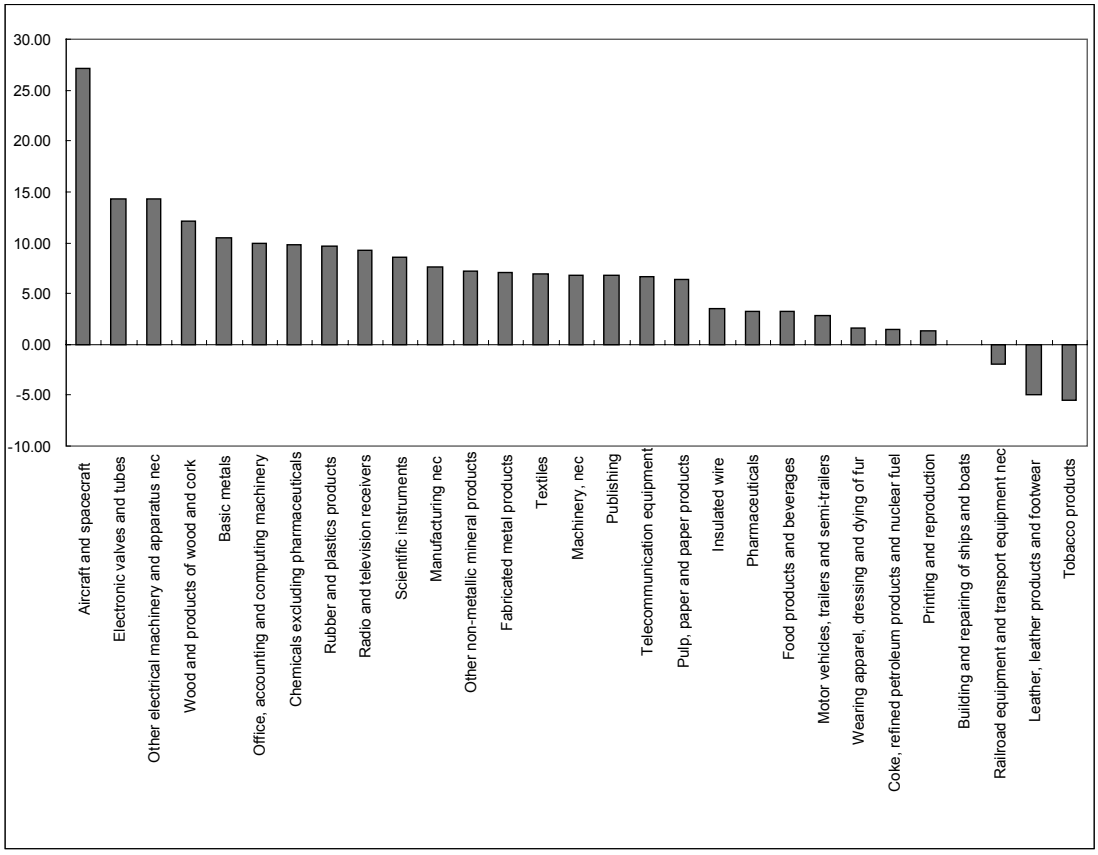
# Appendix

## *Graph 23-A1 Growth Rates of Labor Productivity in Manufacturing (1972-03/%)*

**Growth Rates of Labor Productivity in Manufacturing (1972–03)**
in percent

**G 23-A1**



## *Graph 23-A2 Growth Rates of Labor Productivity in Service (1972-03/ %)*

**Growth Rates of Labor Productivity in Service (1972–03)**
in percent

**G 23-A2**

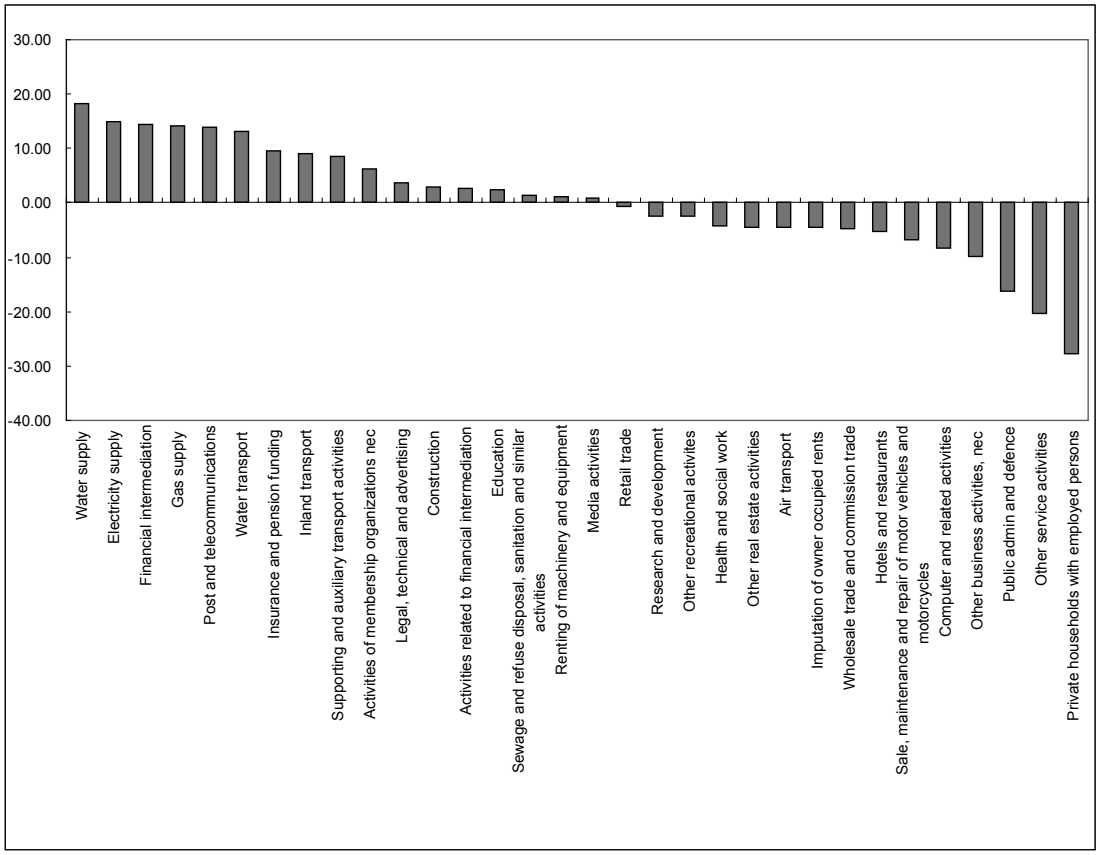


*Table 23-A1 Sectoral TFP growth in manufacturing (%)*

## T 23 – A1 Sectoral TFP Growth in Manufacturing (%)

| Code | Industry | 72–'79 | 80–'89 | 90–'99 | Before crisis 90–'98 | After crisis 99–'03 | 72–'03 |
|---|---|---|---|---|---|---|---|
| 9 | Food products and beverages | -1.52 | -0.65 | -0.61 | -0.59 | 0.12 | -0.73 |
| 10 | Tobacco products | -2.14 | 1.65 | 3.13 | 3.44 | 0.88 | 1.09 |
| 11 | Textiles | 0.97 | 0.38 | 0.33 | 0.05 | 0.73 | 0.49 |
| 12 | Wearing Apparel, Dressing And Dying Of Fur | -1.36 | -0.04 | -1.60 | -2.23 | 1.85 | -0.69 |
| 13 | Leather, leather products and footwear | -5.91 | -1.55 | 2.16 | 2.33 | 0.39 | -1.25 |
| 14 | Wood and products of wood and cork | 3.26 | 0.87 | 0.39 | 0.57 | 0.57 | 1.34 |
| 15 | Pulp, paper and paper products | -0.61 | 0.90 | 0.74 | 0.70 | 0.08 | 0.34 |
| 16 | Publishing | -0.60 | 2.80 | -0.19 | -1.60 | 1.33 | 0.48 |
| 17 | Printing and reproduction | 6.20 | -3.66 | -2.05 | -1.45 | -3.90 | -0.61 |
| 18 | Coke, refined petroleum products and nuclear fuel | -0.84 | -0.27 | -0.84 | -1.01 | 0.19 | -0.55 |
| 19 | Pharmaceuticals | -3.21 | 0.92 | -1.32 | -1.53 | 7.01 | 0.15 |
| 20 | Chemicals excluding pharmaceuticals | 1.48 | 1.29 | 1.23 | 0.98 | 0.57 | 1.14 |
| 21 | Rubber and plastics products | 2.13 | 1.97 | 0.32 | -0.29 | 1.38 | 1.28 |
| 22 | Other non-metallic mineral products | -0.17 | 0.29 | 0.59 | 0.24 | 2.38 | 0.49 |
| 23 | Basic metals | 3.24 | 1.49 | 0.87 | 0.93 | 0.21 | 1.57 |
| 24 | Fabricated metal products | 1.57 | 0.63 | -0.16 | -0.36 | 1.10 | 0.66 |
| 25 | Machinery, nec | 1.46 | 1.01 | 0.78 | 0.26 | 2.76 | 1.18 |
| 26 | Office, accounting and computing machinery | 3.13 | -0.78 | 3.37 | 2.32 | 4.62 | 1.91 |
| 27 | Insulated wire | -4.09 | -0.87 | 2.22 | 1.54 | 3.15 | -0.37 |
| 28 | Other electrical machinery and apparatus nec | 5.33 | 0.75 | 1.40 | 1.14 | 3.58 | 2.45 |
| 29 | Electronic valves and tubes | 5.36 | 2.91 | 1.08 | 0.45 | 3.15 | 2.87 |
| 30 | Telecommunication equipment | -0.05 | 2.12 | 5.02 | 3.99 | 2.32 | 2.13 |
| 31 | Radio and television receivers | 2.22 | 0.29 | 0.95 | -1.36 | 4.61 | 0.98 |
| 32 | Scientific instruments | 0.51 | 0.81 | -0.04 | -0.42 | 0.62 | 0.36 |
| 33 | Other instruments | – | – | – | – | – | – |
| 34 | Motor vehicles, trailers and semi-trailers | 0.00 | 0.74 | -0.37 | -1.43 | 2.98 | 0.29 |
| 35 | Building and repairing of ships and boats | 1.22 | 1.33 | -2.81 | -3.99 | 3.92 | 0.21 |
| 36 | Aircraft and spacecraft | 6.76 | 5.14 | 4.22 | 5.60 | 0.52 | 4.62 |
| 37 | Railroad equipment and transport equipment nec | -2.96 | -2.00 | 1.22 | 1.32 | -5.06 | -1.78 |
| 38 | Manufacturing nec | -0.24 | 2.18 | 0.04 | -0.08 | 0.30 | 0.65 |
| 39 | Recycling | – | – | – | – | – | – |

*Table 23-A2 Sectoral TFP Growth in Service (%)*

## T 23 – A2 Sectoral TFP Growth in Service (%)

| Code | Industry | 72–'79 | 80–'89 | 90–'99 | Before crisis 90–'98 | After crisis 99–'03 | 72–'03 |
|---|---|---|---|---|---|---|---|
| 40 | Electricity supply | 2.20 | 0.76 | 1.10 | 1.18 | 0.77 | 1.24 |
| 41 | Gas supply | 15.03 | 14.00 | 7.31 | 7.10 | 2.29 | 10.34 |
| 42 | Water supply | 8.67 | 3.38 | -2.19 | -2.51 | -0.39 | 2.46 |
| 43 | Construction | -0.13 | 2.31 | -0.91 | -0.36 | -1.27 | 0.39 |
| 44 | Sale, maintenance and repair of motor vehicles and motorcycles | – | – | -12.91 | -14.71 | 2.09 | -8.71 |
| 45 | Wholesale trade and commission trade | -3.04 | -2.46 | -1.28 | -2.21 | 1.26 | -1.95 |
| 46 | Retail trade | -0.77 | -3.31 | -0.73 | -0.71 | 0.41 | -1.36 |
| 47 | Hotels and restaurants | -4.75 | -4.69 | -4.59 | -6.20 | 1.80 | -4.11 |
| 48 | Inland transport | 4.14 | 3.06 | -0.42 | -0.72 | 1.90 | 2.09 |
| 49 | Water transport | 4.72 | 2.21 | 1.31 | 1.92 | 0.71 | 2.52 |
| 50 | Air transport | -10.49 | -0.79 | -2.20 | -1.85 | 2.70 | -2.97 |
| 51 | Supporting and auxiliary transport activities; activities of travel agencies | 5.71 | 0.76 | -4.52 | -4.83 | 1.50 | 0.54 |
| 52 | Post and telecommunications | 6.51 | 2.24 | 5.36 | 5.08 | 5.18 | 4.56 |
| 53 | Financial intermediation, except insurance and pension funding | 7.45 | 5.61 | 3.20 | 3.05 | 2.89 | 4.93 |
| 54 | Insurance and pension funding, except compulsory social security | 1.46 | 5.81 | 0.99 | 4.76 | -0.28 | 3.47 |
| 55 | Activities related to financial intermediation | – | – | -2.77 | -9.28 | 7.03 | -3.46 |
| 56 | Imputation of owner occupied rents | -8.68 | -7.03 | 5.12 | 7.66 | -11.66 | -4.03 |
| 57 | Other real estate activities | -6.44 | -3.41 | -2.86 | -3.70 | 12.35 | -1.79 |
| 58 | Renting of machinery and equipment | -1.69 | 3.45 | 4.14 | 9.44 | -4.13 | 2.66 |
| 59 | Computer and related activities | - | - | -7.89 | -10.08 | 0.07 | -6.45 |
| 60 | Research and development | -0.73 | -1.19 | -2.51 | -2.91 | 3.54 | -0.82 |
| 61 | Legal, technical and advertising | -2.67 | -0.04 | -1.22 | -1.24 | 0.38 | -0.97 |
| 62 | Other business activities, nec | -11.74 | 3.97 | -2.54 | -4.20 | 2.69 | -2.46 |
| 63 | Public admin and defence | -29.94 | 4.94 | -18.73 | -22.09 | 11.51 | -10.36 |
| 64 | Education | 16.39 | 2.01 | -2.35 | -3.77 | -12.68 | 1.68 |
| 65 | Health and social work | -32.93 | 9.88 | 1.43 | 1.88 | -4.19 | -5.27 |
| 66 | Sewage and refuse disposal, sanitation and similar activities | – | – | – | – | – | – |
| 67 | Activities of membership organizations nec | -3.54 | -0.31 | 1.36 | 2.52 | -2.73 | -0.70 |
| 68 | Media activities | -16.43 | -0.25 | -9.24 | -11.98 | 29.66 | -2.92 |
| 69 | Other recreational activites | -4.15 | 2.90 | -17.29 | -20.27 | 13.60 | -3.71 |
| 70 | Other service activities | -30.77 | 6.08 | -18.93 | -19.42 | 16.12 | -8.74 |
| 71 | Private households with employed persons | -32.53 | 3.78 | 5.72 | 5.77 | -23.15 | -8.95 |
| 72 | Extra-territorial organizations and bodies | – | – | – | – | – | – |

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