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Estimates of Total Factor Productivity, the Contribution of ICT, and Resource Reallocation Effects in Japan and Korea

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Abstract

The purpose of our study is to identify the sources of economic growth based on a KLEMS model for Japan and Korea. We also identify the growth contribution of ICT assets and resource reallocation effects in the two economies. Both Japan and Korea enjoyed high TFP growth in ICT-producing sectors but suffered low TFP growth in ICT-using sectors. For Japan, we find that the main factor underlying the Lost Decade is the slow-down in TFP growth. We also found that Korea's TFP growth was slow until the Asian financial crisis of 1997-1999 but then accelerated after the crisis. It seems that before the crisis, Korea was following a catch-up process with developed economies that was predominantly input-led and manufacturing-based, as documented by Timmer (1999) and Pyo (2001). However, through the drastic economic reform undertaken during the crisis, Korea seems to have shifted to a new phase of economic growth since the end of the 1990s. TFP growth rates, especially those in manufacturing sectors, have substantially increased in post-crisis Korea. Both in Japan and Korea, productivity in service sectors is much lower than in manufacturing. The reason probably is excessive regulation and a lack of competition in service sectors. And these factors seem to have impeded introduction of ICT in service industries. As for ICT capital accumulation, the ICT investment/GDP ratio of Korea is higher than that of Japan. Especially, the speed of ICT accumulation in the ICT sector in Korea is much faster than that in Japan. Both in Japan and Korea, the largest component in ICT investment is computing equipment. In the case of resource reallocation across sectors, the reallocation effect of capital input was negligible or negative for most periods both in Korea and Japan. After the financial crisis of 1997-99, the resource allocation effect of capital in Korea remained negative, although the size of the negative effect declined. On the other hand, the reallocation effect of labor input was positive for most periods both in Korea and Japan.

1. Introduction

As Krugman (1994), Young (1994), and Lau and Kim's (1994) studies have shown, the East Asian economic miracle may be characterized as "input-led" growth. However, more recently, at least in Japan and the Republic of Korea, investment has been stagnating, average working hours have been falling, and the working age population has been decreasing as a result of the decline in the fertility rate. This means that a surge in productivity is required for renewed sustainable growth in these countries. The purpose of our study is to identify the sources of economic growth based on a KLEMS model for Japan and Korea, which experienced a Lost Decade and a financial crisis in 1997-1998, respectively. We also identify the growth contribution of ICT assets and resource reallocation effects in the two economies.

Both Japan and Korea enjoyed high TFP growth in ICT-producing sectors but suffered low TFP growth in ICT-using sectors. For Japan, we find that the main factor underlying the Lost Decade is the slow-down in TFP growth. We also found that Korea's TFP growth was slow until the Asian financial crisis of 1997-1999 but then accelerated after the crisis. It seems that before the crisis, Korea was following a catch-up process with developed economies that was predominantly input-led and manufacturing-based, as documented by Timmer (1999) and Pyo (2001). However, through the drastic economic reform undertaken during the crisis, Korea seems to have shifted to a new phase of economic growth since the end of the 1990s. TFP growth rates, especially those in manufacturing sectors, have substantially increased in post-crisis Korea.

Both in Japan and Korea, productivity in service sectors is much lower than in manufacturing. The reason probably is excessive regulation and a lack of competition in service sectors. And these factors seem to have impeded introduction of ICT in service industries.

As for ICT capital accumulation, the ICT investment/GDP ratio of Korea is higher than that of Japan. Especially, the speed of ICT accumulation in the ICT sector in Korea is much faster than that in Japan. Both in Japan and Korea, the largest component in ICT investment is computing equipment.

In the case of resource reallocation across sectors, the reallocation effect of capital input was negligible or negative for most periods both in Korea and Japan. After the financial crisis of 1997-99, the resource allocation effect of capital in Korea remained negative, although the size of the negative effect declined. On the other hand, the reallocation effect of labor input was positive for most periods both in Korea and Japan.

This paper is organized as follows. Section 2 examines estimates of sectoral TFP of Japan and Korea by following the guidelines of database by EU KLEMS project accounting framework for the market economy. Section 3 identifies the contribution of ICT capital accumulation in Japan and Korea. Section 4 provides estimates of resource reallocation effects in Japan and Korea. Section 5 examines how the global financial crisis affected the two economies. Finally, Section 6 concludes the paper.

2. Growth Accounting and TFP Growth

2.1 Overview of Growth Accounting for Japan and Korea in Comparison with the Major EU Economies and the United States

We first report the results of growth accounting for Japan and Korea and compare them with the major EU economies (Germany, France, the UK, and Italy) and the United States in Table 1.[1]

Table 1. Growth Accounting for the Market Economy in Advanced Countries

(%)

Country	Gross value added growth	Contribution of labor service input growth	Contribution of capital service input growth	TFP growth
	1980-95			
Japan	3.8	0.4	1.9	1.5
Korea	9.5	2.2	7.1	0.2
Germany	1.9	-0.2	1.2	0.8
France	1.8	-0.1	0.7	1.2
UK	2.5	-0.2	1.2	1.5
Italy	1.9	0.2	0.9	0.9
United States	3.3	1.1	1.4	0.8
	1995-2007			
Japan*	1.1	-0.3	0.9	0.5
Korea	4.8	0.6	3.1	1.1
Germany	1.4	-0.4	0.9	0.7
France	2.5	0.7	0.9	0.8
UK	3.2	0.8	1.4	1.1
Italy	1.5	0.9	1.1	-0.4
United States	3.5	0.8	1.5	1.2

Source: EU KLEMS Database, November 2009.
* Growth accounting for Japan is for the period 1995-2006.

[1] The growth accounting analysis for the Japanese economy in this section is based on the EU KLEMS Database, November 2009. For details regarding this database, see Timmer et al. (2007).

Specifically, the table shows the growth accounting results for the market sector of these countries for the periods 1980-1995 and 1995-2007.[2] Although Korea's economic growth slowed down significantly after the financial crisis of 1997, the country nevertheless recorded the highest growth among the seven countries in both periods. The table also shows that Japan experienced a severe slowdown in growth from 3.8% in 1980-1995 (the second highest during that period) to 1.2% in 1995-2006 (the lowest during that period). Germany and Italy experienced a mild slowdown in economic growth from 1.9% to 1.4% and from 1.9% to 1.5% respectively.[3] The US experienced a relatively high growth rate of over 3.0% in both periods. Growth in France accelerated from 1.8% to 2.5%, and that in the UK from 2.5% to 3.2%.

Next, let us look at the contribution of the individual components to overall growth. In Japan, all the three factors – labor service input, capital service input and TFP – contributed to the slowdown in growth in the market sector. However, of the three, the deceleration in TFP growth played the most important role, accounting for 53% of the slowdown, while the deceleration in capital accumulation and the decline in labor input accounted for 34% and 14% of the slowdown, respectively.

Turning to Korea, the most important factor underlying the slowdown in overall growth is the deceleration in capital service input growth: of the 4.7 percentage-point overall decline in the growth rate, 85% was accounted for by the deceleration in capital accumulation. The slowdown in labor input growth accounted for 34% of the decline of Korea's growth rate. On the other hand, TFP growth accelerated from 0.2% to 1.1%.

Let us examine the TFP growth performance in the different countries. Comparing the two periods, Japan's average TFP growth rate dropped by 1 percent

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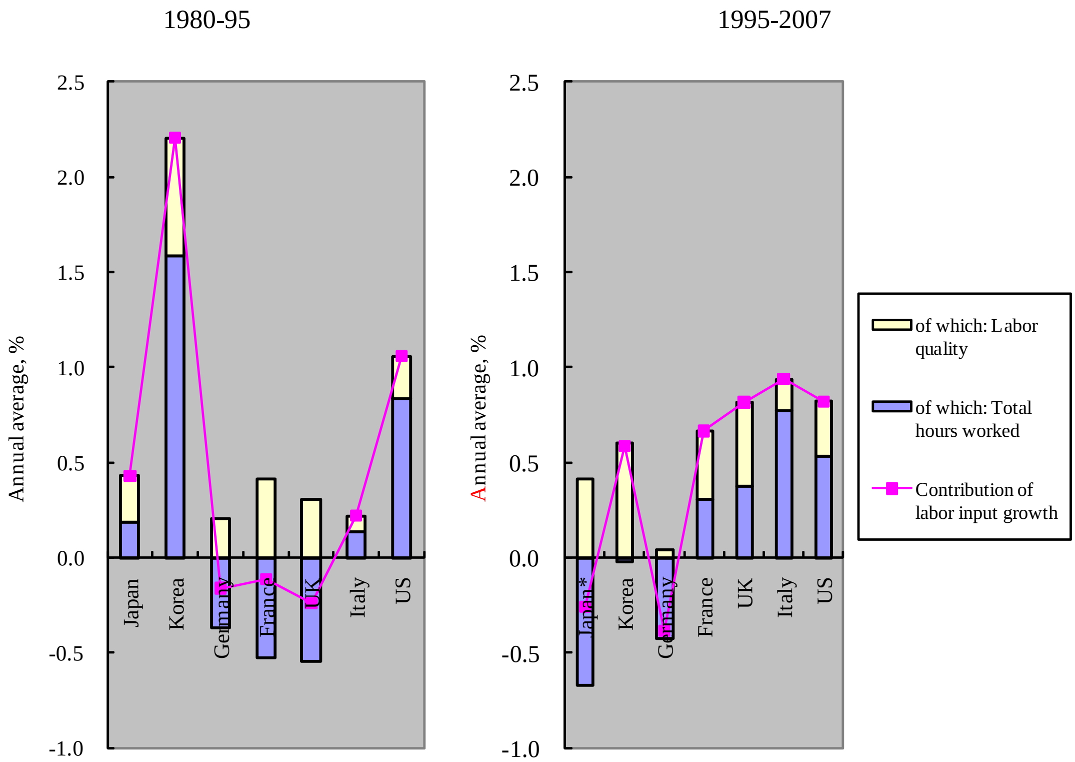
[2] The EU KLEMS Growth and Productivity Accounts are a kind of gross output growth accounting in which output is measured by gross output, and inputs are decomposed into capital (K), labor (L), energy (E), material (M), and service inputs (S). Since this methodology is essentially based on gross output, it has the advantage of separating the productivity effects of intermediate inputs from the productivity effects of other inputs, thereby allowing a more accurate measurement of productivity by industry. Moreover, the assumption on real value-added production function (separability assumption) is not usually guaranteed (See Berndt and Christensen (1973, 1974), Berndt and Wood (1975), Denny and Fuss (1977), and Yuhn (1991) for the US, and Pyo and Ha (2007) for Korea), 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. Therefore, for international productivity comparison, value-added growth accounting has been used more often explicitly or implicitly assuming the separability between primary inputs of capital and labor and non-primary inputs such as energy, intermediate goods and services. We follow this convention in the present paper and adopt value-added growth accounting of the private economy as defined in EU KLEMS.

[3] The EU KLEMS data on Germany for years before Germany's unification include East Germany.

point, from 1.5% in 1980-95 to 0.5% in 1995-2006, while in Korea, the TFP growth rate increased by 0.9 percent points, from 0.2% in 1980-95 to 1.1% in 1995-2007. Meanwhile, in the four major EU economies, a mild slowdown can be observed. Taken together, the TFP growth rate in the four major economies declined by 0.5 percentage-points from 1.1% in 1980-95 to 0.6% in 1995-2007. Finally, the United States experienced an acceleration in TFP growth from 0.8% to 1.2%. Thus, among the seven major developed economies examined here, Korea and the United States are exceptional in the acceleration in TFP growth they experienced.

These different trends in TFP growth indicate that there is a stark difference in the causes underlying the acceleration in overall growth in France, the UK, and Italy on the one hand and the United States on the other. In the three EU countries, the acceleration in economic growth was mainly achieved through labor input growth. As Figure 1 shows, the increase in labor input growth in Italy did not take the form of improvements in labor quality but of an increase in total hours worked. In contrast, in the case of the UK and France, the quality of labor input improved substantially. Until 1995, these three countries suffered high unemployment rates, especially among the less-educated young, but subsequently succeeded in creating jobs for these unemployed. The average of the standardized unemployment rate of the three countries declined from 11.3% in 1995 to 7.4% in 2004. On the other hand, the standardized unemployment rate in Japan increased from 3.1% to 4.7% during the same period (OECD 2006). In contrast with the three EU countries just mentioned, the main cause of the growth acceleration in the United States was the increase in TFP growth mentioned above.

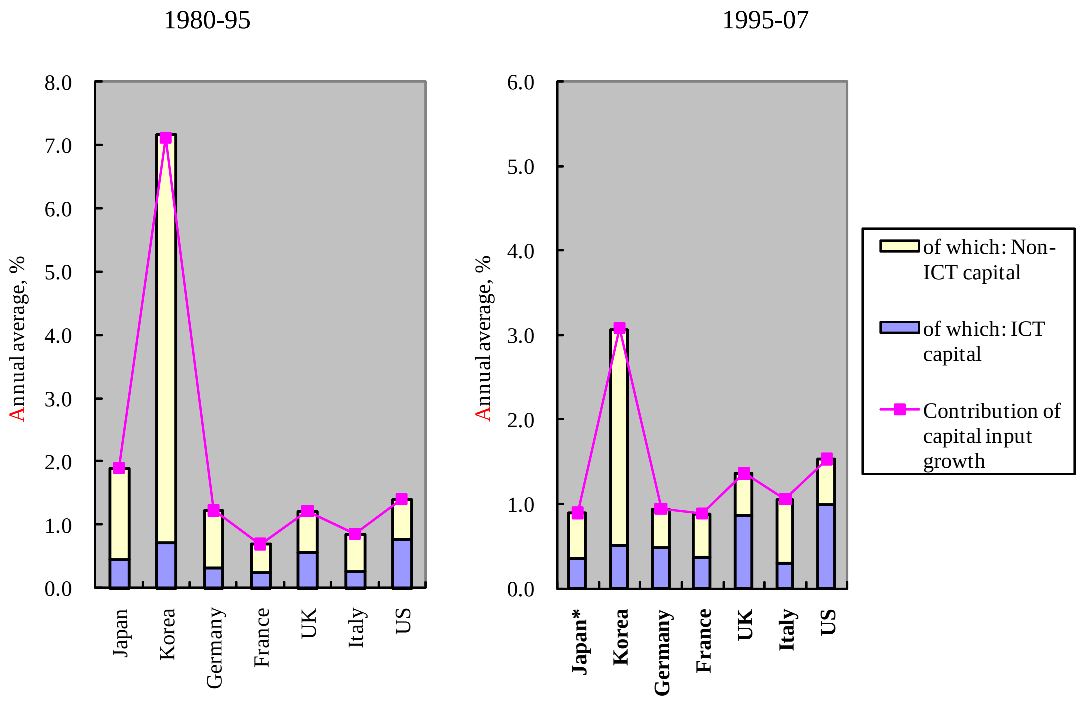
Figure 1. Contribution of Labor Input Growth: Japan, Korea, the United States and the Major EU Economies



Source: EU KLEMS Database, November 2009.
* Growth accounting for Japan is for the period 1995-2006.

Next, Figure 2 depicts the contribution of capital accumulation. In Japan, there was a large decline in the contribution of capital accumulation to economic growth. The contribution of capital accumulation also declined slightly in Korea and Germany. In contrast, in all the other four countries, the contribution of capital input growth increased. In particular the United States and the UK experienced an acceleration in capital accumulation. This capital deepening in the two countries was mainly caused by the rapid accumulation of ICT capital.

Figure 2. Contribution of Capital Input Growth: Japan, Korea, the United States and the Major EU Economies



Source: EU KLEMS Database, November 2009.
* Growth accounting for Japan is for the period 1995-2006.

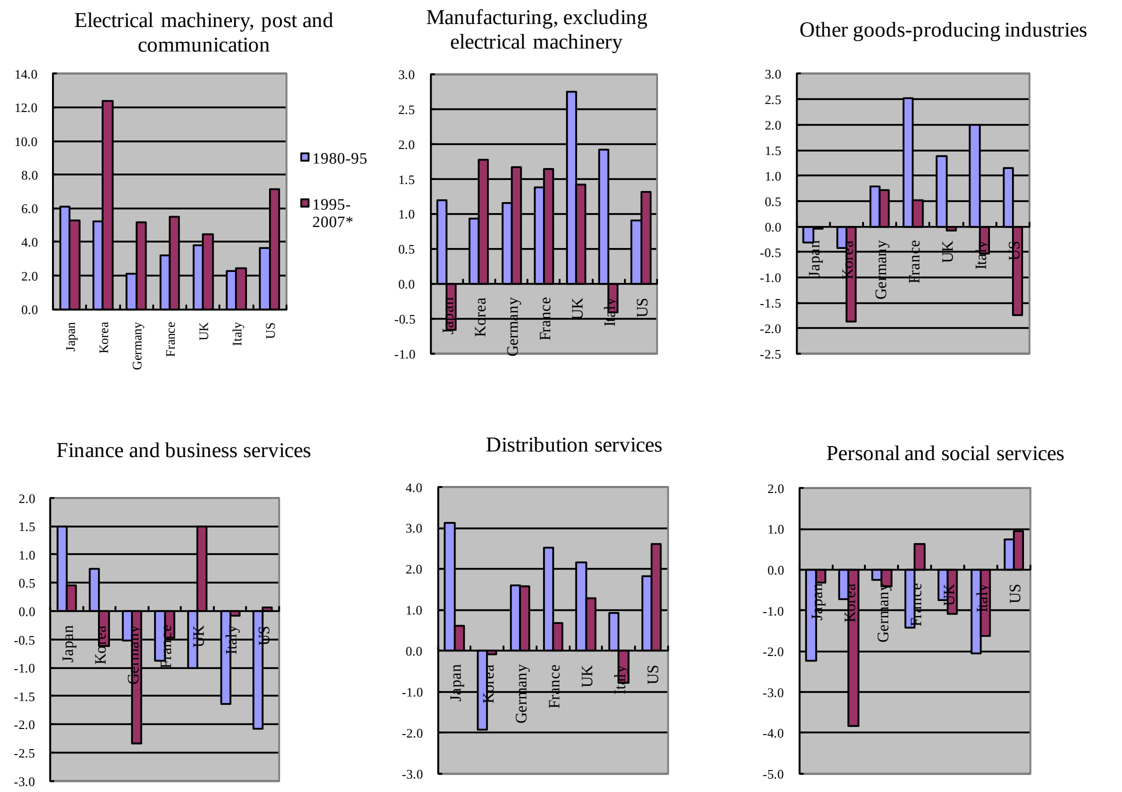
To sum up the analysis so far, Korea and the US are exceptional in experiencing accelerations in TFP growth. The four major EU economies (Germany, France, the UK and Italy) and Japan experienced a slowdown in TFP growth of a similar magnitude after 1995. It is not differences in TFP growth but differences in factor input growth that are responsible for the large difference in the economic growth performance of France, the UK and Italy on the one hand and Japan on the other in the period after 1995.

Next, we compare industry level TFP growth in the seven countries before and after 1995 (Figure 3). Beginning with the electrical machinery, post and communication sector (the ICT-producing sector), we find that Korea still had the highest TFP growth in the period after 1995, followed by the United States. The ICT-producing sector is the leading sector for enhancing productivity growth in Korea The input of ICT capital services in the ICT-producing sector having also increased strongly since 1995.[4] On the other hand, Japan's TFP growth in the ICT-producing sector after 1995 declined to a level in the middle-range of the seven economies. However, both in Korea and in Japan, TFP growth in this sector is higher than that in the other five sectors. The problem for

[4] See Ha and Pyo (2004) and Table 3 in Section 3.2 below.

Korea and Japan though is that, like in the other countries, the share of this sector in the overall economy is not very large. The average share of labor input (hours worked) in this sector in Korea's and Japan's total labor input in 1995-2007 was 4.8% and 4.1%, respectively. In the United States, this share was 3.8%.

Figure 3. TFP Growth in the Market Sector: by Sector and by Country: 1980-95 and 1995-2007*



Source: EU KLEMS Database, November 2009.
* Growth accounting for Japan is for the period 1995-2006.

The largest declines in TFP growth in Japan occurred in distribution services (retail, wholesale, and transportation) and in manufacturing other than electrical machinery. The labor input shares of these two sectors were 22.8% and 16.5%, respectively. Korea experienced a severe slowdown in TFP growth in all sectors except the ICT-producing sector, the rest of the manufacturing sector and the distribution sector. In the case of Korea, we observe that the estimated TFP growth rates in manufacturing in general are larger than in services. This may be due to the fact that innovations such as product or process innovation are more common in manufacturing than in services. Also, R&D investment for innovation is in general more intensive in manufacturing than in services. This may explain why TFP growth rates in manufacturing are greater than in services.

TFP growth in personal and social services was negative in all the countries examined here except in the United States (both periods) and France (1995-2007). Moreover, with the exception of the United States, the UK and Japan, TFP growth in finance and business services was negative in all the countries examined here.

To sum up the above analysis, Korea and Japan experienced relatively high TFP growth in the ICT-producing sector. However, the problem for the two countries is that TFP growth in ICT-using sectors, such as distribution services (retail, wholesale and transportation) and in the rest of the manufacturing sector, especially in Japan, declined substantially after 1995, and these ICT-using sectors have larger shares in the economy than the ICT-producing sector.

2.2. The Cumulative Contribution of Sectors to TFP Growth in Japan and Korea

Following Farrell, Baily and Remes (2005) and Fukao, Kim and Kwon (2006), we plot a modified Harberger (1998) diagram to examine the contribution of individual sectors to macro-level productivity growth. The results for the Japanese economy are shown in Figures 4, 5, and 6. The vertical axes display the cumulative sector contributions to aggregate TFP growth, while the horizontal axes depict the cumulative share of sectoral weights, that is, each sector's gross output over the summation of all the sectors' gross output. Sectors are lined up by descending order of their TFP contribution.

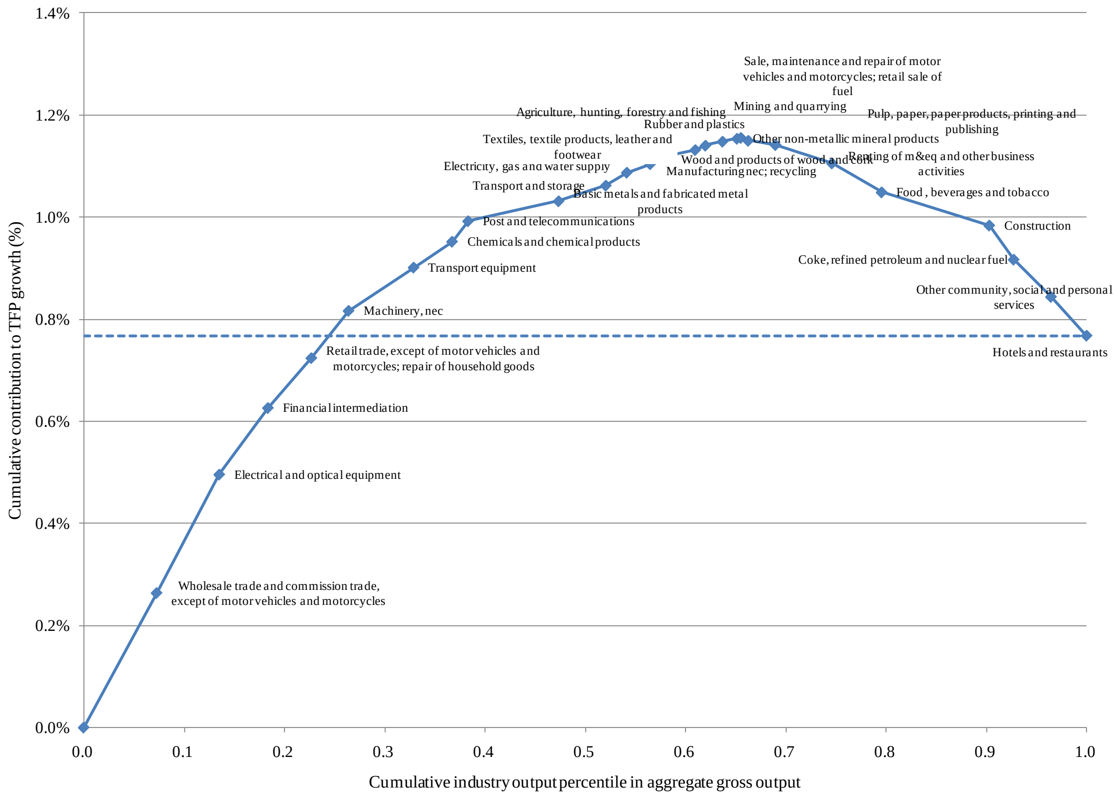
Figure 4 shows the sectoral TFP growth contribution for the period 1973-2006 for the market economy. The weight of the sectors with positive TFP growth is 66%, while the weight of sectors with negative TFP growth is 34%. The top five sectors in terms of their TFP growth contribution are wholesale trade, electrical and optical equipment, financial intermediation, retail trade, and machinery, nec.. As can be seen, productivity growth in the economy as a whole, which is represented by the broken horizontal line, was lower than the sum of the contributions of these five leading sectors. Sectors whose contribution to economy-wide TFP growth was negative include construction, hotels and restaurants, and real estate.

Figure 5 shows the cumulative contribution to TFP growth within the manufacturing sector. In manufacturing, most industries made a positive contribution to TFP growth: the weight of the gross output of industries with positive TFP growth is 79%. Only three industries, pulp, paper and publishing, food, beverages and tobacco, and coke, refined petroleum and nuclear fuel underwent substantial negative TFP growth.

Next, Figure 6 shows the cumulative contribution to TFP growth within the service sector. In services, the TFP contribution of growth in about half of the industries was negative. The weight of gross output of industries with negative TFP growth is 50% and, as a result, TFP growth of the overall service sector in the period 1973-2006 was relatively small.

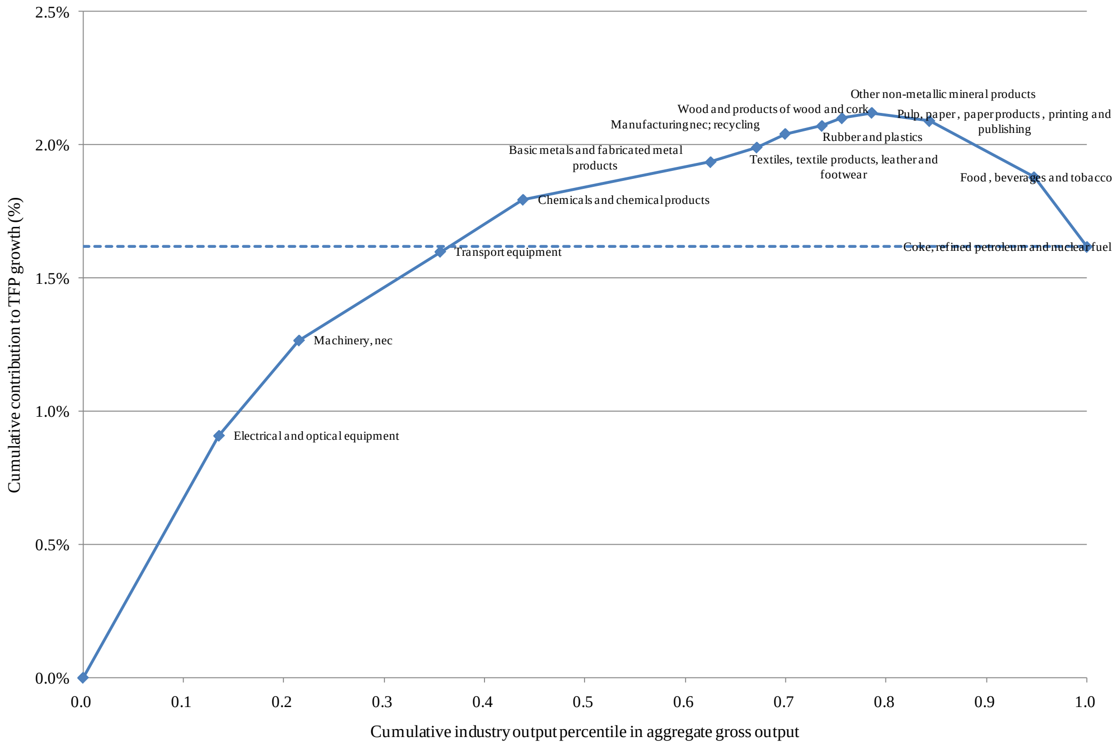
The above results indicate that for Japan's economy to achieve sustained TFP growth, an acceleration of productivity growth in the service sector is indispensable.

Figure 4. Cumulative Contribution of Industries to TFP Growth: Japan, 1973-2006, Market Economy



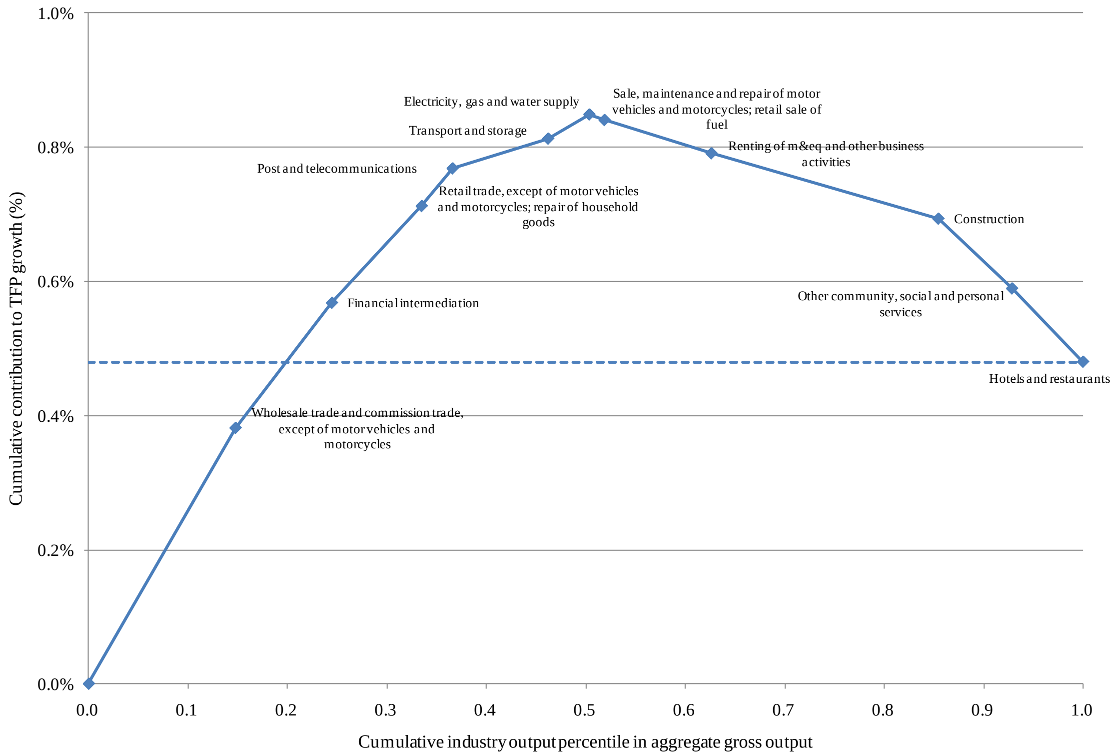
Source: EU KLEMS Database, November 2009.

Figure 5. Cumulative Contribution of Industries to TFP Growth: Japan, 1973-2006, Manufacturing



Source: EU KLEMS Database, November 2009.

Figure 6. Cumulative Contribution of Industries to TFP Growth: Japan, 1973-2006, Service



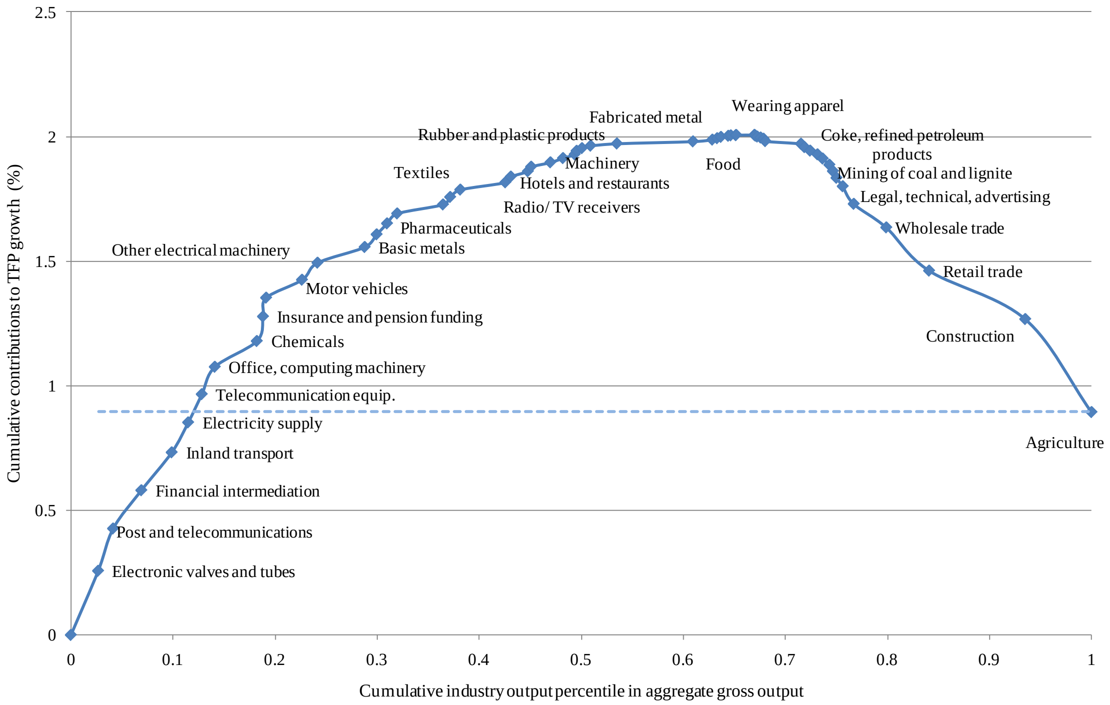
Source: EU KLEMS Database, November 2009.

Figures 7, 8 and 9 show the results for Korea. We start considering the economy as a whole, where the weight of gross output of sectors with positive TFP growth in the period 1972-2007 is about 68%, while that of sectors with negative TFP growth is about 32%. Figure 7 shows which sectors made a positive contribution to economy-wide TFP growth. Leading sectors in this group include post and telecommunications and financial intermediation in services, and electronic valves and tubes, telecommunication equipment, office, accounting and computer machinery in manufacturing. On the other hand, sectors with a negative contribution to economy-wide TFP growth were, for example, agriculture, construction, retail trade, wholesale trade, and legal, technical and advertising services.

Figure 8 shows the industry contribution to TFP growth in the manufacturing sector. The weight of the gross output of industries that made a positive TFP growth contribution in manufacturing is 93%, while the weight of those that made a negative TFP growth contribution is 7%. Industries making a leading contribution to TFP growth include the ICT industries, i.e., electronic valves and tubes, telecommunication equipment, office, accounting and computing machinery, other electrical machinery and apparatus, radio and TV receivers, and a number of non-ICT industries, including chemicals, basic metals, motor vehicles, textiles, and pharmaceuticals. On the other hand, industries with negative TFP growth are coke, refined petroleum products and nuclear fuel, printing and reproduction, and railroad equipment and transport equipment.

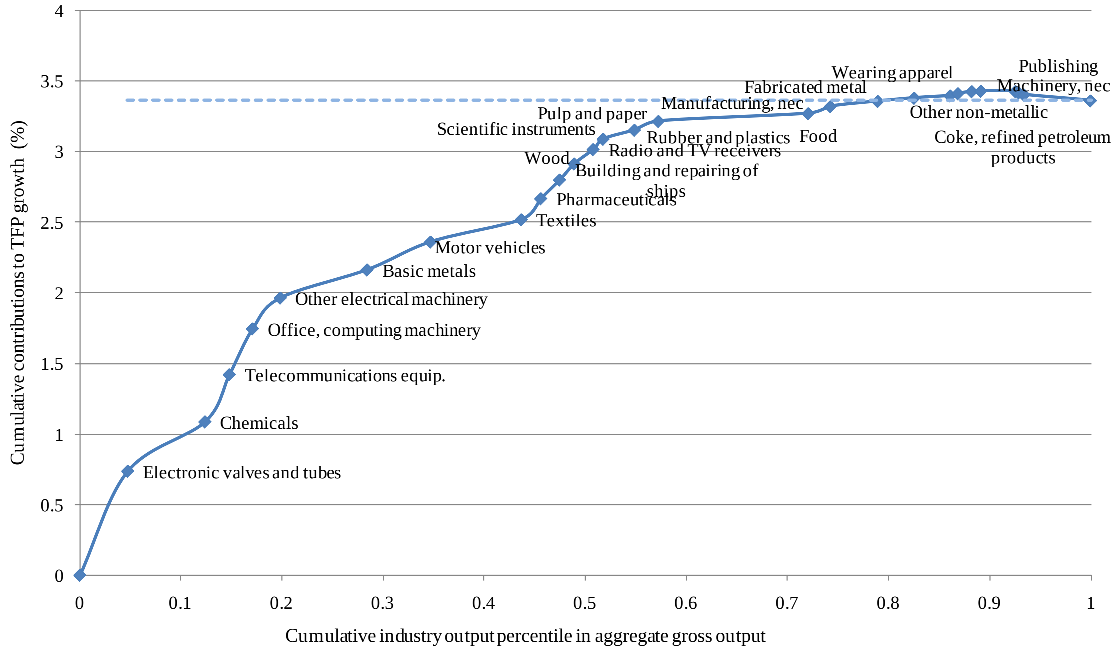
Results for services are shown in Figure 9. The weight of the gross output of sectors with positive TFP growth in services is only about 44%, while the weight of sectors with negative TFP growth is 56%. Service industries that made a positive contribution to TFP growth include inland transport, post and telecommunications, financial intermediation, electricity supply, and insurance and pensions. Industries with negative TFP growth include construction, retail trade, wholesale trade, legal, technical and advertising services, research and development, and other service activities.

Figure 7. Cumulative Contribution of Industries to TFP Growth: Korea, 1972-2007, Market Economy



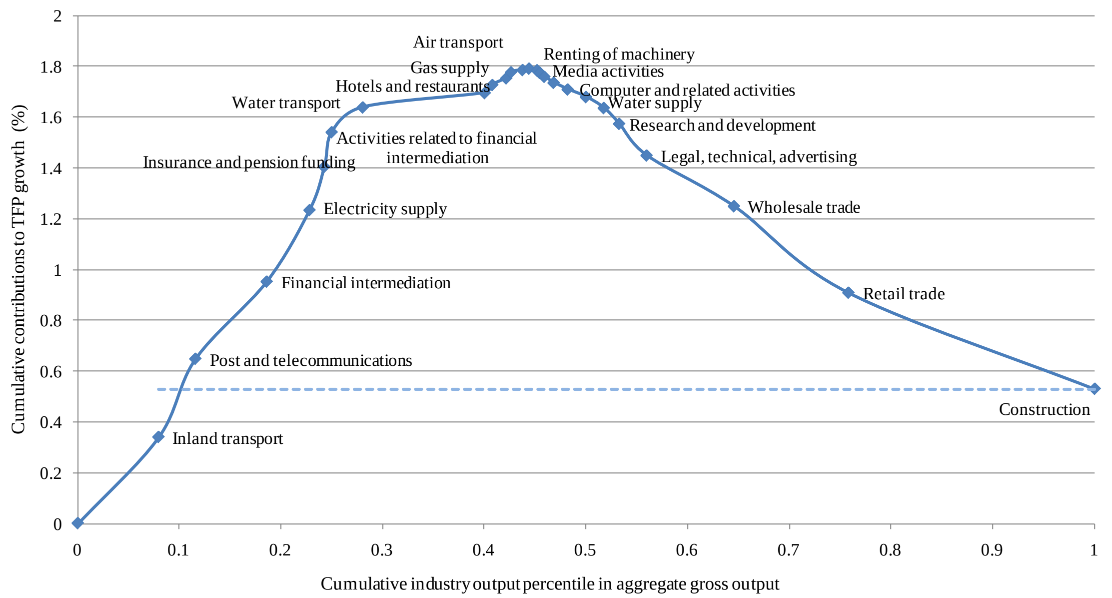
Source: EU KLEMS Database, November 2009.

Figure 8. Cumulative Contribution of Industries to TFP Growth: Korea, 1972-2007, Manufacturing



Source: EU KLEMS Database, November 2009.

Figure 9. Cumulative Contribution to Industries to TFP Growth: Korea, 1972-2007, Services



Source: EU KLEMS Database, November 2009.

3. Has ICT Investment Contributed to Economic Growth in Japan and Korea?

3.1 Accumulation of ICT Assets in Japan and Korea

Using the EU KLEMS Database, November 2009, the JIP Database 2009,[5] and the KIP Database 2009[6] we are able to extract data on ICT assets and compare the trends in ICT investment in the two countries.[7] Following the classification in the EU KLEMS Database, ICT assets consist of computer and peripheral equipment, communication equipment, and software.

Developments in ICT investment in Japan are shown in Figure 10. ICT investment in Japan grew steadily until 1991 and for the period 1970-2006 overall, its average growth rate was 11.7% per annum. However, since the early 1990s growth has been more uneven. Stagnating in the first half of the 1990s, ICT investment picked up again during the second half of the decade and has continued to increase. In 2006, ICT investment stood at 19.6 trillion yen (in 2000 constant prices), accounting for 15% of total investment. The biggest component within ICT investment is investment in computers and other ICT equipment, which in 2006 amounted to 9.9 trillion yen or 50% of total ICT investment.

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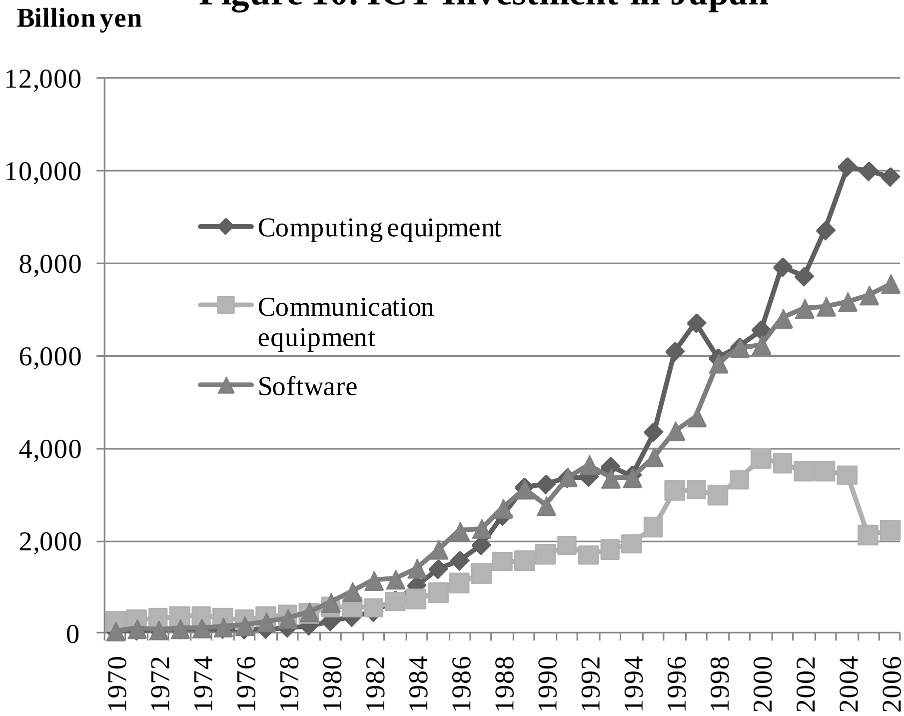
[5] For details on the JIP Database, see Fukao et al. (2007). The JIP Database 2009 contains annual data on 108 sectors in economy-wide during 1970-2006.

[6] The KIP Database 2009 contains annual data on 72 sectors in economy-wide during 1970-2007.

[7] The EU KLEMS Database, November 2009 does not provide ICT investment and ICT capital services in the market sector in Japan and Korea. Therefore, in the following figures and tables in Section 3, we constructed ICT investment and ICT capital services series in the market economy using the JIP Database 2009 and the KIP Database 2009.

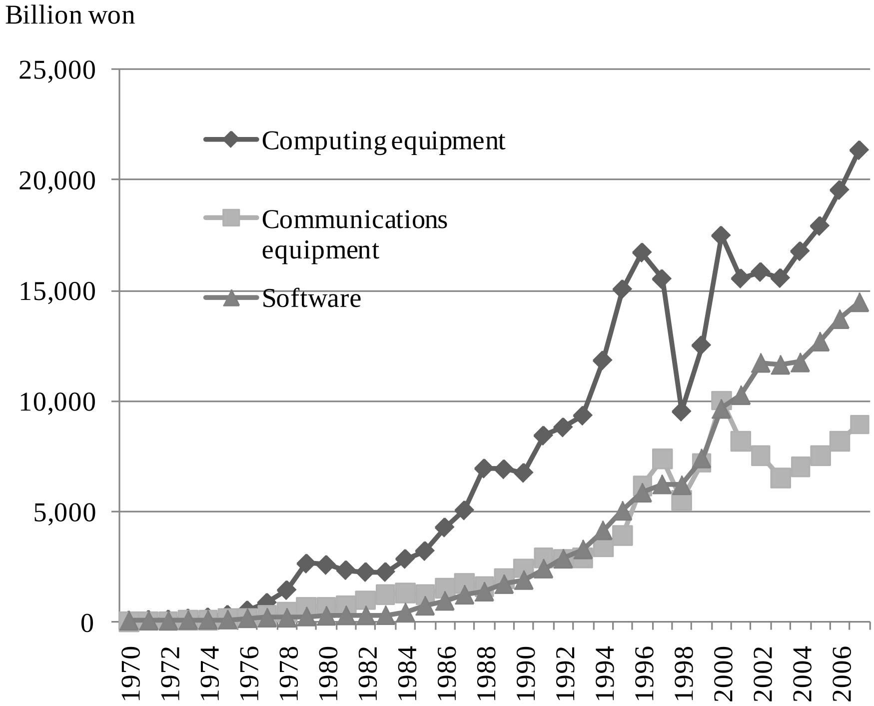
Figure 10. ICT Investment in Japan



Source: EU KLEMS Database, November 2009, and JIP Database 2009.

The trend in ICT investment in Korea is shown in Figure 11. The annual average growth rate of ICT investment in Korea for the period 1970-2007 is 15.5%, which is higher than the growth rate in Japan. However, for the period 1995-2007, the growth rate of Korean ICT investment, at 5.3%, was almost the same as that of Japanese ICT investment (5.9% for 1995-2006). Although Korean ICT investment showed steady growth until 1997, it declined drastically in 1998 due to the Asian currency crisis. However, it recovered rapidly and reached to 45 trillion won in 2007. The share of ICT investment in total investment in Korea was 19.4% in 2007. As in Japan, the largest component in ICT investment in Korea is computing equipment, accounting for 47.6% of total ICT investment.

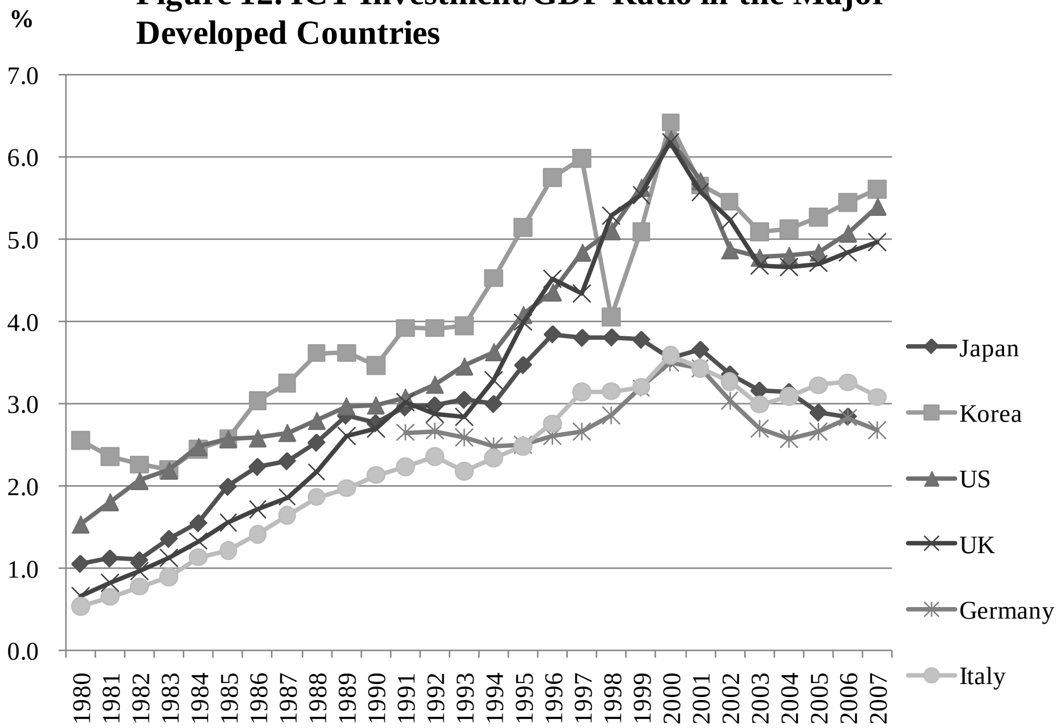
Figure 11. ICT Investment in Korea



Source: KIP Database 2009.

Next, we compare the ICT investment/GDP ratios of major developed economies, including Japan and Korea, both expressed in nominal terms (Figure 12). We find that the trends in the ICT investment/GDP ratios in the major developed countries since the late 1990s fall into two groups. In Korea, the United States, and the UK, the ratios increased rapidly and reached almost 5% in 2007. Although ICT investment in these countries slowed down after the collapse of the ICT bubble in the early 2000s, it subsequently recovered gradually. On the other hand, in the other countries, the ratios were only in the order of 3%. While Japan's ICT investment/GDP ratio was as high as those in the United States and the UK until the mid 1990s, it has stagnated since 1995. In contrast to Japan, Korea's ICT investment/GDP ratio caught up with that of the United States and the UK, although it fell drastically in 1998 due to the Asian financial crisis.

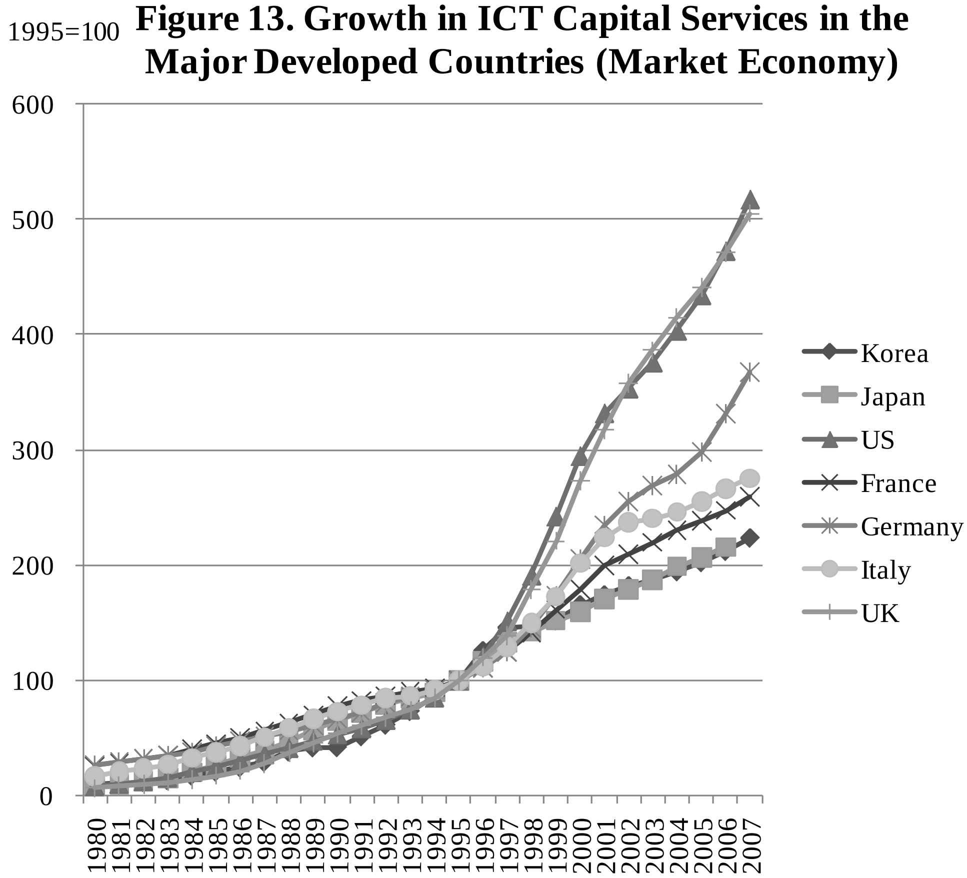
Figure 12. ICT Investment/GDP Ratio in the Major Developed Countries



Sources: EU KLEMS Database, November 2009 ; JIP Database 2009; KIP Database 2009.

Turning to the growth in ICT capital services in the major developed economies, the trends are shown in Figure 13. In three countries (the UK, the United States, and Korea) the growth rates of ICT capital services in the period after 1995 exceeded 10% per annum. However, the growth rate of ICT capital services for Japan was one of the lowest due to the long-term stagnation of the economy.

Figure 13. Growth in ICT Capital Services in the Major Developed Countries (Market Economy)



Sources: EU KLEMS Database, November 2009; JIP Database 2009; KIP Database 2009.

3.2 The Contribution of ICT Capital Services to Economic Growth in Korea and Japan

Using the growth accounting method we compare the contribution of ICT capital services to economic growth in Korea and Japan (Table 2). We find that in the period 1980-2007, the growth rate of value added in Korea was considerably higher than that in Japan. As shown in the table, the high growth rate in Korea was largely driven by the rapid increase in capital services, while in Japan the increase in capital services was much slower. However, the substantial gap between the two countries in the contribution of capital services is not the result of a difference in the growth of ICT capital services but the difference in the growth of non-ICT capital services.

Table 2. Growth Accounting Including ICT Capital Services (Market economy) (%)

	1980-1995		1995-2000		2000-2007	
	Korea	Japan	Korea	Japan	Korea	Japan*
Value added	9.5	3.9	5.0	1.0	4.6	1.0
Labor	2.2	0.4	0.2	-0.4	0.8	-0.7
Man-hours	1.6	0.1	-0.2	-0.9	0.1	-1.0
Labor quality	0.6	0.3	0.5	0.4	0.7	0.4
Capital	7.1	2.0	3.9	1.1	2.5	1.1
ICT capital	0.7	0.5	0.7	0.5	0.4	0.4
Non-ICT capital	6.5	1.5	3.1	0.6	2.2	0.6
TFP	0.2	1.5	0.8	0.4	1.3	0.6

Sources: EU KLEMS Database, November 2009, and KIP Database 2009.
*Growth accounting for Japan is for the period from 2000 to 2006.

Next, we compare the contribution of ICT capital services to economic growth by industry for all seven countries considered here. As shown in Table 3, the contribution of capital services in the market economy in 1995-2000 and 2000-2007 was highest in the UK and the United States, although in the latter period it declined in all advanced countries, except in the United States.

Table 3. Contribution of ICT Capital Services Input Growth to Economic Growth (%)

	1995-2000							2000-2007						
	France	Germany	Italy	Japan	Korea	UK	US	France	Germany*	Italy*	Japan**	Korea	UK	US
Market economy total	0.54	0.68	0.43	0.50	0.73	0.95	0.57	0.26	0.34	0.13	0.37	0.36	0.56	0.57
Electrical machinery, post and communication	0.16	0.18	0.80	1.30	0.47	2.46	0.82	0.65	0.25	0.15	0.77	0.59	0.96	0.45
Manufacturing, excluding electrical	0.33	0.20	0.28	0.32	0.95	0.46	0.24	0.09	0.12	0.06	0.21	0.39	0.21	0.31
Other goods producing industries	0.28	0.09	0.15	0.22	0.09	0.20	0.64	0.07	0.03	0.06	0.12	0.11	0.17	0.32
Distribution services	0.54	0.49	0.46	0.16	0.69	0.81	0.53	0.19	0.21	0.07	0.08	0.23	0.55	0.54
Finance and business services	1.00	2.13	0.76	0.45	1.19	1.73	0.75	0.51	0.99	0.34	0.37	0.62	1.01	1.04
Personal and social services	0.48	0.27	0.38	0.12	1.45	0.49	0.57	0.09	0.10	0.12	0.08	0.15	0.21	0.17

Sources: EU KLEMS Database, March 2008, and November 2009.
* 2000-2005
**2000-2006

Looking at individual industries, we find that in the electrical machinery, post and communication industry, the contribution of ICT capital services in Japan was relatively high in 1995-2000. The contribution of ICT capital services in the Japanese electrical machinery, post and communication industry declined in the latter period, whereas that in Korea increased.

In the service sector, notable results include the low contribution of capital services to economic growth in the Japanese service sector when compared with the other countries examined here.

Another notable pattern is the relatively high contribution of ICT capital services in Korea's finance and business services when compared with other sectors in the country.

4. Resource Reallocation Effects in Japan and Korea

4.1 Measurement Methodology and Results for the Market Economy as a Whole

It is commonly observed that factor prices for the same category of labor and rates of return to capital are different across industries. If such differences are caused by institutional obstacles to inter-industry factor movements and each factor price is equal to the marginal product of that production factor, GDP can be raised by shifting production factors from industries with low factor prices to those with high factor prices. In this section, we analyze how such resource reallocations have contributed to Japan's and Korea's economic growth.[8]

Let us examine this issue in a growth accounting framework. As Jorgenson et al. (2007) have shown, the way in which the resource reallocation effect is measured in growth accounting depends on the type of growth accounting method chosen. In the case of growth accounting in the EU KLEMS project, factor price equalization between industries is not assumed and macro-level factor inputs are calculated by a Tornqvist index, in which factor input growth across industries is aggregated by using the factor income in each industry as aggregation weights. Therefore, if production factors move from low factor price industries to high factor price industries, this reallocation will be treated as an increase in macro-level factor inputs. Jorgenson et al. (2007) labeled this type of growth accounting method the "direct aggregation across industries" approach.

However, there is another type of growth accounting method, which Jorgenson et al. (2007) called the "production possibility frontier" approach. In this case, each input is assumed to receive the same price in all industries. The macro-level quantity of each input is the simple sum of inputs across industries. In this approach, reallocation effects are included in macro TFP growth.

Jorgenson et al. (2007) showed the following relationship between the macro TFP growth derived from the production possibility frontier approach, v_T, and the macro TFP growth derived from the direct aggregation across industries approach, v_T^D:

[8] For more details on the analysis of resource reallocation effects in Japan, see Fukao, Miyagawa and Takizawa (2007).

$$v_T = v_T^{\ D} + \left(\sum_j \left(\overline{w}_j \frac{\overline{v}_{K,j}}{\overline{v}_{V,j}} \Delta \ln K_j \right) - \overline{v}_K \Delta \ln K \right) + \left(\sum_j \left(\overline{w}_j \frac{\overline{v}_{L,j}}{\overline{v}_{V,j}} \Delta \ln L_j \right) - \overline{v}_L \Delta \ln L \right) \tag{1}$$

where v_T^D is equal to the weighted sum of industry level TFP growth, v_j, across industries:

$$v_T^{\ D} = \left(\sum_j \frac{\overline{w}_j}{\overline{v}_{V,j}} \overline{v}_j \right) \tag{2}$$

The upper bars denote the average values across periods *t* and t+1. Δ represents the change of a value from period *t* to period *t*+1, w_j is the proportion of industry *j*'s value added in aggregate value added, $v_{K,j}$ and $v_{L,j}$ are the share of capital and of labor income in industry *j*'s gross output, and $v_{V,j}$ stands for industry *j*'s value added-gross output ratio. Therefore the coefficient of v_j, $wj/v_{K,j}$, in equation (2) denotes the ratio of industry *j*'s gross output to aggregated value added. Equation (2) implies that the macro TFP growth derived from the direct-aggregation-across-industries approach, v_T^D, is equal to the direct aggregation of each industry's TFP growth with Domar weights.

In equation (1), K_j denotes the Tornqvist index of capital input in industry *j* and L_j the Tornqvist index of labor input in industry *j*:

$$\Delta \ln K_j = \sum_k \overline{w}_{k,j} \Delta \ln K_{k,j}$$

$$\Delta \ln L_j = \sum_l \overline{w}_{l,j} \Delta \ln L_{l,j}$$

where

$$w_{k,j} = \frac{P_{K,k,j} K_{k,j}}{\sum_k P_{K,k,j} K_{k,j}}$$

$$w_{l,j} = \frac{P_{L,l,j} L_{l,j}}{\sum_l P_{L,l,j} L_{l,j}}$$

$K_{k,j}$ denotes input of type *k* capital in industry *j* and $L_{l,j}$ input of type *l* labor in industry *j*. Similarly, $P_{K,k,j}$ denotes the price for type *k* capital in industry *j* and $P_{L,l,j}$ the price for type *l* labor in industry *j*.

K and L denote the macro-level capital input index and the macro-level labor input index, which are calculated under the assumption of identical factor prices across industries:

$$\Delta \ln K = \sum_k \overline{w}_k \Delta \ln K_k$$

$$\Delta \ln L = \sum_l \overline{w}_l \Delta \ln L_l$$

where

$$K_k = \sum_j K_{k,j}$$

$$L_l = \sum_j L_{l,j}$$

and w_k and w_l are defined by

$$w_k = \frac{P_{K,k} K_k}{\sum_k P_{K,k} K_k}$$

$$w_l = \frac{P_{L,l} L_l}{\sum_l P_{L,l} L_l}$$

$P_{K,k}$ stands for the economy-wide average price for type k capital and $P_{L,l}$ the economy-wide average price for type l labor. In equation (1), v_K represents the aggregated capital income-value added ratio and v_L the aggregated labor income-value added ratio.

The second term on the right-hand side of equation (1) denotes the effect of capital reallocation on macro TFP growth, v_T, which is derived from the production possibility frontier approach. Similarly, the third term on the right-hand side of equation (1) denotes the effect of labor reallocation on macro TFP growth, v_T, which is derived from the production possibility frontier approach. We can rewrite the second term on the right-hand side of equation (1) as

$$\begin{aligned} \sum_j \left(\overline{w}_j \frac{\overline{v}_{K,j}}{\overline{v}_{V,j}} \Delta \ln K_j \right) - \overline{v}_K \Delta \ln K &= \sum_j \left(\overline{w}_j \frac{\overline{v}_{K,j}}{\overline{v}_{V,j}} \Delta \ln K_j - \overline{w}_{K,j} \overline{v}_K \Delta \ln K \right) \\ &= \sum_j \left(\overline{w}_j \frac{\overline{v}_{K,j}}{\overline{v}_{V,j}} - \overline{w}_{K,j} \overline{v}_K \right) \Delta \ln K_j + \overline{v}_K \left(\sum_j \overline{w}_{K,j} \Delta \ln K_j - \Delta \ln K \right) \end{aligned} \tag{3}$$

where $w_{K,j}$ is defined by

$$w_{K,j} = \frac{\sum_k P_{K,k} K_{k,j}}{\sum_j \sum_k P_{K,k} K_{k,j}}$$

In equation (3), the value of $w_j v_{K,j}/v_{V,j}$ is equal to the ratio of capital income in industry j to the macro-level value added. The value of this coefficient shows the percentage increase in GDP for a one-percent increase in capital input in industry j. On the other hand, the value of $w_{K,j} v_K$ shows the percentage increase in GDP for a one-percent increase in capital input in industry j when the average price of capital across different types of capital in industry j is equal to the economy-wide average price of capital, that is, $\Sigma_k P_{K,k,j} K_{k,j} = \Sigma_k P_{K,k} K_{k,j}$.

Therefore, the first term on the right-hand side of equation (3) denotes the inter-industry reallocation effect of aggregated capital. If the industry-level growth rate of capital input, $\Delta \ln K_j$, is positive in industries where the industry-level average capital price is higher than the macro-level average capital price, i.e., $\Sigma_k P_{K,k,j} K_{k,j} > \Sigma_k P_{K,k} K_{k,j}$, and if the industry-level growth rate of capital input, $\Delta \ln K_j$, is negative in industries where the industry-level average capital price is lower than the macro-level average capital price, i.e., $\Sigma_k P_{K,k,j} K_{k,j} < \Sigma_k P_{K,k} K_{k,j}$, then there will be a positive inter-industry reallocation effect of aggregated capital.

In the case of the continuous time version of equation (3), the second term on the right-hand side of equation (3) can be expressed as

$$v_K \sum_j \left(\frac{\sum_k P_{K,k} K_{k,j}}{\sum_j \sum_k P_{K,k} K_{k,j}} \sum_k \left(\left(\frac{P_{K,k,j} K_{k,j}}{\sum_k P_{K,k,j} K_{k,j}} - \frac{P_{K,k} K_{k,j}}{\sum_k P_{K,k} K_{k,j}} \right) \hat{K}_{k,j} \right) \right)$$

Therefore, we can interpret the second term on the right-hand side of equation (3) as the reallocation effect of changes in the capital composition within each industry. Suppose that the relative price of type k capital to the average value of prices for other types of capital in industry j is lower than the macro-level average relative price of type k capital, then an increase of capital input of this type in industry j will improve resource allocation and raise the macro TFP growth rate derived from the production possibility frontier approach, v_T.

A similar interpretation applies to the labor reallocation effect. The third term on the right-hand side of equation (1) can be decomposed into the inter-industry reallocation effect of aggregated labor and the reallocation effect of changes in the labor composition within each industry.

Using this methodology, let us now look at our estimates of reallocation effects for the market economy as whole for the two countries. For an analysis of resource reallocation effects, it is preferable to use a database with well disaggregated industry classification. Therefore, we use the JIP Database 2009 and the KIP Database 2009 instead of the EU KLEMS Database. Table 4 shows the TFP growth in Japan and Korea derived from the production possibility frontier approach, v_T, the TFP growth derived from the approach by direct aggregation across industries, v_T^D, the reallocation effect of capital input, and the reallocation effect of labor input for each period. It should be noted that the analysis here only focuses on reallocation effects in the market economy, not the economy as a whole.

This table shows that in Japan the reallocation effect of labor input was negative in all periods. However, there was a positive and substantial reallocation effect of capital input for the whole period analyzed except for the period 2000-06. The table also shows that, during the period 1990-2000, the total reallocation effect of labor and capital input became greater than the Domar-weighted TFP growth (macro TFP growth derived from the approach by direct aggregation across industries approach), v_T^D. However, during the period 2000-06 Japan experienced a large negative reallocation effect of labor and of capital input.

In contrast to the case of Japan, the reallocation effect of labor input in Korea was greater than the reallocation effect of capital input in all periods. For the period 1980-2000 we find relatively large negative values for the reallocation effect of capital input. However, the reallocation effect of labor input was positive and greater than the Domar-weighted TFP growth during the period 1980-90. Thus, while the reallocation of labor, that is the shift of labor from low wage industries to high wage industries, has made a substantial positive contribution to Korea's aggregate TFP growth, the contribution of capital reallocation has been negative.[9]

To sum up the above analysis, it seems that Japan has problems mainly in the reallocation of labor input, while Korea's problems lie more in the reallocation of capital input.

[9] Korea was hit by Asian financial crisis during 1997-1999. In order to analyze resource reallocation effects under normal economic conditions, we also calculated aggregate reallocation effects for 1990-97 and 1999-2007 in Table 4.

Table 4. Aggregate Reallocation Effects in Japan and Korea

(Average annual growth rates: %)

Japan		1975-80	1980-90	1990-2000	2000-06
(1) Growth rate of aggregated TFP, v_T	a=b+c+d	2.71	1.64	0.23	0.51
(2) Domar weighted TFP growth, v_T^D	b	2.60	1.73	0.10	1.13
(3) Reallocation effect of capital input	c	0.13	0.27	0.15	-0.29
(4) Reallocation effect of labor input	d	-0.01	-0.36	-0.03	-0.33

Korea		1972-80	1980-90	1990-2000	2000-07	1990-97	1999-2007
(1) Growth rate of aggregated TFP, v_T	a=b+c+d	-0.81	-0.56	-0.12	0.52	-0.64	0.69
(2) Domar weighted TFP growth, v_T^D	b	0.17	0.08	0.57	1.01	0.14	1.18
(3) Reallocation effect of capital input	c	-1.39	-1.20	-0.84	-0.57	-0.99	-0.55
(4) Reallocation effect of labor input	d	0.41	0.56	0.14	0.08	0.21	0.05

*The estimates for Japan are from Fukao, Miyagawa and Takizawa (2007).

4.2 Industry-Level Reallocation Effects of Capital and Labor in Japan

While the results shown in Table 4 are instructive, they show us neither in what sectors factor prices are high, nor how production factors have moved between industries. In order to intuitively understand the process of capital and labor input reallocation, we examine reallocation effects across industries. The results are shown in Tables 5(a) and (b).

We begin with the table for capital input (Table 5(a)), which shows the aggregate reallocation effect, $(w_j v_{K,j}/v_{V,j} - w_{K,j}v_K)\Delta\ln K_j$, as well as its two components, $w_j v_{K,j}/v_{V,j} - w_{K,j}v_K$ and $\Delta\ln K_j$, for the periods 1975-1990, 1990-2000, and 2000-2006. Values are on an annual basis. As explained above (Section 4.1), $w_j v_{K,j}/v_{V,j} - w_{K,j}v_K$ is positive in industries where the industry-level average capital price is higher than the macro-level average capital price. We also prepared a similar table to show the process of labor input reallocation across sectors (Table 5(b)).

Because the number of industries used for the derivation of Table 4 is too large to obtain instructive results, the tables here show resource reallocation effects based on more aggregated industry classifications. Specifically, the whole market economy is decomposed into seven sectors, that is, ICT-using manufacturing, ICT-using non-manufacturing, ICT-producing manufacturing, ICT-producing non-manufacturing, non-ICT intensive manufacturing, non-ICT intensive non-manufacturing, and other industries. We then examine resource reallocation across these sectors, definitions of which are provided in Appendix Table 1.

Table 5(a) shows that, in almost all industries, capital inputs increased in the three periods. Therefore, industries with high capital prices, such as the ICT-using non-manufacturing sector (e.g., finance, insurance, gas and water supply, wholesale, retail) contributed to the improvement of capital allocation. On the other hand, industries with low capital prices, such as the non-ICT intensive non-manufacturing sector (e.g., real estate, transportation, eating and drinking places), were responsible for negative reallocation effects. In Japan, capital inputs declined substantially in the ICT-producing manufacturing sector after 2000. This probably reflects the fact that Japanese electronics firms were losing their competitiveness in the 2000s, capital prices in this industry declined substantially, and this change created the small positive reallocation effect of capital inputs after 2000.

Table 5(b) shows the industry-level reallocation effect of aggregated labor input, $(w_j v_{L,j}/v_{V,j} - w_{L,j} v_L)\Delta \ln L_j$, and the two components of this value, $w_j v_{L,j}/v_{V,j} - w_{L,j} v_L$ and $\Delta \ln L_j$, in Japan for the periods 1975-1990, 1990-2000 and 2000-2006. Labor prices are highest in the ICT-producing non-manufacturing sector (e.g., telephone and information services, broadcasting). The labor input decrease in this sector after 2000 created negative reallocation effects. The second-highest labor prices can be found in the ICT-producing manufacturing sector. Again, the rapid decrease of labor inputs in this sector resulted in negative labor reallocation effects in the 2000s. In other industries (the primary sector, construction and civil engineering), in which labor prices are low, the decline of labor input created a positive reallocation effect.

4.3 Industry-Level Reallocation Effect of Capital and Labor in Korea

Table 6(a) shows the industry-level reallocation effect of aggregated capital inputs in Korea for each period. As in Japan, capital inputs increased in the three periods in all industries. Therefore, industries with high capital prices, such as ICT-producing non-manufacturing, contributed positively to the improvement of capital allocation during 1990-2000. In contrast with Japan, where capital prices are highest in the ICT-using non-manufacturing sector, capital prices in Korea are highest in ICT-producing non-manufacturing (post and telecommunication), and these industries created slightly positive reallocation effects. On the other hand, as in Japan, capital prices in the non-ICT intensive non-manufacturing sector (e.g., real estate, transportation, eating and drinking places) were low and this sector was responsible for large negative reallocation effects.

Table 6(b) shows the industry-level reallocation effect of aggregated labor inputs in Korea for each period.

As in Japan, other industries (the primary sector, construction and civil engineering) have the lowest labor prices. In Korea, labor inputs in this sector declined steadily over the last three decades at an annual rate of about two percent. This continuous movement of workers from the low labor price sector to other sectors created large positive labor reallocation effects in Korea.

Until 1990, jobs were mainly created in the manufacturing sectors. After that, however, the two sectors that absorbed the most workers were ICT-producing non-manufacturing and non-ICT intensive non-manufacturing (e.g., real estate, transportation, eating and drinking places). The ICT-producing non-manufacturing sector has high labor prices and was responsible for positive labor reallocation effects. On the other hand, the non-ICT intensive non-manufacturing sector has low labor prices and was responsible for negative labor reallocation effects.

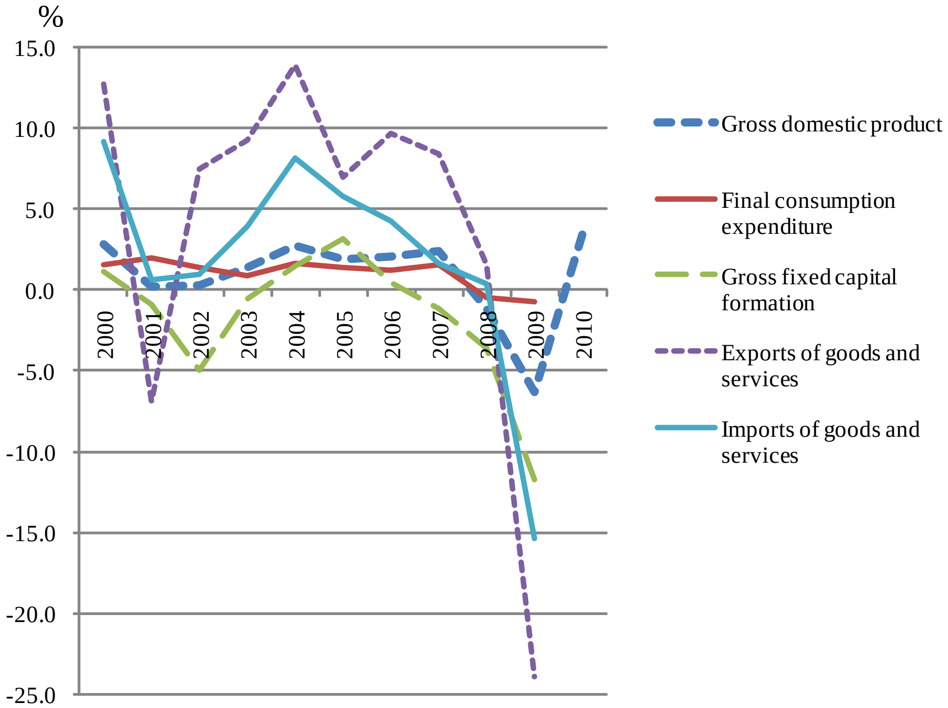
5. How Did the Global Financial Crisis Affect the Japanese and Korean Economies?

In this section, we examine how the global financial crisis of 2008 has affected the Japanese and Korean economies. Unfortunately, sectoral growth accounting data for the post-crisis period are not available yet. Therefore, we mainly use SNA statistics and the Conference Board Total Economy Database (TED) in this section. First, we analyze how macroeconomic demand and production changed in the two countries.

Before the global financial crisis, Japan and Korea enjoyed export driven economic growth. As Figures 14(a) and (b) show, in both countries, exports of goods and services recorded the highest growth among all the demand components from 2002 to 2007. Because of bad loan problems in the 1990s, banks were conservative and financial regulation was relatively strict in the two countries. The global financial crisis hit these economies mainly through the sharp drop in exports (Figures 14(a) and (b)). Not only exports to the United States and European countries, but also exports to East Asian developing economies, such as China, declined sharply. This is because Japan and Korea exported huge amounts of advanced parts and components to East Asian developing countries, where these were used as inputs for the production of final goods, which were then exported to the United States and Europe.[10]

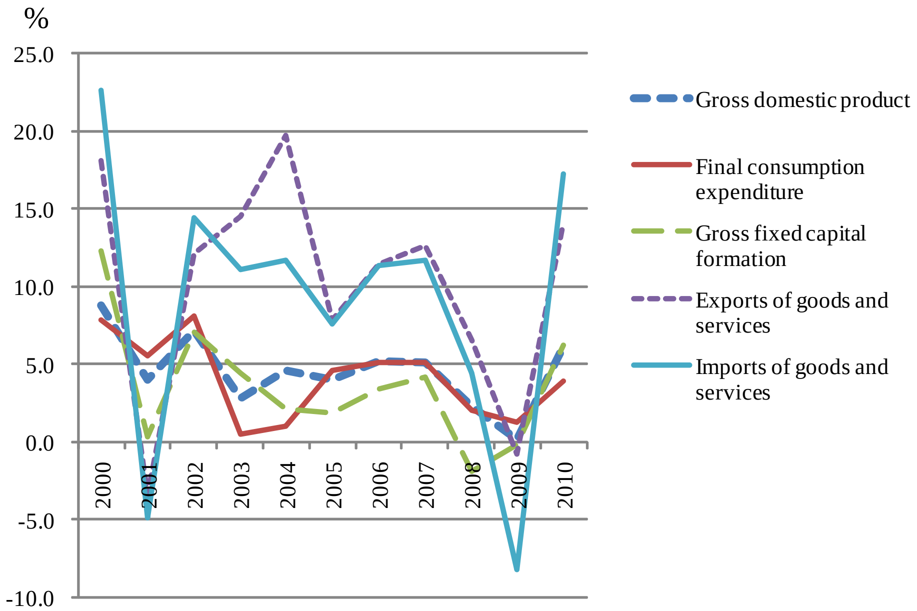
[10] This trade pattern is called “triangle trade.” In exchange for their exports of parts and components, Japan and Korea purchased US federal bonds. In this way, the triangle was closed. For more details on intra-regional trade and the division of labor within East Asia, see Ahn, Fukao, and Ito (2008) and Fukao and Yuan (2009).

Figure 14(a). Growth Rates of Real GDP and Its Principal Demand Components: Japan



Source: Downloaded from Economic and Social Research Institute, Cabinet Office, Japan (http://www.esri.cao.go.jp/en/sna/menu.html).

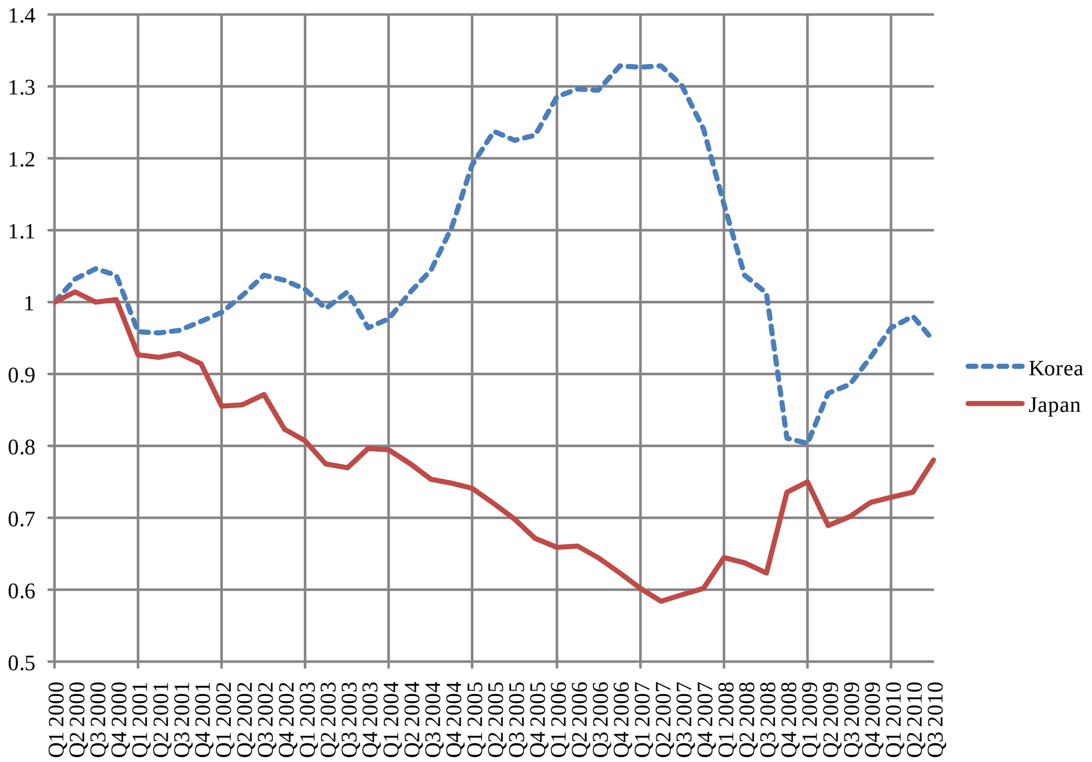
Figure 14(b) Growth Rates of Real GDP and Its Principal Demand Components: Korea



Source: Downloaded from the Bank of Korea Economic Statistics System (http://ecos.bok.or.kr/EIndex_en.jsp).

Comparing Figure 14(a) with Figure 14(b), we find that Japan's exports and GDP dropped much more sharply than Korea's. Several factors are responsible for this difference between the two countries. First, compared with Korea's exports, Japan's exports consist more of capital goods and high-end parts and components, which were hit hardest by the crisis. Second, in the pre-crisis period, Japan's exports were concentrated on the United States, the EU, and East Asia. Compared with Japan's, Korea's exports were more globally diversified. Third, the real effective exchange rates of the currencies of the two countries moved very differently (Figure 15). Since Japan's interbank interest rates were already very low in the pre-crisis period, there was no room for Japan's central bank to substantially cut interest rates. In this situation, interest reductions abroad resulted in an increase in the value of the Japanese yen. On the other hand, Korea succeeded in reducing the value of the Korean won. Fourth, it seems that Japanese automobile companies, such as Toyota, were very nimble in reducing their exports and domestic production in the wake of the crisis, probably in order to avoid an increase in their inventories abroad.

Figure 15. Unit Labor Cost-Based Real Effective Exchange Rates: Korea and Japan (2000 Q1=1)

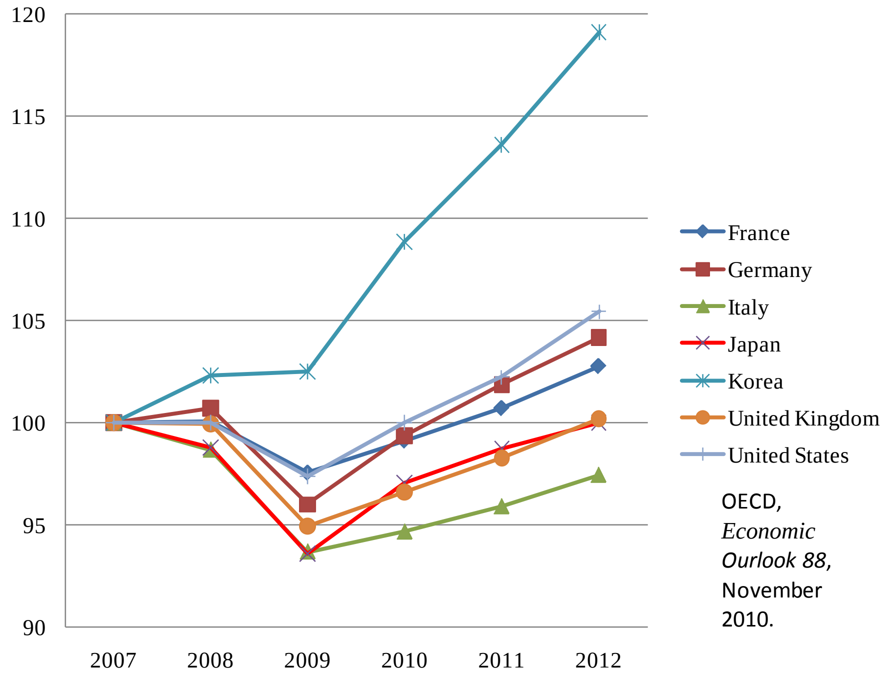


Source: IMF, *International Financial Statistics.*

Mainly because of the drop in exports, Japan's gross fixed capital formation also declined sharply. The drop in net exports and investment reduced Japan's GDP by 7%

from 2007 to 2009 (Figure 16). In contrast with Japan, Korea was the best performer in the major seven developed economies from the viewpoint of economic growth after the crisis.

Figure 16. Real GDP of Major OECD Countries: Past Records and Forecasts (2007=100)

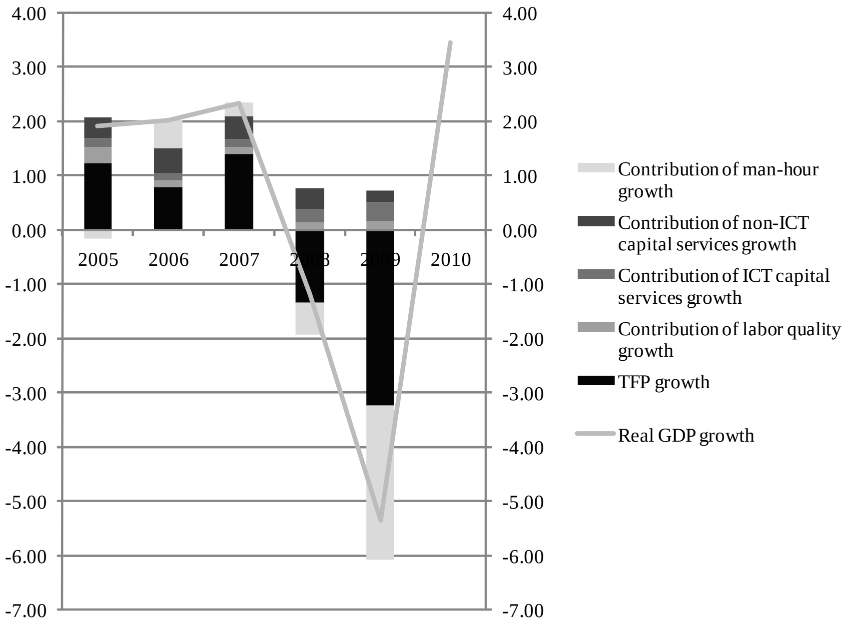


Finally, let us see what happened on the supply-side in Japan and Korea after the crisis. Figures 17(a) and (b) show growth accounting results at the macro-level for the two economies for recent years. For the analysis, we use the Conference Board Total Economy Database (TED).

In both economies, a sharp drop in labor input and TFP occurred after the crisis. Probably capital and labor hoarding contributed to the drop in TFP. In addition to the sharp drop in labor input and TFP, in the case of Japan, the contribution of changes in capital input became negative in the wake of the crisis. In contrast with this, Korea experienced a relatively mild slowdown in capital accumulation and the contribution of changes in capital input stayed positive in Korea in the wake of the crisis.

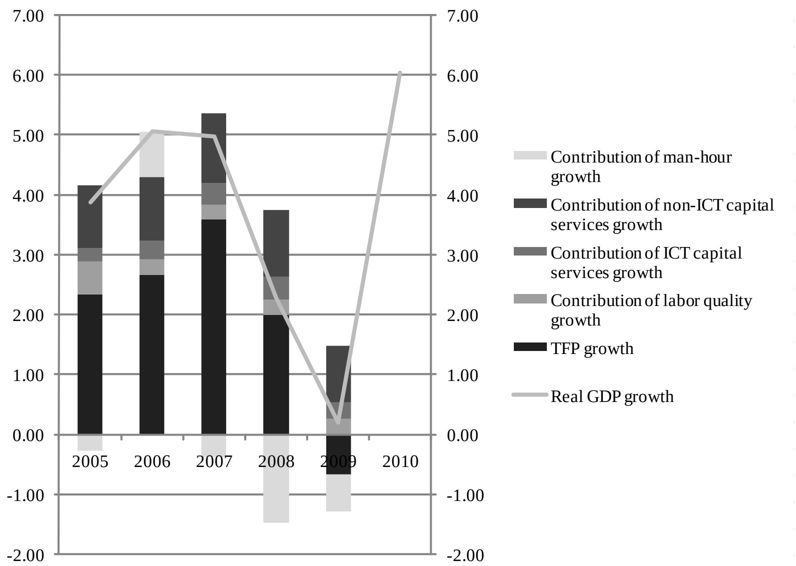
According to a recent study by the IMF, which examined 88 banking crises and 222 currency crises, many crisis-hit countries around the world experienced a large and prolonged drop in TFP and a sharp decline in investment (IMF 2009). Using plant-level data on Argentina's manufacturing sector, Sandleris and Wright (2010) considered productivity dynamics before and after the systemic banking crisis of 2001 and found that more than half of the roughly 10% decline in measured TFP could be explained by the deterioration in the allocation of resources both across and within sectors. Against this background, an interesting question is how much of the TFP drops in Japan and Korea was caused by the deterioration in the allocation of resources. In order to answer this question, we need to wait until sectoral and firm-level data become available.

Figure 17(a). Growth Accounting for the Macro Economy Based on TED: Japan



Source: The Conference Board Total Economy Database (TED), January 2011 (http://www.conference-board.org/data/economydatabase/).

Figure 17(b). Growth Accounting for the Macro Economy Based on TED: Korea



Source: The Conference Board Total Economy Database, January 2011 (http://www.conference-board.org/data/economydatabase/).

6. Conclusion

Using the recently released EU KLEMS Database (November 2009) and other statistics, we conducted growth accounting analyses for Korea and Japan. We also compared the movement in ICT investment in Japan with that in Korea based on the data of Pyo, Jung and Cho (2007). In addition, we compared the impact of ICT capital services on economic growth in Japan and the United States and major EU countries. Using the KIP Database 2009 and the JIP Database 2009, we also examined the reallocation of resources in Korea and Japan. We analyzed this issue in a growth accounting framework based on Jorgenson et al. (2007).

The major results obtained through our analysis are as follows.

First, we found that the slow-down in TFP growth was a main factor behind Japan's Lost Decade. We also found that Korea's TFP growth was slow until the Asian financial crisis of 1997-1999. However, after the crisis, Korea's TFP growth, especially in manufacturing sectors, accelerated. It seems that before the crisis, Korea was in a catch-up process with developed economies that was predominantly input-led and manufacturing-based, as documented in Timmer (1999) and Pyo (2001).

Second, we observe that the estimated TFP growth rates in manufacturing are in general much greater than in services both in Korea and Japan.

Third, both economies experienced a slowdown in economic growth in the 1990s. However, growth accounting for both economies tells different stories. The Japanese economy experienced similar problems as the major EU economies with regard to the slowdown in TFP growth.[11] On the other hand, the slowdown in capital accumulation is a major factor underlying the slowdown in economic growth in Korea after the currency crisis in 1997.

Fourth, the TFP growth rate in the ICT-producing sector in the Japanese and Korean economies is higher than that in other sectors, including ICT-using sectors. In particular the TFP growth rate in the Korean ICT-producing service sector is extraordinarily high.

Fifth, as for ICT capital accumulation, the ICT investment/GDP ratio in Korea was much higher than that in Japan. Comparing ICT capital accumulation in Japan with that in the United States and the major EU countries we find that Japanese ICT capital accumulation was slower than that in other countries except Italy after 1995. Both in Japan and Korea, the largest component in ICT investment is computing equipment.

[11] Among the seven major developed economies, the United States and Korea are exceptional in the acceleration in TFP growth they experienced.

Sixth, the capital reallocation effect was negligible or negative for most of the periods both in Korea and Japan. After the financial crisis of 1997-99, the capital resource allocation effect in Korea remained negative, but the size of the negative effect declined. On the other hand, the labor reallocation effect was positive for most of the periods both in Korea and Japan.

Seventh and finally, the recent global financial crisis hit the Korean and Japanese economies mainly through a sharp drop in exports. Japan's exports and GDP dropped much more sharply than Korea's. Korea was the best performer among the seven major developed economies considered here from the viewpoint of economic growth in the wake of the crisis.

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Appendix Table 1. Classification of ICT sectors

JIP code	IT-using manufacturing sector
20	Printing, plate making for printing and bookbinding
23	Chemical fertilizers
24	Basic inorganic chemicals
29	Pharmaceutical products
34	Pottery
38	Smelting and refining of non-ferrous metals
42	General industry machinery
45	Office and service industry machines
46	Electrical generating, transmission, distribution and industrial apparatus
53	Miscellaneous electrical machinery equipment
56	Other transportation equipment
59	Miscellaneous manufacturing industries

JIP code	IT-using non-manufacturing sector
63	Gas, heat supply
67	Wholesale
68	Retail
69	Finance
70	Insurance
79	Mail
82	Medical(private)
85	Advertising
86	Rental of office equipment and goods
88	Other services for businesses
92	Publishers

JIP code	IT-producing manufacturing sector
47	Household electric appliances
48	Electronic data processing machines, digital and analog computer, equipment and accessories
49	Communication equipment
50	Electronic equipment and electric measuring instruments
51	Semiconductor devices and integrated circuits
52	Electronic parts
57	Precision machinery & equipment

JIP code	IT-producing non-manufacturing sector
78	Telegraph and telephone
90	Broadcasting
91	Information services and internet based services

JIP code	Non-IT intensive manufacturing sector
8	Livestock products
9	Seafood products
10	Flour and grain mill products
11	Miscellaneous foods and related products
12	Prepared animal foods and organic fertilizers
13	Beverages
14	Tobacco
15	Textile products
16	Lumber and wood products
17	Furniture and fixtures
18	Pulp, paper, and coated and glazed paper
19	Paper worked products
21	Leather and leather products
22	Rubber products
25	Basic organic chemicals
26	Organic chemicals
27	Chemical fibers
28	Miscellaneous chemical products
30	Petroleum products
31	Coal products
32	Glass and its products
33	Cement and its products
35	Miscellaneous ceramic, stone and clay products
36	Pig iron and crude steel
37	Miscellaneous iron and steel
39	Non-ferrous metal products
40	Fabricated constructional and architectural metal products
41	Miscellaneous fabricated metal products
43	Special industry machinery
44	Miscellaneous machinery
54	Motor vehicles
55	Motor vehicles parts and accessories
58	Plastic products

JIP code	Non-IT intensive non-manufacturing sector
62	Electricity
64	Waterworks
65	Water supply for industrial use
66	Waste disposal
71	Real estate
73	Railway
74	Road transportation
75	Water transportation
76	Air transportation
77	Other transportation and packing
81	Research (private)
87	Automobile maintenance services
89	Entertainment
93	Video picture, sound information, character information production and distribution
94	Eating and drinking places
95	Accommodations
96	Laundry, beauty and bath services
97	Other services for individuals

JIP code	Other Industries
1	Rice, wheat production
2	Miscellaneous crop farming
3	Livestock and sericulture farming
4	Agricultural Services
5	Forestry
6	Fisheries
7	Mining
60	Construction
61	Civil engineering