

# **Multifactor Productivity in Korea and an International Comparison: Data and Productivity Estimates of the Korea Industrial Productivity Database**

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The purpose of our study is to identify sources of economic growth for the Republic of Korea, which experienced a financial crisis in 1997 after joining the OECD. We provide estimates of output, input, and productivity based on the newly constructed Korea Industrial Productivity (KIP) database following EU KLEMS project guidelines. We find that Korea's catch-up process with industrial nations during its period of late industrialization has been predominantly input-led and manufacturing-based. However, following the financial crisis in December 1997, the Korean economy growth seems to have shifted to productivity-led growth. However, lower productivity in the service industries seems to work against a renewed sustainable growth path.

*Keywords:* Economic growth, EU KLEMS, Korea Industrial Productivity (KIP) database, Multifactor productivity

*JEL Classification:* O14, O47

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## I. Introduction

In recent years, especially since the financial crisis of 1997 in East Asian countries, including Korea, considerable changes such as investment stagnation (Pyo and Ha 2005) and changes in production input patterns have taken place. One of the most important of such changes has been the demand for high productivity, which compensates for the recent slowdowns of growth rates in capital and labor inputs. As Krugman (1994), Lau and Kim (1994), and Young (1994) have shown, the East Asian economic miracle may be summarized as 'input-led' growth. Korea is no exception with regard to this type of growth pattern.

However, both stagnation in investment and a 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 a productivity increase in order to improve present income levels and to support the large elderly population, especially given the relatively small number of working adults. For these reasons, 'productivity-driven' growth is indispensable for Korea. According to Lewis (2004), fast economic growth in Korea has been the result of both a large labor force and capital accumulation. He argues that the average number of working hours is 40 percent higher than that of the U.S., and almost a third of the 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 the amount of input put into production to how efficiently those inputs are organized.

In this paper we explain the data structure of the Korea Industrial Productivity (KIP) database following the guideline of the EU KLEMS project and present preliminary estimates of multifactor productivity (MFP).<sup>1</sup> Furthermore, we perform an international comparison of MFP growth for Korea, the European Union, the United States, and Japan. We use a 72-industry classification following the EU KLEMS guideline for comparability with the European Union member states, the United States, and Japan.<sup>2</sup> Therefore, an analysis based on detailed industry

<sup>1</sup>The preliminary KIP database includes gross output and KLEMS variables for 72 industries from 1970 to 2005 and is available at [http://www.kpc.or.kr/publicwork\\_stat/kip\\_sub1\\_e.asp](http://www.kpc.or.kr/publicwork_stat/kip_sub1_e.asp). For the final release of the EU KLEMS database, the raw dataset of the KIP database is currently being compiled by the EU KLEMS team.

<sup>2</sup>The U.S. data in the EU KLEMS database is constructed using the BEA, BLS, and Jorgenson, Ho, and Stiroh (2005) datasets. Japanese data in the EU

classification gives us a better view of productivity and growth, one that is difficult to grasp using broader industrial classifications. Different industries in a single economy have shown different productivity trends and growth patterns, according to their characteristics of production, competition policies, and other economic and non-economic circumstances.

We perform value-added growth accounting for the market economy, including 6 sectors, using the KIP database for the period 1980-2005.<sup>3</sup> For international comparison, we also use EU KLEMS growth accounting results for the EU, the U.S., and Japan. We find that Korea's catch-up process with industrial nations during its late industrialization has been predominantly input-led and manufacturing-based, as documented in Timmer (1999) and Pyo (2001). Economic growth rates decreased from the 1980s to the 1990s, and fell further after the financial crisis in December 1997. However, since the 1997 financial crisis, the sources of growth seem to have switched to be MFP-growth based. The productivity resurgence in the post-crisis period is highly concentrated in high-tech manufacturing industries. However, lower productivity in service industries seems to work against a renewed sustainable growth path.

This paper is organized as follows. Section 2 examines the data structure, including the methodology, with regard to measuring gross output, intermediate inputs, labor hours and composition, and capital input. Section 3 presents the value-added growth accounting results and compares the results of the Korean market economy and 6 sectors with those in the EU, Japan, and the U.S. Section 4 examines structural changes in the Korean economy after the 1997 financial crisis, focusing particularly on changes in sectoral contributions of MFP growth. Section 5 concludes the paper.

KLEMS is based on the Japan Industry Productivity (JIP) database. See Fukao *et al.* (2007) for details on the JIP database. The latest version (March 2008) of the EU KLEMS database is now available at <http://www.euklems.net>. In addition to the EU states, the EU KLEMS also includes Australia, Canada, Japan, and the U.S.

<sup>3</sup>For cross-country comparison, the EU KLEMS database reports growth accounting tables based on value-added, but not gross, output. Thus, we conduct value-added growth accounting although both the KIP and EU KLEMS databases follow the KLEMS methodology. As documented in the productivity literature, the separability assumption on the real value-added production function is not usually guaranteed. See Berndt and Christensen (1973) and Denny and Fuss (1977) for the U.S., and Pyo and Ha (2007) for Korea.

## II. Data Structure

In this section, we construct gross output and inputs of capital, labor, energy, materials, and purchased services (KLEMS) variables following Timmer *et al.* (2007a, 2007b) (hereafter EU KLEMS Manual) from 1970 to 2005 for 72 industries.<sup>4</sup> Industry names in the 72-industry classification and coverage of the dataset are available in Table A1 of the Appendix.<sup>5</sup>

### A. Gross Output and Intermediate Inputs

National Accounts by the Bank of Korea (available at the Bank of Korea website)<sup>6</sup> report the annual series (1970-2005) of nominal gross outputs at basic prices, nominal and real value-added at basic prices, the nominal compensation of employees, and operating surplus at current prices of 78 industries, including 34 manufacturing industries. Since some industries in this 78-industry classification do not match our 72-industry classification, we use Bank of Korea internal data, which include both the nominal and real gross output series for 397 industries.<sup>7</sup> National Accounts (1987, 1994, 1999, 2004) also report the annual series (1985-2002) of both nominal and real Make Tables (V-Tables) as well as real Use Tables (U-Tables).

In addition to nominal gross output and both nominal and real value-added, real gross output at basic prices and real intermediate inputs at purchasers' prices can be obtained from Use Tables. However, since the Make Tables and Use Tables for the years 1970-1984 and 2003-2005 are unavailable, we use the 1985 tables for the period 1970-1984, and the 2002 tables for the period 2003-2005. As the published Use Tables of National Accounts in Korea present the

<sup>4</sup> More detailed methods for variable construction are available in Rhee (2007).

<sup>5</sup> Industries 6, 33, 39, 56, and 72 are not (separately) available for the whole sample period of 1970-2005 and industries 5, 36, 54, and 55 are (separately) available only for the periods of 2004-2005, 1976-2005, 1976-2005, and 1986-2000, respectively.

<sup>6</sup> National Accounts are available at the Economic Data System of the Bank of Korea (<http://ecos.bok.or.kr>).

<sup>7</sup> The breakdown of these industries, with the exception of transportation industries (48-51), has been made using weights obtained from the IO tables of Korea. We also have used information from the Report on the Transport Survey, published by Korea National Statistical Office (NSO).

Domestic and Import Use Tables combined, we are unable to isolate them into two separate tables. For Use Tables before 1995, all intermediate commodity inputs by industry are measured at purchasers' prices. Since 1995, those inputs have been measured at incomplete basic prices in the sense that they include trade and transportation margins but isolate net production tax to the last row of the intermediate input matrix. Since we have no information for the transformation of the Use Tables from purchasers' prices to basic prices before 1995, and the Use Tables after 1995 have been measured using incomplete basic prices, we changed the Use Tables at basic prices after 1995 into Use Tables at purchasers' prices, allocating the net production tax to each commodity proportional to each volume.

In order to decompose intermediate inputs into energy, material, and service inputs, we have identified Coal and lignite (4), Crude petroleum and natural gas (5), Uranium and thorium ores (6), Coke, refined petroleum products and nuclear fuel (18), Gas (40), and Electricity (41) as energy inputs, while both primary commodities and remaining manufacturing commodities are classified as material inputs, and remaining service inputs are service inputs.

### *B. Labor Input*

In order to measure labor input for the KLEMS model, we must obtain the quantity data of labor inputs such as employment and hours worked, as well as quality factors such as sex, education, and age. To obtain employment numbers for the period 1970-2005, we use the Economically Active Population (EAP) Yearbook, published by the National Statistical Office, which reports statistics for the employed, unemployed, not-economically-active, and economically active populations. The Report on Monthly Labor Survey by the Ministry of Labor publishes the monthly earnings and working days of regular employees. The Survey Report on Wage Structure (SRWS) by the same ministry reports wages, and nominal wages are also available from this survey.

Since the EAP does not provide detailed industry-level data, we use other sources for breaking down the labor data. For the breakdown of employment numbers into 72 industries, we use the SRWS, which contains detailed industry data at the 3-digit level except for 1971-1974 (4-digit level) and 2001-2005 (2-digit level). There are breaks between the 1970-1992 and 1993-2005 periods due to industry reclassification so, to correct the breaks in the manufacturing sector, we

use the Mining and Manufacturing Census and Survey. To correct discontinuity in the service sector, we use the Employment Table published as a supporting table to the Input-Output Table.

Following the suggestion in the EU KLEMS Manual and Jorgenson, Gallop, and Fraumeni (1987), we use two types of gender (male and female), three types of age (below 30, 30-49, and 50 or above), and three types of education (middle school or below, high school, and college or above) and therefore, there are 18 categories of labor. After calculating the proportions falling into the 18 categories for each year and industry, we took the average share of 1970-1976 as the benchmark share for 1970, the average share of 1977-1985 for 1977, and the average share of 1986-1992 for 1986. We then interpolated the shares for years in the three periods, 1971-1976, 1978-1985, and 1987-1992. In contrast to the earlier period, the data for 1993-2005 shows stability, so we stopped using interpolation for that period. We constructed this labor composition for 15 industries (including 6 manufacturing industries) with the assumption of the composition at the lower level industry being the same as that at the higher level.

### *C. Capital Input*

The success of late industrialization by newly industrializing economies would not have been possible if the rapid accumulation of capital and its changing distribution among sectors had not been realized in the development process. However, it is difficult to identify these factors empirically because time series data of capital stocks in fast-developing economies by both type of asset and industry 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 an economy-wide national wealth survey four times since 1968. Korea is one of a few countries to have conducted economy-wide national wealth surveys at a regular interval. Since the first National Wealth Survey (NWS) was conducted in 1968, surveys have been conducted every ten years: 1977, 1987, and 1997. Since such regular surveys with economy-wide coverage are very rare in both developed and developing countries, an analysis of 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 asset type and by industry was made by Pyo (2003) through a modified perpetual inventory method and polynomial benchmark year estimation method using four benchmark-year estimates. We have extended his estimates to the year 2005.<sup>8</sup> Since the database of Pyo (2003) covers 10 broad categories for each industrial sector, together with 28 sub-sectors of Manufacturing, it has been reclassified and reconciled with the 72-industry classification using other sources such as the Mining & Manufacturing Census and Surveys, Wholesale and Retail Surveys, and so on. We have classified assets into five categories;<sup>9</sup> Residential building (1), Non-residential building (2), Infrastructure (3), Transportation equipment (4), and Machinery (5+6+7), while excluding large animals & plants, household durables, and inventory stocks. Estimated depreciation rates for each asset and period are shown in Pyo (2003). Since Software (9) and Other intangibles (10) are not included in the NWS, we estimated the stock of software and intangibles using gross fixed capital formation in the National Accounts. Following the EU KLEMS manual, we use a 31.5% depreciation rate for software and other intangibles.

### III. International Comparison

#### A. MFP Growth in the Market Economy

As suggested in the EU KLEMS Manual, we focus on the market economy to make an international comparison of output and MFP growth. The market economy excludes the following non-market service industries: Imputation of owner occupied rents (56), Other real estate activities (57), Public admin and defense and compulsory social security (63), Education (64), and Health and social work (65).<sup>10</sup> The market economy consists of one ICT — (information and communication technology), two goods —, and three services-producing sectors: Electrical machinery and post & communication services (26-33, 52), Manufacturing excluding electrical machinery (9-25, 34-39), Other goods pro-

<sup>8</sup> In contrast, EU KLEMS is currently constructing capital stock using the perpetual inventory method for the whole sample period of 1970-2005 and uses depreciation rates provided by the EU KLEMS manual.

<sup>9</sup> Numbers in parentheses are EU KLEMS' asset classification codes.

<sup>10</sup> Numbers in parentheses are EU KLEMS' 72-industry classification codes. See Table A1 in Appendix.

ducing industries (1-8, 40-43), Distribution Services (44-46, 48-51), Finance and business services excluding real estate (53-55, 58-62), and Personal and social services (47, 66-71).

We define multifactor productivity (MFP) growth as

$$\Delta \ln MFP_{it} = \Delta \ln V_{it} - \sum_{X=L,K} \bar{v}_{X,t} \Delta \ln X_{it},$$

where  $V$ ,  $L$ ,  $K$  are real value-added, labor, and capital inputs, respectively.  $\bar{v}_{X,t} = 0.5(v_{X,t} + v_{X,t-1})$ , and  $\sum_{X=L,K} v_{X,t} = 1$ . Labor services are further decomposed into hours and compositional change. Regarding the shares of inputs, we use compensation of employees as shares of labor inputs and remaining value-added as shares of capital inputs.

### B. Cross-County Analysis

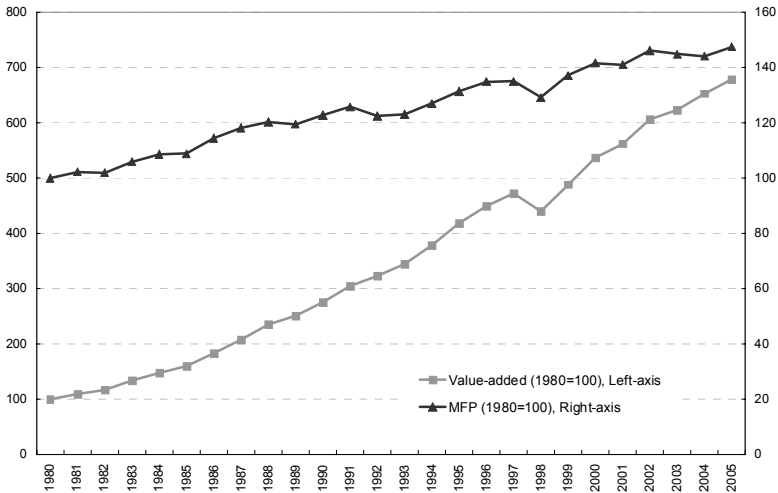
For the cross-country comparison, we examine the EU-15 (excluding 5 countries),<sup>11</sup> Japan, the U.S., and Korea. The latest EU KLEMS dataset (March 2008 version) includes data up to 2005. Following the EU KLEMS growth accounting framework, we compare two periods: 1980-1995 and 1995-2005. Following Timmer, O'Mahony, and van Ark (2007c), we divide the sample period into 1980-1995 and 1995-2005 because some countries, such as the United States, exhibited faster productivity growth after 1995, while many European countries did not.<sup>12</sup> The growth accounting format and results for the EU, Japan, and the U.S. are the same as those reported in Timmer, O'Mahony, and van Ark (2007c).

There was a break in output growth in Korea's economy-wide economic performance in 1998 only, following the financial crisis in December 1997, as shown in Figure 1. Even during the first oil crisis of 1973-1974 and the second oil crisis of 1979-1980, the Korean economy's real output continued to grow without major setbacks (not shown in Figure 1). After the economic crisis in December 1997, the Korean economy had to go through an IMF-mandated adjustment and

<sup>11</sup> European Union-15 includes the 15 old member countries (AUT, BEL, DNK, FIN, FRA, GER, GRC, IRL, ITA, LUX, NLD, ESP, PRT, SWE, UK). The five excluded countries are GRC, IRL, LUX, PRT, and SWE.

<sup>12</sup> Acceleration in productivity growth in the U.S. after 1995 is well-documented in Jorgenson and Stiroh (2000). Using 2-digit level U.S. industry data, Stiroh (2002) also linked this productivity acceleration to the use of information technologies.



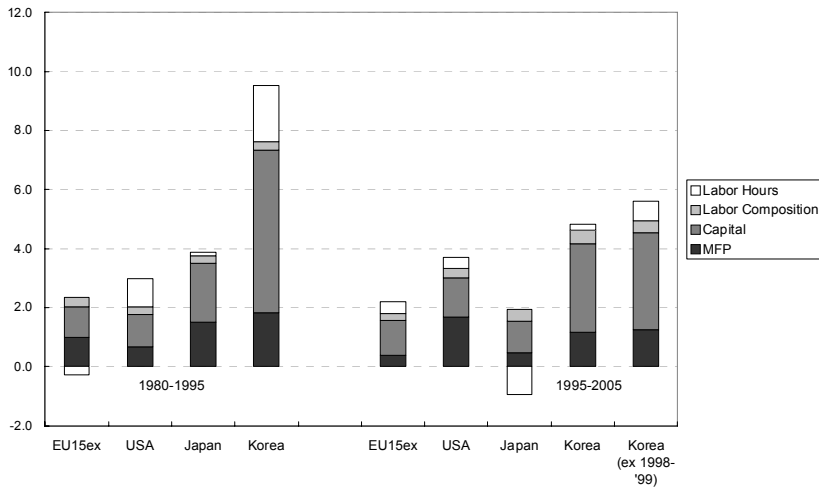


**FIGURE 1**  
 MARKET ECONOMY REAL VALUE-ADDED AND MFP TREND IN KOREA,  
 1980-2005

restructuring program, as documented in Pyo (2004). Thus, the period of 1995-2005 that excludes the period 1998-1999 is additionally provided for Korea.

Table 1 and Figure 2 show the market economy real value-added, inputs, and MFP growth of the EU, Japan, the U.S., and Korea during the periods 1980-1995 and 1995-2005. From 1980-1995, the value-added or GDP growth rate of the Korean market economy was 9.5%, which is about a two to four times higher rate than those of the other three. During the same period, the contribution of capital input to GDP growth reached about 58%, while labor and MFP contributions were about 23% and 19%, respectively. The pattern of economic growth in the Korean market economy can be characterized as input-led growth. Capital input is a major contributor to faster GDP growth in Korea during the period 1980-1995 (before the 1997 financial crisis). In contrast, the other three countries exhibited lower GDP growth in 1980-1995 compared to Korea, but their MFP contributions to GDP growth were higher, varying from 23% to 48%.

The MFP growth rate decelerated in the EU and Japan from 1980-1995 to 1995-2005 while MFP growth rates in the U.S. significantly accelerated, from 0.7% per year during 1980-1995 to 1.7%



**FIGURE 2**

CONTRIBUTIONS TO MARKET ECONOMY VALUE-ADDED GROWTH:  
1980-1995 AND 1995-2005

during 1995-2005. The MFP growth rate in Korea also decelerated from an average of 1.8% during 1980-1995 to 1.2% in the period 1995-2005 (excluding 1998-1999). However, the pattern of MFP deceleration in Korea is quite different from that of the EU, where the value-added growth rate accelerated. The GDP growth rate in the Korean market economy also decreased significantly over the 1995-2005 period, as compared to the previous period. However, this slowdown in GDP growth was not due to lowered productivity growth. The contribution of MFP to value-added growth in the Korean market economy increased slightly from 19% in the 1980-1995 period to 25% during 1995-2005.<sup>13</sup> The slowdown in Korean economic growth during the more recent ten years is mainly due to a slowdown in input growth, especially in labor hours and capital input, but not in MFP growth. This change in input contributions and MFP growth may be attributed to the restructuring in the Korean economy after the 1997 financial crisis.

Table 2 shows the growth accounting results at the sectoral level, while Figure 3 also shows sectoral contributions to market economy value-added and MFP growth. The sectoral composition of Korea

<sup>13</sup> Although we exclude the 1998-1999 period, MFP contribution to market economy value-added growth changes little.

**TABLE 1**  
 MARKET ECONOMY VALUE-ADDED GROWTH AND CONTRIBUTIONS:  
 1980-1995 AND 1995-2005

	VA	L	LH	LC	K	MFP
	(1)=(2)+(5)+(6)	(2)=(3)+(4)	(3)	(4)	(5)	(6)
<b>European Union (EU-15EX)</b>						
1980-1995	2.1	0.0	-0.3	0.3	1.1	1.0
1995-2005	2.2	0.6	0.4	0.2	1.2	0.4
1995-2000	3.0	0.9	0.8	0.2	1.5	0.5
2000-2005	1.4	0.3	0.0	0.3	0.9	0.2
<b>United States</b>						
1980-1995	3.0	1.2	1.0	0.2	1.1	0.7
1995-2005	3.7	0.7	0.4	0.3	1.3	1.7
1995-2000	5.1	1.8	1.6	0.2	1.9	1.4
2000-2005	2.3	-0.5	-0.8	0.4	0.8	2.0
<b>Japan</b>						
1980-1995	3.9	0.4	0.1	0.3	2.0	1.5
1995-2005	1.0	-0.6	-0.9	0.4	1.1	0.5
1995-2000	1.0	-0.4	-0.9	0.4	1.1	0.4
2000-2005	1.0	-0.7	-1.0	0.4	1.1	0.6
<b>Korea</b>						
1980-1995	9.5	2.2	1.9	0.3	5.5	1.8
1995-2005	4.8	0.7	0.2	0.5	3.0	1.2
1995-2005 (excl. 1998-99)	5.6	1.1	0.7	0.4	3.3	1.2
1995-2000	5.0	0.2	-0.2	0.4	3.3	1.5
1995-2000 (excl. 1998-99)	6.0	0.4	-0.1	0.4	4.4	1.3
2000-2005	4.7	1.1	0.6	0.5	2.7	0.8

Notes: European Union: 15 old member states (AUT, BEL, DNK, FIN, FRA, GER, GRC, IRL, ITA, LUX, NLD, ESP, PRT, SWE, UK). Five excluded countries are GRC, IRL, LUX, PRT, and SWE.

VA=Value-added growth rate (%)

L=Contribution of labor input

LH=Contribution of labor hours

LC=Contribution of labor composition

K=Contribution of capital input

MFP=Contribution of multifactor productivity growth=(1)-(2)-(5)

Among 72 industries (See Table A1 in Appendix for the 72-industry classification of EU KLEMS), the market economy excludes the following five industries: Imputation of owner occupied rents (56), Other real estate activities (57), Public admin and defense and compulsory social security (63), Education (64), and Health and social work (65).

**TABLE 2**  
 VALUE-ADDED GROWTH AND CONTRIBUTIONS:  
 SIX SECTORS IN THE MARKET ECONOMY, 1980-1995 AND 1995-2005

Panel A. EU-15 (excl. Greece, Ireland, Luxemburg, Portugal, and Sweden)

	VA	L	LH	LC	K	MFP	VA
	(1)	(2)	(3)	(4)	(5)	(6)	weight
	=(2)+(5)+(6)	=(3)+(4)					
<b>1980-1995</b>							
<b>Market Economy</b>	2.1	0.0	-0.3	0.3	1.1	1.0	100
Electrical mach & comm services	3.6	-0.6	-0.9	0.3	1.6	2.6	7.1
Manufacturing excl. Electrical	1.1	-1.2	-1.5	0.3	0.7	1.7	28.0
Other goods producing industries	1.1	-1.1	-1.4	0.2	0.7	1.6	18.7
Distribution services	2.6	0.3	0.1	0.2	0.8	1.5	21.1
Finance and business services	3.5	2.4	1.9	0.4	2.1	-1.0	17.8
Personal and social services	1.7	1.8	1.5	0.3	0.9	-1.1	7.4
<b>1995-2005</b>							
<b>Market Economy</b>	2.2	0.6	0.4	0.2	1.2	0.4	100
Electrical mach & comm services	5.5	-0.4	-0.6	0.2	1.7	4.1	6.7
Manufacturing excl. Electrical	0.8	-0.4	-0.7	0.3	0.6	0.7	24.8
Other goods producing industries	1.1	0.0	-0.1	0.2	0.7	0.4	15.5
Distribution services	2.3	0.6	0.5	0.1	1.1	0.6	21.3
Finance and business services	3.6	2.2	1.9	0.3	2.2	-0.8	22.7
Personal and social services	1.7	1.5	1.4	0.1	1.0	-0.8	9.0

Panel B. United States

	VA	L	LH	LC	K	MFP	VA
	(1)	(2)	(3)	(4)	(5)	(6)	weight
	=(2)+(5)+(7)	=(3)+(4)					
<b>1980-1995</b>							
<b>Market Economy</b>	3.0	1.2	1.0	0.2	1.1	0.7	100
Electrical mach & comm services	6.6	0.1	-0.3	0.4	1.9	4.6	8.4
Manufacturing excl. Electrical	1.7	0.1	-0.2	0.3	0.6	0.9	24.6
Other goods producing industries	0.7	0.7	0.4	0.3	0.7	-0.7	18.0
Distribution services	3.9	1.3	1.2	0.2	1.2	1.3	21.4
Finance and business services	4.4	2.9	2.7	0.2	1.8	-0.3	20.2
Personal and social services	2.9	2.5	2.5	0.1	0.5	-0.2	7.5
<b>1995-2005</b>							
<b>Market Economy</b>	3.7	0.7	0.4	0.3	1.3	1.7	100
Electrical mach & comm services	10.5	-0.4	-0.8	0.5	2.2	8.7	8.1
Manufacturing excl. Electrical	1.8	-1.0	-1.4	0.3	0.6	2.2	21.5
Other goods producing industries	1.6	1.1	1.0	0.1	0.8	-0.3	14.4
Distribution services	4.1	0.6	0.3	0.3	1.5	2.1	20.7
Finance and business services	4.3	1.9	1.5	0.4	1.9	0.4	26.7
Personal and social services	2.6	1.7	1.4	0.3	0.9	0.0	8.5

(Table 2 Continued)

Panel C. Japan

	VA	L	LH	LC	K	MFP	VA
	(1)	(2)	(3)	(4)	(5)	(6)	weight
	= (2) + (5) + (6)	= (3) + (4)					
<b>1980-1995</b>							
<b>Market Economy</b>	3.9	0.4	0.1	0.3	2.0	1.5	100
Electrical mach & comm services	11.0	0.5	0.3	0.1	3.4	7.1	7.4
Manufacturing excl. Electrical	3.1	-0.2	-0.4	0.2	2.0	1.4	28.8
Other goods producing industries	1.0	0.0	-0.3	0.3	1.3	-0.3	18.0
Distribution services	4.3	0.1	-0.1	0.2	1.0	3.1	23.0
Finance and business services	6.1	1.9	1.5	0.4	3.6	0.7	13.4
Personal and social services	1.6	1.4	0.8	0.5	2.3	-2.1	9.5
<b>1995-2005</b>							
<b>Market Economy</b>	1.0	-0.5	-0.9	0.4	1.1	0.5	100
Electrical mach & comm services	7.2	-0.8	-1.1	0.4	2.5	5.4	8.0
Manufacturing excl. Electrical	-0.3	-0.9	-1.2	0.3	1.2	-0.7	24.0
Other goods producing industries	-1.0	-1.3	-1.7	0.4	0.3	0.0	15.2
Distribution services	0.0	-1.1	-1.5	0.4	0.3	0.9	24.8
Finance and business services	3.2	1.1	0.6	0.5	2.2	-0.1	17.8
Personal and social services	0.6	0.1	-0.4	0.4	0.6	-0.1	10.1

(Table 2 Continued)

contrasts with those of the other three. In particular, the share of the two goods-producing sectors, excluding the ICT sector, is the highest in Korea, and decreased from an average of 55% in the 1980-1995 period to 48% in the 1995-2005 period. The value-added share of the electrical machinery and post and communication services sector (ICT sector) in the market economy is also highest among the four. The contribution of the two goods-producing and ICT sectors to GDP growth in the Korean market economy was about 61% in 1980-1995, and increased to 68% in 1995-2005, proportions which are significantly higher than those in the other countries (about 30-50%).

The productivity growth rate in the ICT sector is known to be very high. Panel B of Figure 3 shows that the contribution of the ICT sector to the market economy MFP growth is relatively high in Korea, not only because of the larger sectoral share, but also because of the higher MFP growth. In addition, MFP growth in the manufacturing sector, excluding ICT industries, exhibits a relatively high rate in Korea compared to the other three. In Korea, the manufacturing sector contributes about half of the market economy GDP growth, and most of the market economy MFP growth.

Panel D. Korea

	VA	L	LH	LC	K	MFP	VA weight
	(1)	(2)	(3)	(4)	(5)	(6)	
	= (2)+(5)+(6)	= (3)+(4)					
<b>1980-1995</b>							
<b>Market Economy</b>	9.5	2.2	1.9	0.3	5.5	1.8	100
Electrical mach & comm services	16.9	2.2	1.7	0.5	6.4	8.3	8.2
Manufacturing excl. Electrical	10.2	2.3	1.7	0.6	5.2	2.7	27.8
Other goods producing industries	6.6	1.1	1.1	0.1	6.6	-1.1	27.4
Distribution services	8.0	1.6	1.4	0.1	4.3	2.2	18.7
Finance and business services	13.7	6.2	6.0	0.2	4.5	3.1	11.7
Personal and social services	7.9	2.9	2.3	0.5	7.3	-2.2	6.2
<b>1995-2005</b>							
<b>Market Economy</b>	4.8	0.7	0.2	0.5	3.0	1.2	100
Electrical mach & comm services	15.9	1.2	0.7	0.4	5.0	9.7	12.4
Manufacturing excl. Electrical	4.1	-0.4	-0.9	0.5	2.3	2.2	26.2
Other goods producing industries	1.6	-0.2	-0.6	0.4	2.9	-1.0	21.6
Distribution services	3.4	0.6	0.1	0.5	2.7	0.1	15.7
Finance and business services	4.2	2.6	2.0	0.6	3.3	-1.7	16.8
Personal and social services	3.7	2.8	2.4	0.4	2.1	-1.5	7.2
<b>1995-2005 (excluding 1998-1999)</b>							
<b>Market Economy</b>	5.6	1.1	0.7	0.4	3.3	1.2	100
Electrical mach & comm services	14.2	0.7	0.3	0.4	5.3	8.2	12.5
Manufacturing excl. Electrical	4.8	0.0	-0.5	0.4	2.7	2.1	26.2
Other goods producing industries	3.3	1.0	0.6	0.4	3.1	-0.8	21.3
Distribution services	4.1	0.4	-0.2	0.6	3.0	0.7	15.7
Finance and business services	5.5	2.7	2.4	0.3	3.4	-0.5	17.0
Personal and social services	4.0	3.8	3.5	0.3	2.5	-2.5	7.3

Notes: European Union: 15 old member states (AUT, BEL, DNK, FIN, FRA, GER, GRC, IRL, ITA, LUX, NLD, ESP, PRT, SWE, UK). Five excluded countries are GRC, IRL, LUX, PRT, and SWE.

VA= Value-added growth rate (%)

L= Contribution of labor input

LH= Contribution of labor hours

LC= Contribution of labor composition

K= Contribution of capital input

MFP= Contribution of multifactor productivity growth= (1)-(2)-(5)

EU KLEMS Sector Classification (See Table A1 in Appendix)

Among 72 industries, the market economy excludes the following five industries: Imputation of owner occupied rents (56), Other real estate activities (57), Public admin and defense and compulsory social security (63), Education (64), and Health and social work (65).

Electrical machinery and post & communication services (26-33, 52)

Manufacturing excluding electrical machinery (9-25, 34-39)

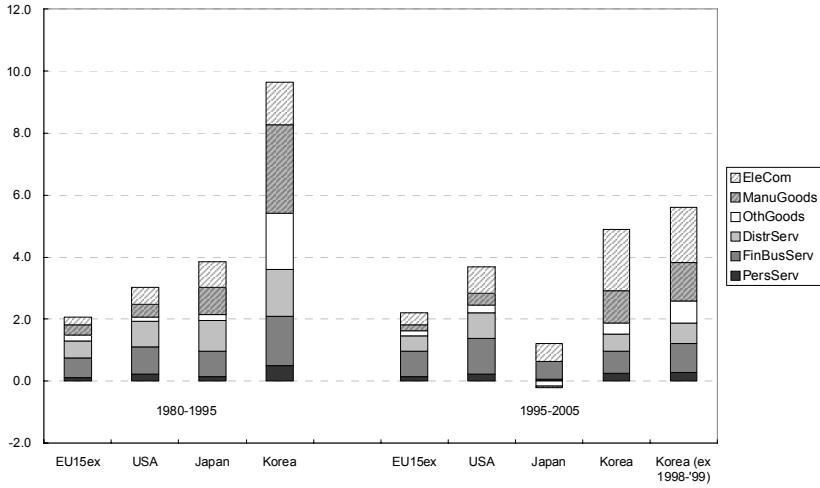
Other goods producing industries (1-8, 40-43)

Distribution Services (44-46, 48-51)

Finance and business services (53-55, 58-62)

Personal and social services (47, 66-71)

Panel A. Sectoral Contributions to Market Economy Value-Added Growth



Panel B. Sectoral Contributions to Market Economy MFP Growth

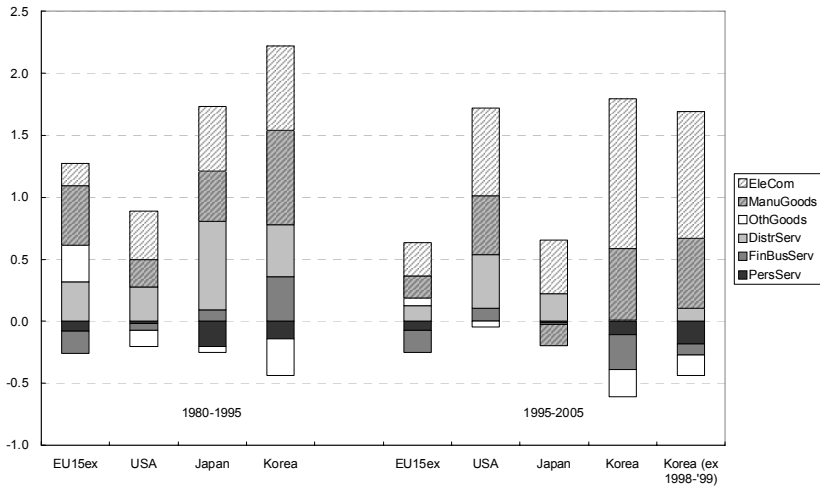


FIGURE 3

SECTORAL CONTRIBUTIONS TO MARKET ECONOMY VALUE-ADDED AND MFP GROWTH, 1980-1995 AND 1995-2005

#### **IV. Structural Changes in Korea after the 1997 Financial Crisis**

After the financial crisis of December 1997, the Korean economy went through the IMF-mandated adjustment and restructuring program, as documented in Pyo (2004). During the ten years after the crisis, the Korean economy experienced many structural changes. In this section, we examine this structural change, focusing on changes in sectoral contributions to aggregate productivity growth. Although the financial crisis occurred in 1997, the impact on economic growth was reflected in 1998 and 1999. Thus, we divide the sample period of 1980-2005 into three periods (1980-1990, 1990-1997, and 1999-2005) and exclude the period of the financial crisis (1998-1999). We also follow EU KLEMS' sectoral classification used in the previous section.

Table 3 shows the value-added growth accounting results for the Korean market economy during the three sub-periods. From 1980 to 2005, the contribution of labor inputs to output growth declined, mainly due to the fall in labor hours rather than to compositional changes in labor input. The contribution of capital input also steadily declined from 1980, but fell more rapidly after the 1997 crisis. In particular, the contribution of capital was very high, on average, which was a major reason for the fast growth of the Korean economy prior to the crisis. However, the slowdown in investment after the crisis significantly lowered the market economy value-added growth. The post-crisis slowdown in the contribution of capital input was significant in manufacturing except for ICT, other goods producing, and personal and social services sectors. In contrast to the slowdown in output and input growth since 1980, the contribution of MFP growth to output growth in the market economy shows a U-shaped pattern: 2.1% per year over 1980-1990, 1.3% over 1990-1997, and 1.9% over 1999-2005. MFP growth explains about 16.9% and 20.8% of output growth in the two sub-periods before the crisis, but up to 28.8% in the post-crisis period. The TFP growth rate in the 1980s was the highest among the three sub-periods, but the MFP contribution was rather the lowest. Overall, labor input growth accounts for 20% of value-added growth and its contribution changes little, while capital input growth explains about 60% and 50% of value-added growth in the pre- and post-crisis periods, respectively. In contrast, MFP growth explains about 20% of the market economy GDP growth before the crisis, but almost 30% in



**TABLE 3**  
STRUCTURAL CHANGES IN KOREA:  
BEFORE AND AFTER THE 1997 FINANCIAL CRISIS

	VA	L	LH	LC	K	MFP	VA
	(1)	(2)	(3)	(4)	(5)	(6)	weight
	= (2) + (5) + (6)	= (3) + (4)					
<b>1980-1990</b>							
<b>Market Economy</b>	10.1	2.1	1.8	0.3	6.0	2.1	100
Electrical mach & comm services	17.2	3.0	2.5	0.5	7.9	6.2	7.8
Manufacturing excl. Electrical	11.6	2.8	2.2	0.6	5.6	3.1	28.4
Other goods producing industries	7.1	0.8	0.6	0.1	7.1	-0.7	28.4
Distribution services	8.8	1.5	1.3	0.2	4.7	2.6	20.7
Finance and business services	14.0	6.0	5.8	0.2	4.9	3.1	9.3
Personal and social services	7.7	1.6	0.9	0.7	7.0	-0.8	5.5
<b>1990-1997</b>							
<b>Market Economy</b>	7.7	1.8	1.6	0.3	4.5	1.3	100
Electrical mach & comm services	15.0	-0.4	-0.8	0.4	3.2	12.1	8.8
Manufacturing excl. Electrical	6.9	0.4	-0.1	0.5	4.4	2.2	27.1
Other goods producing industries	5.5	1.5	1.4	0.1	5.4	-1.4	26.3
Distribution services	6.3	1.5	1.2	0.3	3.5	1.3	16.7
Finance and business services	11.2	5.5	5.5	0.1	3.5	2.1	14.2
Personal and social services	7.2	5.1	4.9	0.2	7.6	-5.5	6.9
<b>1999-2005</b>							
<b>Market Economy</b>	6.6	1.3	0.9	0.4	3.3	1.9	100
Electrical mach & comm services	17.1	2.0	1.6	0.3	5.0	10.0	12.3
Manufacturing excl. Electrical	6.1	0.3	-0.2	0.4	2.8	3.1	26.2
Other goods producing industries	3.1	0.8	0.5	0.2	3.3	-0.9	21.7
Distribution services	5.3	0.7	0.3	0.5	3.1	1.5	15.8
Finance and business services	6.1	2.9	2.4	0.5	3.2	0.1	16.7
Personal and social services	5.4	3.7	3.5	0.2	2.9	-1.3	7.2

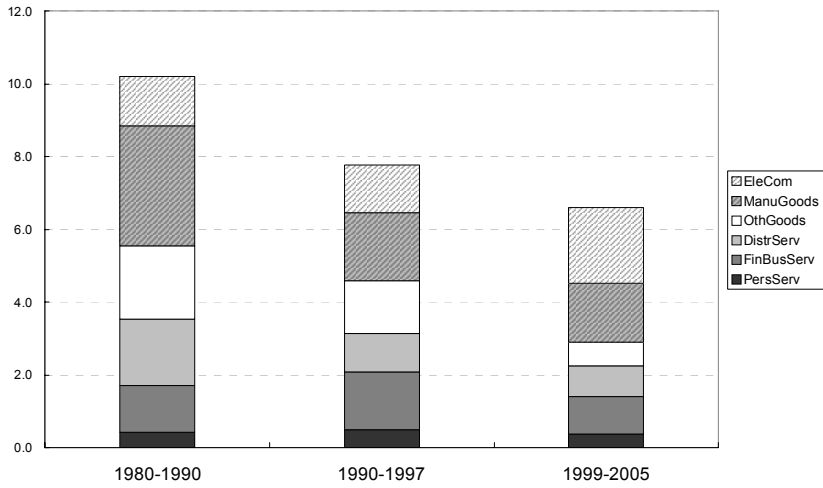
the post-crisis period.

The revival in productivity growth in the post-crisis period can be attributed to the IMF-mandated industrial restructuring (Pyo and Ha 2005).<sup>14</sup> Moreover, intensified competition due to the globalization and/or diffusion of new information technologies could be another source of the resurgence in productivity growth. We will not investigate the underlying factors for the post-crisis MFP growth resurgence, but focus on changes in sectoral contributions to the post-crisis MFP growth resurgence.

To assess sectoral shifts in output and MFP growth after the 1997 crisis, we begin with sectoral shifts away from service sectors (distribution, finance and business, personal and social services) toward the

<sup>14</sup>The role of productivity gain in Manufacturing in the catch-up process of Korea has been well-documented by Timmer (1999) and Pyo (2001).

Panel A. Sectoral Contributions to Market Economy Value-Added Growth



Panel B. Sectoral Contributions to Market Economy MFP Growth

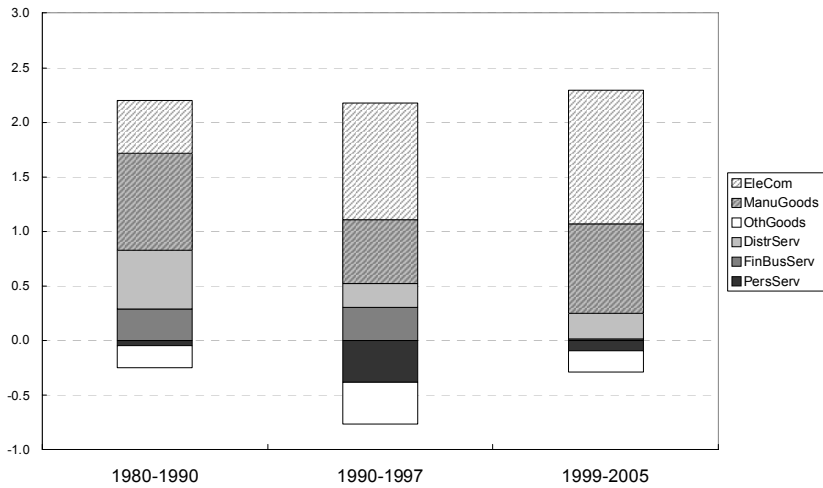


FIGURE 4

STRUCTURAL CHANGE IN KOREA: SECTORAL CONTRIBUTIONS TO MARKET ECONOMY VALUE-ADDED AND MFP GROWTH

**TABLE 4**  
SECTORAL CONTRIBUTIONS TO MARKET ECONOMY  
VALUE-ADDED AND MFP GROWTH

	1980-1990	1990-1997	1999-2005
<b>Value-Added Growth</b>			
<b>Market Economy</b>	10.1 (100)	7.7 (100)	6.6 (100)
Electrical mach & comm services	1.3 (13.2)	1.3 (17.0)	2.1 (31.8)
Manufacturing excl. Electrical	3.3 (32.3)	1.9 (24.0)	1.6 (24.1)
Other goods producing industries	2.0 (19.8)	1.4 (18.6)	0.7 (10.2)
Distribution services	1.8 (17.9)	1.1 (13.5)	0.8 (12.7)
Finance and business services	1.3 (12.8)	1.6 (20.5)	1.0 (15.4)
Personal and social services	0.4 (4.2)	0.5 (6.4)	0.4 (5.9)
<b>MFP Growth</b>			
<b>Market Economy</b>	2.1 (100)	1.3 (100)	1.9 (100)
Electrical mach & comm services	0.5 (24.7)	1.1 (75.5)	1.2 (61.3)
Manufacturing excl. Electrical	0.9 (45.7)	0.6 (41.3)	0.8 (40.5)
Other goods producing industries	-0.2 (-10.2)	-0.4 (-26.8)	-0.2 (-9.7)
Distribution services	0.5 (27.2)	0.2 (15.6)	0.2 (11.8)
Finance and business services	0.3 (14.9)	0.3 (21.4)	0.0 (0.8)
Personal and social services	0.0 (-2.3)	-0.4 (-27.0)	-0.1 (-4.7)

Note: Table 4 shows underlying data for Figure 4. Numbers in parentheses are sectoral contributions whose sum is normalized to 100%.

goods-producing and ICT sectors. Table 4 and Figure 4 show this change.<sup>15</sup> Value-added growth declined from 1980-1990 to 1990-1997 and further declined in the post-crisis period of 1999-2005. Slowdown in value-added growth in the ICT and goods-producing sectors accounts for most of the decline in the market economy value-added growth from 1980-1990 to 1990-1997. However, the post-crisis slowdown in the market economy value-added growth is not confined to a particular sector. All sectors, except for the ICT sector, exhibit slowdown in value-added growth rates after the crisis.

Table 4 shows the sectoral contribution to the market economy value-added or MFP growth. The contribution of the ICT sector to the market economy value-added growth has grown significantly since 1980, which explains about 13.2% of the market economy value-added

<sup>15</sup>The share of the manufacturing sector (measured by the value-added share in the Korean economy) increased from the 1970s and reached its highest level in the 1980s, after which it slowly declined in the 1990s but rose again after the crisis. The service sector share steadily increased from 1970 but, as shown in Table 4, the share of the other goods producing sector (especially, agriculture and mining industries) has rapidly declined since 1970.

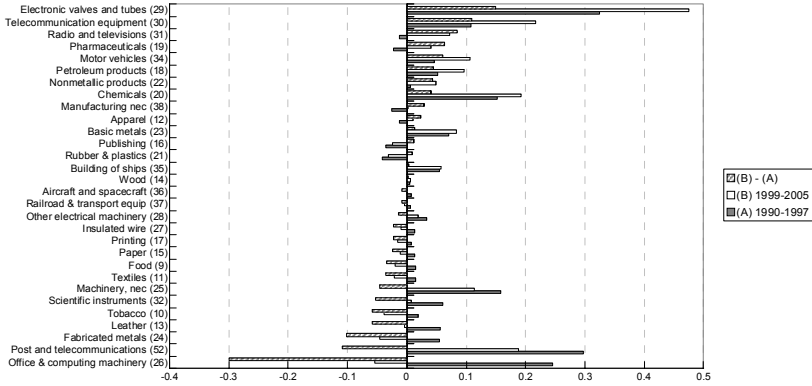
growth in 1980-1990, 17.0% in 1990-1997, and 31.8% in 1999-2005. In contrast, the contribution of manufacturing excluding ICT, other goods producing, and distribution service sectors to the market economy value-added growth decreased from 1980. The finance and business services sector contributions to the market economy value-added growth rose from the 1980s to the pre-crisis period, but fell again after the 1997 crisis. Overall, the sectoral contribution to the market economy value-added growth after the crisis decreased for all sectors except for the ICT sector.

Contributions to the resurgence of the market economy MFP growth after the crisis are highly concentrated in three sectors: ICT, manufacturing, and other goods-producing sectors. However, the channels of contribution to the market economy MFP growth are very different among the three sectors. The contribution of the manufacturing sector to the market economy MFP growth increased through its higher MFP growth rate while those of the ICT and other goods-producing sectors increased through the expansion of their sectoral shares. The finance and business sector as well as the personal and social services sector negatively contributed to the market economy MFP growth in the post-crisis period through lowered MFP growth in addition to expanded sectoral share.<sup>16</sup>

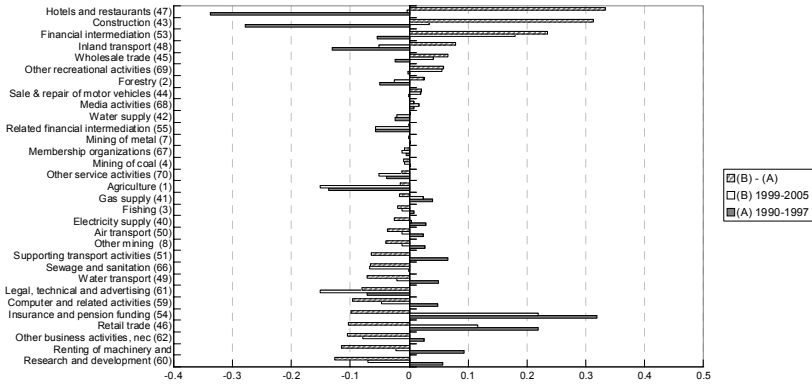
Figure 5 shows the 72-industry-level contributions to the market economy MFP growth before and after the 1997 crisis. The bars with the diagonal line in Figure 5 measure the difference between sectoral contributions of the 1991-1997 and 2000-2005 periods to the Korean market economy MFP growth and are sorted in decreasing order. In Panel A, the pattern of the ICT and manufacturing industries' contributions to the market economy MFP growth show that there has been an industrial shift within the manufacturing sector, away from low-tech industries to high-tech industries such as motor vehicles, basic metals, chemicals, and so on. This suggests that the post-crisis MFP growth resurgence might be a result of more active innovations in these industries. In Panel B, which shows non-manufacturing industries (excluding ICT industries), only a few industries, such as hotel and restaurants, construction, wholesale, and financial intermediation,

<sup>16</sup>These findings can suggest that sectoral growth in the service sector may not be related to its efficiency but rather to demand factors, such as higher demand for social services and more active business services outsourcing by the manufacturing sector.

Panel A. ICT and MFG Industries



Panel B. Non-MFG Industries (Excluding ICT Industries)



Notes: Red bars with the diagonal line measure the difference between the sectoral contributions of the 1991-1997 and 2000-2005 periods to the Korean market economy MFP growth and are sorted in decreasing order. Industries in Panel A include Electrical machinery, post & communication services (26-33, 52) and Manufacturing, excluding electrical machinery (9-25, 34-39), while industries in Panel B include the other four sectors of Other goods producing industries (1-8, 40-43), Distribution services (44-46, 48-51), Finance and business services (53-55, 58-62), and Personal and social services (47, 66-71).

FIGURE 5

CONTRIBUTIONS TO MFP GROWTH IN THE MARKET ECONOMY: ICT AND MFG VERSUS NON-MFG, BEFORE AND AFTER THE 1997 FINANCIAL CRISIS

exhibit increased contributions to the market economy MFP growth from pre- to post-crisis periods. Except for these industries, Panel B confirms that the post-crisis slowdown in MFP growth prevails across industries within the non-manufacturing sector. Therefore, our findings through the 72-industry-level data are consistent with those in the sectoral level analysis in the previous section. Structural changes after the crisis result in productivity-driven growth across the manufacturing and ICT industries. However, productivity growth is not observed in most non-manufacturing or service industries.

The relatively sluggish productivity gain in the service sector was pointed out by the IMF in their recent consultation with the Korean authorities as a bottleneck for sustainable growth in 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. According to Kim (2007), while the share of the service sector in Korea has increased sharply, reaching the 56% level of GDP and 65% of total employment in 2005, service productivity is not only low in level terms, compared to developed countries' levels, but also lags behind in terms of the growth rate. Kim (2007) has also pointed out that Korea's inter-industry linkage effect between manufacturing and service is about half the size of those in developed countries. Although small-sized businesses, skill mismatch, and a small domestic market are often considered as sources of low productivity in the service sector, more rigorous studies are needed.

## V. Conclusion

The purpose of this paper is to explore how the Korea Industrial Productivity (KIP) database has been constructed for estimating productivities by industry following the EU KLEMS industry classification and guideline and estimating 72-industry MFP growth. Using both the KIP and EU KLEMS databases, we first report value-added growth accounting results for the market economy, including 6 sectors, and perform a cross-country comparison of growth accounting for Korea, the EU, the U.S., and Japan.

We find that lower MFP contribution to economic growth confirms input-led growth in Korea. Since the financial crisis of December 1997, the GDP growth rate in the Korean economy has declined; however, the sources of growth now seem to have switched to being productivity-

growth based. After the 1997 financial crisis there was a sectoral shift away from other goods producing (agriculture, mining, utility, and construction) and toward manufacturing and service sectors. Moreover, the gap in MFP growth between manufacturing and service sectors did not shrink but, rather, has expanded after the 1997 crisis. Therefore, the post-crisis revival in productivity growth may be mainly attributed to strong productivity gains in ICT and manufacturing industries. Results also suggest that post-crisis productivity resurgence in ICT and high-tech manufacturing industries might be due to increased innovation activities and intensified competition associated with restructuring and globalization. Slowdown in service MFP can be associated with regulations and lack of competition.

Productivities in an economy are not identical across industries, and productivity differences are also observed when compared with other economies. For example, productivity growth in Korea after the 1990s have been mainly attributed to strong productivity growth in ICT goods-producing industries such as the semiconductor, telecommunication equipment, and high-tech manufacturing industries such as motor vehicles, machinery, basic metal, and chemicals. The international comparison of industry-level productivity demonstrates the relative productivity of each industry, illustrating whether goods and services are produced relatively efficiently, and referring to the appropriate policies for improvement such as competition, restriction, R&D policies, and so on. The establishment of a dataset with the same standards across countries for productivity measurement will facilitate these inter-industry and international comparisons, and will contribute to a better understanding of economic growth.

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**Appendix**

**APPENDIX TABLE A1**  
72-INDUSTRY CLASSIFICATION AND COVERAGE

Code	Industry Name	Note
<b>Agriculture and Mining (1-8)</b>		
1	Agriculture	
2	Forestry	
3	Fishing	
4	Mining of coal and lignite; extraction of peat	
5	Extraction of crude petroleum and natural gas and services	2004-2005
6	Mining of uranium and thorium ores	N.A.
7	Mining of metal ores	
8	Other mining and quarrying	
<b>Manufacturing (9-39)</b>		
9	Food products and beverages	
10	Tobacco products	
11	Textiles	
12	Wearing apparel, dressing and dying of fur	
13	Leather, leather products and footwear	
14	Wood and products of wood and cork	
15	Pulp, paper and paper products	
16	Publishing	
17	Printing and reproduction	
18	Coke, refined petroleum products and nuclear fuel	
19	Pharmaceuticals	
20	Chemicals excluding pharmaceuticals	
21	Rubber and plastics products	
22	Other non-metallic mineral products	
23	Basic metals	
24	Fabricated metal products	
25	Machinery, nec	
26	Office, accounting and computing machinery	
27	Insulated wire	
28	Other electrical machinery and apparatus nec	
29	Electronic valves and tubes	
30	Telecommunication equipment	
31	Radio and television receivers	
32	Scientific instruments	
33	Other instruments	
34	Motor vehicles, trailers and semi-trailers	
35	Building and repairing of ships and boats	
36	Aircraft and spacecraft	1976-2005
37	Railroad equipment and transport equipment nec	
38	Manufacturing nec	
39	Recycling	N.A.

(Appendix Table A1 Continued)



Code	Industry Name	Note
<b>Utilities and Construction (40-43)</b>		
40	Electricity supply	
41	Gas supply	
42	Water supply	
43	Construction	
<b>Services (44-72)</b>		
44	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	
45	Wholesale trade and commission trade, except of motor vehicles and motorcycles	
46	Retail trade, except of motor vehicles and motorcycles; repair of household goods	
47	Hotels and restaurants	
48	Inland transport	
49	Water transport	
50	Air transport	
51	Supporting and auxiliary transport activities; activities of travel agencies	
52	Post and telecommunications	
53	Financial intermediation, except insurance and pension funding	
54	Insurance and pension funding, except compulsory social security	1976-2005
55	Activities related to financial intermediation	1986-2005
56	Imputation of owner occupied rents	N.A. (Incl. in 57)
57	Real estate activities	
58	Renting of machinery and equipment	
59	Computer and related activities	
60	Research and development	
61	Legal, technical and advertising	
62	Other business activities, nec	
63	Public admin and defense; compulsory social security	
64	Education	
65	Health and social work	
66	Sewage and refuse disposal, sanitation and similar activities	
67	Activities of membership organizations nec	
68	Media activities	
69	Other recreational activities	
70	Other service activities	
71	Private households with employed persons	
72	Extra-territorial organizations and bodies	N.A.

Note: EU KLEMS Sector Classification.

Electrical machinery and post & communication services (26-33, 52), Manufacturing excluding electrical machinery (9-25, 34-39), Other goods producing industries (1-8, 40-43), Distribution Services (44-46, 48-51), Finance and business services (53-55, 58-62), Personal and social services (47, 66-71), Non-market services (56-57, 63-65).

**References**

- Berndt, Ernst R., and Christensen, Laurits R. "The Translog Function and the Substitution of Equipment, Structures, and Labor in U. S. Manufacturing, 1929-1968." *Journal of Econometrics*, 1 (No. 1 1973): 81-114.
- Denny, Michael, and Fuss, Melvyn A. "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates." *American Economic Review*, 67 (No. 3 1977): 404-18.
- Fukao, Kyoji, Hamagata, Sumio, Inui, Tomohiko, Ito, Keiko, Kwon, Hyeog Ug, Makino, Tatsuji, Miyagawa, Tsutomu, Nakanishi, Yasuo, and Tokui, Joji. Estimation Procedures and TFP Analysis of the JIP Database 2006. RIETI Discussion Paper Series 07-E-003, June 2007.
- Inklaar, Robert, Timmer, Marcel P., and van Ark, Bart. Mind the Gap!: International Comparisons of Productivity in Services and Goods Production. GGDC Research Memorandum GD-89, Groningen Growth and Development Centre, University of Groningen, 2006.
- Jorgenson, Dale W., Gallop, Frank M., and Fraumeni, Barbara M. *Productivity and U.S. Economic Growth*. Cambridge, MA: Harvard University Press, 1987.
- Jorgenson, Dale W., Ho, Mun S., and Stiroh, Kevin J. *Productivity Volume 3: Information Technology and American Growth Resurgence*. Cambridge, MA: MIT Press, 2005.
- Jorgenson, Dale W., and Stiroh, Kevin J. "Raising the Speed Limit: U.S. Economic Growth in the Information Age." *Brookings Papers on Economic Activity* 31 (No. 1 2000): 125-233.
- Kim, Hyunjeong. "The Shift to the Service Economy: Causes and Effects." *Bank of Korea Economic Papers* 10 (No. 1 2007): 169-211.
- Krugman, Paul. "The Myth of Asia's Miracle." *Foreign Affairs* 73 (No. 6 1994): 62-78.
- Lau, Lawrence J., and Kim, Jong-Il. "The Sources of Growth of East Asian Newly Industrialized Countries." *Journal of the Japanese and International Economies* 8 (No. 3 1994): 235-71.
- Lewis, W. William. *The Power of Productivity: Wealth, Poverty, and the Threat to Global Stability*. Chicago: University of Chicago Press, 2004.

- Pyo, Hak K. "Economic Growth in Korea (1911-1999): A Long-term Trend and Perspective." *Seoul Journal of Economics* 14 (No. 1 2001): 59-125.
- \_\_\_\_\_. "Estimates of Capital Stocks by Industries and Types of Assets in Korea (1953-2000)." *Journal of Korean Economic Analysis* 9 (No. 1 2003): 203-81 (in Korean).
- \_\_\_\_\_. "Interdependency in East Asia and the Post-Crisis Macroeconomic Adjustment in Korea." *Seoul Journal of Economics* 17 (No. 1 2004): 117-51.
- Pyo, Hak K., and Ha, Bongchan. Productivity Convergence and Investment Stagnation in East Asia. Presented at CIRJE seminar, University of Tokyo, Japan, July 21, 2005.
- \_\_\_\_\_. "A Test of Separability and Random Effects in Production Function with Decomposed IT Capital." *Hitotsubashi Journal of Economics* 48 (No. 1 2007): 67-82.
- Rhee, Keun Hee. *International Comparison of Multifactor Productivity*. Seoul, Korea: Korea Productivity Center, 2007 (in Korean).
- Stiroh, Kevin J. "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?" *American Economic Review* 92 (No. 5 2002): 1559-76.
- Timmer, Marcel P. *The Dynamics of Asian Manufacturing: A Comparative Perspective, 1963-1993*. Eindhoven Centre for Innovation Studies, Dissertation Series, 1999.
- Timmer, Marcel P., Moergastel, Ton van, Stuivenwold, Edwin, Ypma, Gerard, O'Mahony, Mary, and Kangasniemi, Mari. *EU KLEMS Growth and Productivity Accounts (Version 1.0, Part I Methodology)*. EU KLEMS Consortium, March 2007a.
- Timmer, Marcel P., O'Mahony, Mary, and van Ark, Bart. *EU KLEMS Growth and Productivity Accounts: Overview*. EU KLEMS Consortium, March 2007b.
- \_\_\_\_\_. *EU KLEMS Growth and Productivity Accounts: Overview November 2007 Release*. EU KLEMS Consortium, November 2007c.
- Young, Alwyn. "Lessons from the East Asian NICs: A Contrarian View." *European Economic Review Papers and Proceedings* 38 (Nos. 3-4 1994): 964-73.