Productivity Analysis on the Service Sector in Korea: Evidence from Industry-Level and Firm-Level Data

Hak K. Pyo and Keunhee Rhee

One of the most dramatic characterizations of late industrialization is the speed and scope of structural transformation from manufacturing-based to service-based economy. This study aims to analyze this transformation in the Korean economy in terms of productivity performance in its service sector over the period of 1995–2013 in which the economy experienced two financial crises in the years 1997 and 2007. The major finding is that, while the growth rate of gross output in the service sector has decelerated more rapidly than in the manufacturing sector, the growth rate of total factor productivity (TFP) has improved from near 0% during 1996–2010 to 1.41% during 2011–2013. Particularly, the improvement in TFP in distribution and producer services has been impressive, which indicates that the Korean economy is transforming itself toward a service-oriented growth and that two financial crises have helped such transformation. However, the relative level of TFP in the service sector remains to be far behind than that of the US and Japan.

Keywords: Labor productivity, Total factor productivity, Harberger Diagram

JEL Classification: D24, E22, O47

Hak K. Pyo, Corresponding author, Professor Emeritus, Department of Economics, Seoul National University, Address (E-mail):hakkpyo@gmail.com , (Tel):010-2812-3179, (Fax):02-880-5432; Keunhee Rhee, Visiting research fellow, Korea Labor Institute, #543 C Bldg., Sejong National Research Complex, 370, Sicheong-daero, Sejong-si, 30147, South Korea. (E-mail): ghlee@kli.re.kr, (Tel):044-287-6402, (Fax):044-287-6797, respectively.

[**Seoul Journal of Economics** 2018, Vol. 31, No. 1]

I. Introduction

One of the most dramatic characterizations of late industrialization is the speed and scope of structural transformation from manufacturing-based to service-based economy. In recent years, the structural transformation has been affected by two trends in the world economy. One is the fast speed of ICT revolution, and the other is repeated financial crisis. Both of these trends have made firms substitute labor with ICT and intangible capital and substitute long-term with short-term capital. These trends have also affected the productivity performance of firms as reviewed in Pyo (2018b).

This study aims to analyze this transformation in the Korean economy in terms of productivity performance in its service sector over the period of 1995–2013 in which the economy experienced a rapid adoption of ICT in ICT-producing and ICT-using industries and two financial crises in the years 1997 and 2007. The major finding is that, while the growth rate of gross output in the service sector has decelerated more rapidly than that in the manufacturing sector, the growth rate of total factor productivity (TFP) has improved from near 0% during 1996–2010 to 1.41% during 2011–2013. Particularly, the improvement in TFP in distribution and producer services has been impressive, which indicates that the Korean economy is transforming itself toward a service-oriented growth and that two financial crises have helped such transformation. When we conducted KLEMS (capital, labor, energy, material, and service) type growth accounting to gross output growth in manufacturing for the period of 1996–2004 and 2005–2012, we affirmed the relative contribution of service (S) as 13.2% and 16.8%, respectively (Appendix Table 1). From another point of view, the relative contribution of material (M) input to gross output growth in manufacturing was higher than that of service with 58.3% and 55.3%, respectively. This result corroborates that the activities of outsourcing and off-shoring as the service inputs into manufacturing have become important in terms of the value chain in the manufacturing process after the two financial crises than before they happened. This finding is consistent with Whitefoot and Valdivia (2015) who verified that, in the US manufacturing sector, a significant employment change has occurred after the global financial crisis in 2008 and that the different levels of employment changes at different value chain stages emerged. The authors affirmed a significant employment increase in the upstream

stage of value chain, such as market analysis (26%), R&D (13%), and design and technical services (23%) and that a 25% reduction in employment occurred at the actual manufacturing and downstream stages, such as wholesale (−7%), retail (−4%), and after-market service (−5%). However, the relative level of TFP in the service sector in Korea remains to be far behind than that of the US and Japan**.**

While the late industrialization of the Korean economy had been a predominantly input-led and manufacturing-based catch-up process as documented by Van Ark *et al.* (1999) and Pyo (2001), the economic stagnation after the financial crisis of 1997 with the sharp decrease in the fertility rate has turned the Korean economy into an ICT-led productivity- and service-based economy. According to the growth accounting result of Fukao *et al.* (2012), the relative contribution of TFP growth (0.2%) in the total value-added growth (9.5%) of the market economy of Korea was only 2.1% during the period of 1980–1995 but increased to the level of 23% during the period of 1995–2007 with the growth rate of value-added (4.8%) and TFP (1.1%). During this transition, the growth in ICT capital services has played an important role. Fukao *et al.* (2012) validated that the growth in ICT capital services in Korea has grown at the annual rate of 0.4% during the period of 2000–2007, occupying 16% of the total capital input growth (2.5%) and 8.7% of the total value-added growth (4.6%). However, the contribution of ICT capital service input growth to economic growth (percentage) by industries shows that its service was more concentrated in electrical machinery, post, and communication (0.59%), manufacturing, excluding electrical (0.39%), and finance and business services (0.62%) than in other goods-producing industries (0.11%), distribution services (0.23%), and personal and social services (0.15%). Hence, the use of ICT capital services has not been expanded to non-ICT capital intensive manufacturing and service industries due to the lack of deregulation and competition in these sectors. Other productivity studies on the service sector of the Korean economy include Ha and Pyo (2004), Pyo and Ha (2007), Chun *et al.* (2008), Lee and Pyo (2007), Rhee and Pyo (2010, 2012, and 2015), and Kim and Pyo (2012).

Section II presents the labor productivity analysis of the Korean economy during the period of 1996–2013, where the service sector is decomposed by four sub-sectors: (1) Distribution Services, (2) Producer

Services, (3) Social Services, and (4) Personal Services.[1] Section III exhibits our estimation of industry-level total factor productivity in terms of gross-output-based growth accounting and value-added growth accounting and our examination of the relationship between labor productivity and total factor productivity. Section IV deals with the firm-level productivity analysis of the service sector based on the *Survey of Business Structure and Activities* (2006-2014) conducted and compiled by Statistics Korea. Section V analyzes the international comparison of labor productivity, including service industry. Section VI concludes this paper.

II. Productivity Trend in the Service Sector from Industry-Level Data

A. Trends in Gross Output and Gross-Output Labor Productivity in the Service Sector

To examine the overall productivity trend, we first generated the growth rates of gross output, value-added, and labor productivity from the KIP (Korea Industrial Productivity) database during the period of 1996–2013 in which the Korean financial crisis in 1997–1998 and the global financial crisis in 2007–2008 are included. In Appendix Figure 1, the trend of gross output growth (%) is depicted in horizontal axis, whereas the corresponding growth rate (%) of gross output labor productivity is depicted in vertical axis by sector. The relationship between gross output (Q) and gross output labor productivity (Q/L) is roughly positive although the degree of fitness is different by sector (Table 1). As shown in Appendix Figure 1, the year 1998 was an outlier in economy-wide manufacturing and service. The positive labor productivity growth in manufacturing in 1998 reflects the large-scale lay-off by IMF-mandated corporate restructuring. Moreover, after the

[1] The service sector is decomposed by four sub-sectors as shown below: (A) Distribution service: i) wholesale and retail trade, ii) transportation and storage. (B) Producer service: i) publishing, broadcasting, movie, information ser., ii) telecommunication, iii) IT and other information ser., iv) finance and insurance, v) real estate and leasing, vi) professional, scientific, and technical ser., vii) business support ser. (C) Social service: i) public administration and defense, ii) education, iii) health and social work. (D) Personal service: i) restaurants and hotels, ii) cultural and other ser. (Kim, 2006, p. 37; Kim and Pyo, 2012, p. 435)

global financial crisis, the year 2009 appears to be another outlier in the sense that the growth rate of gross output labor productivity turned negative in economy-wide, manufacturing and service and that the growth rates of gross output remained positive. One notable exception is the personal service sub-sector that recorded a mild gross output growth with significant gross output labor productivity (10%), which might reflect another type of structural adjustment in the form of large-scale exit by self-employed proprietors as evidenced in Rhee and Pyo (2015).

In Appendix Figure 2, we examined the trend of the relationship between gross output growth rate and gross output labor productivity over sub-periods: 1996–2000, 2001–2005, 2006–2010, and 2011–2013. While the manufacturing sector was the leader of output growth and per capita output growth, the growth in the service sector was of limited scope during the sub-period of 1996–2000. The trend carried on in the sub-period of 2001–2005 before the breakout of the global financial crisis, but, after 2006, the distribution and producer services caught up with manufacturing in making the transformation of the Korean economy from manufacturing-based to service-based vividly. However, the continuous sluggish demand for Korean exports and domestic production has slowed down the growth of personal service output and its labor productivity.

B. Effect of Output Growth on Gross-Output Labor Productivity

We also analyzed the effect of output growth on per capita output productivity by conducting a regression analysis. In a sense, it could be viewed as the gross-output version of the Kaldor–Verdoorn Law in Kaldor (1967), which stipulates that, if output grows, labor productivity and employment would also grow. If we define output as gross output, then a positive effect of gross output growth on gross output labor productivity is expected. Table 1 exhibits that the estimated Verdoorn coefficients are 1.10 for manufacturing and 0.70 for service. Among the four sub-sectors of service, the Verdoorn coefficient is the largest in distribution service (1.11), followed by personal service (0.75), producer service (0.41), and social service (0.23). If we interpret the Verdoorn coefficient as a measure of pro-cyclicality, then manufacturing and distribution and personal services are highly sensitive to the business cycle. Kaldor (1976) estimated the Verdoorn coefficient as 0.446

TABLE 1
RELATIONSHIP BETWEEN GROSS OUTPUT AND GROSS OUTPUT LABOR PRODUCTIVITY IN KOREA (1996–2013)
$\log(Q/L) = \alpha + \beta\log(Q) + \epsilon$

	Economy-wide	Manufacturing	Service	Distribution service	Producer service	Social service	Personal service
log Q	0.91*** (47.88)	1.10*** (31.87)	0.70*** (30.26)	1.11*** (48.90)	0.41*** (12.54)	0.23*** (5.89)	0.75*** (10.37)
Adj R^2	0.99	0.98	0.98	0.99	0.89	0.65	0.85
D/W	0.98	1.06	0.62	1.25	0.64	1.31	0.39

Notes: (1) Q is gross output, and L is labor input, (2) The values in the parentheses are t-values.
(3) *, **, and *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

from the regression of 12 OECD countries' data of the industrial sector (manufacturing, electricity, gas and water, public service, and construction). Significant recent empirical estimates of the Verdoorn coefficient, such as McCombie (2002), Storm and Naastepad (2008), and Hein and Tarassow (2010), fall in the range of 0.3–0.6 for European countries and 0.1–0.25 for the US. Therefore, we can conclude that the effect of gross output growth on its labor productivity is larger in the Korean economy than in Europe and the US.

C. Trends in Value-Added and Value-Added Labor Productivity in the Service Sector

While the identification of trends in gross-output labor productivity is revealing a pattern of the total supply of factor inputs and intermediate inputs, the productivity analysis on the service sector would be meaningful if we further examine the trend in value-added productivity because the service sector is a value-added intensive sector by nature. For instance, according to the 2013 Input-Output Tables by the Bank of Korea (2015), the value-added ratio (value-added/total inputs) was the largest in service (0.551) compared with manufacturing (0.233), electricity, water, and gas (0.253), and construction (0.335).

Appendix Figure 3 plots the value-added growth rate in the horizontal axis and the growth rate of value-added labor productivity estimated from the KIP database in the vertical axis. As was the case with the gross output labor productivity trend, the observations in

years 1998 and 2009 are outliers. However, the magnitude of negative shock on value added labor productivity was deeper in 1998 than in 2009. Moreover, we affirmed that the negative shock was deepest in distribution service. From another point of view, in social service, although the growth rate of value-added labor productivity was negative and deep, the growth rate of value-added itself was positive in the social service sub-sector, which reveals the nature of the sector's public function as a social safety net in case of an economic crisis. We should also note that the reason why the personal service sector has approximately 14% and 7% growth rates in its value-added productivity in 1999 and 2009, respectively, is because several lay-off cases emerged in self-employed personal service outlets in 2009. Except for the personal service sub-sector, all sectors had recorded negative growth rates of value-added labor productivity. From the regression result in Table 2, we validated that, in the regression of value added in social service sector, the estimated negative coefficient of value added growth on value-added labor productivity with a low degree of fitness (adjusted $R^2 = 0.11$) implies the counter-cyclical nature of the sector. When the economic downturn begins, social workers cannot be laid off.

Appendix Figure 4 illustrates the growth rate of value-added labor productivity by sector over different sub-periods. We should note that the value-added labor productivity in manufacturing is still a dominant player throughout the entire sub-periods. Distribution service has accelerated its value-added growth and labor productivity during the sub-period of 2011–2013. The personal service sector has not performed well, except for the sub-period of 2006–2010.

D. Effect of Value-Added Growth on Value-Added Labor Productivity

We examined the effect of value-added growth on its per capita labor productivity by sector, which is equivalent to the test of the Kaldor–Verdoorn Law in its original version by Kaldor (1976) who defined the output growth as value-added growth and labor productivity as value-added per employee. Table 2 exhibits that the so-called Verdoorn coefficient was highest in distribution service (1.14), followed by manufacturing (1.10), personal service (0.67), total service (0.63), and producer service (0.32). The coefficient of social service is negative, which implies the counter-cyclical nature of social service expenditure by the government. Given that the estimated Verdoorn coefficients

Table 2
Relationship between Value-Added and Value-Added Labor Productivity in Korea (1996–2013)
$\log(Y/L) = \alpha + \beta \log(Y) + \epsilon$

	Economy-Wide	Manufacturing	Service	Distribution service	Producer service	Social service	Personal service
log Y	0.88***	1.10***	0.63***	1.14***	0.32***	-0.10*	0.67***
	(36.22)	(26.09)	(22.57)	(37.40)	(9.33)	(-1.83)	(8.35)
Adj R^2	0.98	0.97	0.96	0.98	0.82	0.11	0.79
D/W	0.98	1.04	0.67	1.17	0.75	1.31	0.39

Notes: (1) Y is value-added, and L is labor input, (2) The values in the parentheses are t-values.
(3) *, **, and *** indicate statistical significance at the 10%, 5%, 1% levels, respectively.

from European and US data fell in the range of 0.2–0.6, the estimates of manufacturing and distribution services appear to be high, thereby reflecting the strong pro-cyclicality of the two sectors.

III. Growth Accounting and Estimation of Total Factor Productivity in the Service Sector

We conducted a growth accounting on gross output and value added to compare growth performance in the service sector with that in other sectors using the KIP (Korea Industrial Productivity) database during the period of 1996–2013. The period was dictated by the availability of new National Accounts Data, which followed the 2008 SNA guidelines. We followed Kim and Pyo (2012) and Kim (2006) for the classification of service sector and reclassified the 38-industry classification of the KIP database.

A. Gross-Output Gross Accounting

Table 3 summarizes the growth accounting result of gross output. During the entire period of 1996–2013, which includes two financial crises in 1997 and 2007, the economy-wide growth rate of gross output increased at the annual average rate of 5.56% with the growth rates of capital input (1.08%), labor input (0.27%), intermediate input (3.71%), and TFP (0.49%). The growth rate of economy-wide gross output has

significantly decelerated from the sub-period of 1996–2004 (6.30%) to the sub-period of 2005–2013 (4.82%). In terms of relative contribution to gross output growth, intermediate input was a dominant contributor (66.8%), followed by capital input (19.4%), TFP (8.9%), and labor input (4.9%). The growth decomposition of manufacturing gross output (7.14%) shows: capital (0.84%), labor (−0.04%), intermediate (5.47%), and TFP (0.86%). By contrast, the gross output growth of the service sector (5.00%) is decomposed by capital (1.55%), labor (0.76%), intermediate (2.57%), and TFP (0.13%). Migration from manufacturing to service employment must have occurred: The relative contribution of labor input in manufacturing to manufacturing gross output growth was −0.5%, whereas that in the service to service gross output growth was 15.1%. In the manufacturing and service sectors, the growth rate of gross output has decelerated from the pre-2005 period to the post-2005 period.

The decomposition of the service sector by four sub-sectors indicates an uneven growth performance by sub-sector in terms of the growth rate of gross output: Producer service (5.43%), social service (4.74%), distribution service (4.69%), and personal service (4.00%). Meanwhile, the growth rate of TFP is the largest in distribution service (0.34%) with a relative rate of contribution to output growth (7.3%), whereas the growth rates of TFP in producer service (0.06%), social service (−0.39%), and personal service (−0.29%) are small or negative. The growth rate of TFP in distribution service has increased from −0.01% in the sub-period of 1996–2004 to 0.69% in the sub-period of 2005–2013. The large-scale investment in distribution by conglomerates and deregulation in distribution business has improved the overall efficiency of the sector. Social and personal services have improved their efficiency from the growth rates of TFP (−0.90% and −0.64%) during the sub-period of 1996–2004 to the growth rates of TFP (0.12% and 0.06%) although they are still lagging behind distribution and producer services in terms of overall efficiency.

Following Farrell *et al.* (2005); Fukao *et al.* (2006); Fukao *et al.* (2012), we plot a modified Harberger (1998) diagram in Figure 1 to examine the contribution of each sector to macro-level productivity growth. The vertical axis depicts the cumulative sector contributions to aggregate TFP growth from gross-output growth accounting. The horizontal axis depicts the cumulative share of sectoral weights, which is the gross output of each sector over the summation of the gross output of all

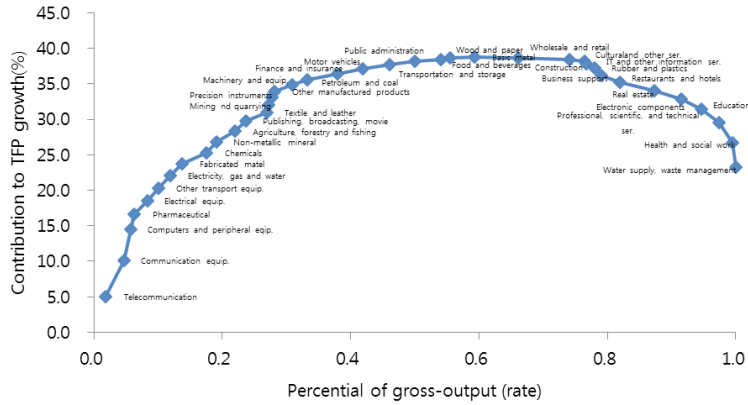
TABLE 3
GROSS OUTPUT GROWTH ACCOUNTING RESULT: KOREAN ECONOMY (1996–2013)

	Gross output	Capital	Labor	Intermediate	TFP
			Economy-wide		
'96–'04	6.30	1.37	0.43	4.09	0.42
	(100.0)	(21.7)	(6.8)	(64.8)	(6.7)
'05–'13	4.82	0.79	0.12	3.34	0.57
	(100.0)	(16.4)	(2.4)	(69.4)	(11.8)
'96–'13	5.56	1.08	0.27	3.71	0.49
	(100.0)	(19.4)	(4.9)	(66.8)	(8.9)
'06–'10	5.19	0.80	0.57	3.51	0.31
	(100.0)	(15.4)	(10.9)	(67.6)	(6.0)
'11–'13	3.91	0.73	-0.48	2.85	0.80
	(100.0)	(18.8)	(-12.3)	(73.0)	(20.6)
			Manufacturing		
'96–'04	8.24	1.02	-0.06	6.24	1.03
	(100.0)	(12.4)	(-0.7)	(75.8)	(12.5)
'05–'13	6.04	0.66	-0.01	4.70	0.69
	(100.0)	(11.0)	(-0.2)	(77.8)	(11.4)
'96–'13	7.14	0.84	-0.04	5.47	0.86
	(100.0)	(11.8)	(-0.5)	(76.6)	(12.1)
'06–'10	6.19	0.62	0.11	4.61	0.85
	(100.0)	(10.1)	(1.7)	(74.5)	(13.7)
'11–'13	5.09	0.66	-0.11	4.21	0.32
	(100.0)	(13.0)	(-2.2)	(82.8)	(6.4)
			Service		
'96–'04	5.64	1.99	1.11	2.72	-0.18
	(100.0)	(35.4)	(19.6)	(48.2)	(-3.2)
'05–'13	4.36	1.10	0.41	2.42	0.44
	(100.0)	(25.2)	(9.3)	(55.5)	(10.0)
'96–'13	5.00	1.55	0.76	2.57	0.13
	(100.0)	(30.9)	(15.1)	(51.4)	(2.5)
'06–'10	5.05	1.17	1.23	2.94	−0.29
	(100.0)	(23.1)	(24.4)	(58.3)	(−5.7)
'11–'13	3.22	0.95	-0.80	1.65	1.41
	(100.0)	(29.6)	(−24.8)	(51.3)	(43.9)

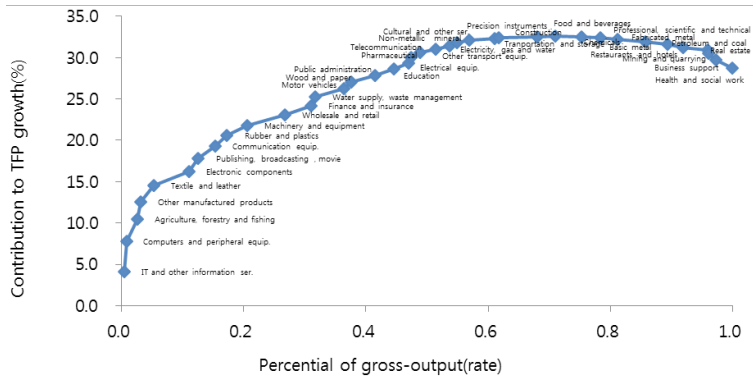
TABLE 3
(CONTINUED)

	Gross output	Capital	Labor	Intermediate	TFP
			(1) Distributive service		
'96–'04	4.56	1.69	0.23	2.65	−0.01
	(100.0)	(37.0)	(5.1)	(58.0)	(−0.4)
'05–'13	4.82	1.27	−0.15	3.01	0.69
	(100.0)	(26.3)	(−3.2)	(62.4)	(14.4)
'96–'13	4.69	1.48	0.04	2.83	0.34
	(100.0)	(31.5)	(0.9)	(60.3)	(7.3)
			(2) Producer service		
'96–'04	6.36	2.65	1.35	2.78	−0.41
	(100.0)	(41.6)	(21.2)	(43.7)	(−6.4)
'05–'13	4.49	1.19	0.43	2.33	0.54
	(100.0)	(26.6)	(9.6)	(51.9)	(11.9)
'96–'13	5.43	1.92	0.89	2.56	0.06
	(100.0)	(35.4)	(16.4)	(47.1)	(1.2)
			(3) Social service		
'96–'04	5.24	1.24	2.09	2.81	−0.90
	(100.0)	(23.7)	(40.0)	(53.6)	(−17.3)
'05–'13	4.25	0.78	1.22	2.12	0.12
	(100.0)	(18.4)	(28.8)	(49.9)	(2.9)
'96–'13	4.74	1.01	1.66	2.47	−0.39
	(100.0)	(21.3)	(35.0)	(52.0)	(−8.2)
			(4) Personal service		
'96–'04	4.89	1.77	1.03	2.73	−0.64
	(100.0)	(36.2)	(21.1)	(55.9)	(−13.2)
'05–'13	3.12	0.98	−0.04	2.12	0.06
	(100.0)	(31.5)	(−1.4)	(68.1)	(1.8)
'96–'13	4.00	1.37	0.49	2.43	−0.29
	(100.0)	(34.4)	(12.3)	(60.7)	(−7.3)

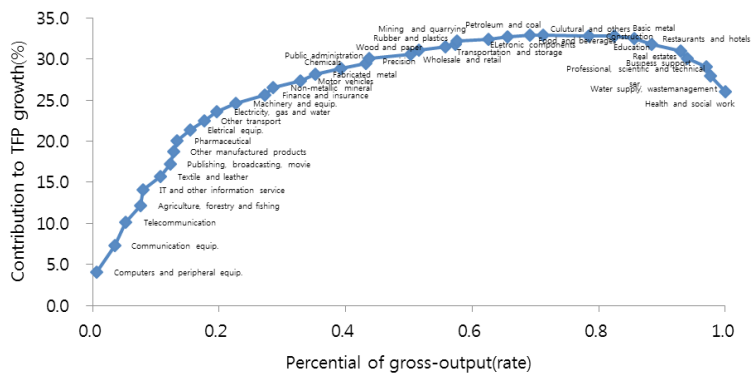
Source: KIP (Korea industrial productivity) database (2015)
( ) notes the contribution to the growth of gross output



(1996–2004)



(2005–2013)



(1996–2013)

FIGURE 1

CUMULATIVE CONTRIBUTION OF INDUSTRIES TO TFP GROWTH (1996–2013): ECONOMY-WIDE

the sectors. Sectors are lined up by descending order of their TFP contribution.

Figure 1 shows the sectoral TFP growth contribution for two sub-periods (1996–2004 and 2005–2013) and the entire period (1996–2013). In the sub-periods of 1996–2004 and 2005–2013, the weights of sectors with positive TFP growth was approximately 78% and 80%, respectively. However, the magnitude of negative contribution to TFP by social services, such as water supply and waste management, health and social work, and education service, was deeper in the period of 1996–2004 than in the period of 2005–2013. We also affirmed that, in the sub-period of 2005–2013, only mining and quarrying, fabricated metal, and petroleum and coal are the non-service sectors that negatively contributed to TFP growth. Generally, the degree of the negative contribution of TFP by social and personal service sectors has been reduced from the period of 1996–2004 to the period of 2005–2013.

In comparison with Fukao *et al.* (2012) who asserted that the weight of the gross output of sectors with positive TFP growth in services was only approximately 44% during the period of 1972–2007, a significant improvement occurred in TFP in service sectors after 2005. However, the dominant sectors of TFP contribution are still IT and other information services, computers and peripheral equipment, agriculture, forestry and fishing, other manufactured products, textile and leather, and electronic components during the period of 2005–2013.

B. Value-Added Growth Accounting

We analyzed the growth accounting of value-added in the Korean economy with attention to the service sector in comparison with economy-wide and manufacturing. Table 4 summarizes the results. The growth rates of value added in the Korean economy have significantly decelerated from the sub-periods of 1996–2004 to 2005–2013: The growth rate of economy-wide value-added decreased from 5.05% to 3.71%, that of manufacturing value-added decreased from 7.22% to 5.36%, and that of service value-added decreased from 4.90% to 3.43%. The decomposition of the value-added growth rate of the service sector (4.16%) throughout the entire period is shown as capital (2.66%), labor (1.29%), and TFP (0.21%). Particularly, the growth rate of TFP in service sector has increased from –0.34% in the sub-period of 1996–2004 to 0.77% in the sub-period of 2005–2013. It is in contrast with the

TABLE 4

VALUE-ADDED GROWTH ACCOUNTING RESULT: KOREAN ECONOMY (1996–2013)

<growth rates(%)>

	Value-added	Capital	Labor	TFP
		Economy-wide		
'96–'04	5.05	3.13	0.99	0.93
	(100.0)	(62.0)	(19.6)	(18.3)
'05–'13	3.71	2.04	0.29	1.38
	(100.0)	(55.0)	(7.9)	(37.2)
'96–'13	4.38	2.59	0.64	1.15
	(100.0)	(59.0)	(14.6)	(26.3)
'06–'10	4.14	2.03	1.48	0.63
	(100.0)	(49.1)	(35.7)	(15.2)
'11–'13	2.89	2.01	-1.31	2.19
	(100.0)	(69.6)	(-45.5)	(75.9)
		Manufacturing		
'96–'04	7.22	3.73	−0.20	3.69
	(100.0)	(51.7)	(−2.8)	(51.1)
'05–'13	5.36	2.77	−0.02	2.60
	(100.0)	(51.8)	(−0.4)	(48.6)
'96–'13	6.29	3.25	−0.11	3.15
	(100.0)	(51.7)	(−1.8)	(50.1)
'06–'10	6.18	2.58	0.49	3.11
	(100.0)	(41.8)	(7.9)	(50.3)
'11–'13	3.87	2.94	-0.50	1.43
	(100.0)	(76.0)	(-13.1)	(37.0)
		Service		
'96–'04	4.90	3.37	1.87	-0.34
	(100.0)	(68.7)	(38.2)	(-6.9)
'05–'13	3.43	1.95	0.71	0.77
	(100.0)	(56.8)	(20.7)	(22.5)
'96–'13	4.16	2.66	1.29	0.21
	(100.0)	(63.8)	(31.0)	(5.2)
'06–'10	3.69	2.05	2.18	−0.54
	(100.0)	(55.6)	(59.1)	(−14.6)
'11–'13	2.85	1.75	−1.46	2.56
	(100.0)	(61.2)	(−51.0)	(89.9)

TABLE 4
(CONTINUED)

	Value-added	Capital	Labor	TFP
		(1) Distributive service		
'96–'04	3.64	3.21	0.45	−0.02
	(100.0)	(88.2)	(12.5)	(−0.7)
'05–'13	3.85	2.69	−0.32	1.48
	(100.0)	(69.7)	(−8.2)	(38.5)
'96–'13	3.75	2.95	0.07	0.73
	(100.0)	(78.7)	(1.8)	(19.5)
		(2) Producer service		
'96–'04	5.68	4.19	2.14	−0.65
	(100.0)	(73.8)	(37.7)	(−11.5)
'05–'13	3.61	1.97	0.71	0.93
	(100.0)	(54.6)	(19.5)	(25.8)
'96–'13	4.64	3.08	1.42	0.14
	(100.0)	(66.3)	(30.7)	(3.0)
		(3) Social service		
'96–'04	3.48	1.84	3.10	−1.45
	(100.0)	(52.8)	(89.0)	(−41.7)
'05–'13	3.25	1.20	1.87	0.18
	(100.0)	(36.8)	(57.6)	(5.6)
'96–'13	3.37	1.52	2.48	−0.64
	(100.0)	(45.1)	(73.8)	(−18.9)
		(4) Personal service		
'96–'04	4.60	3.82	2.22	−1.44
	(100.0)	(83.2)	(48.2)	(−31.4)
'05–'13	2.21	2.20	−0.11	0.12
	(100.0)	(99.3)	(−4.9)	(5.6)
'96–'13	3.41	3.01	1.05	−0.66
	(100.0)	(88.4)	(31.0)	(−19.4)

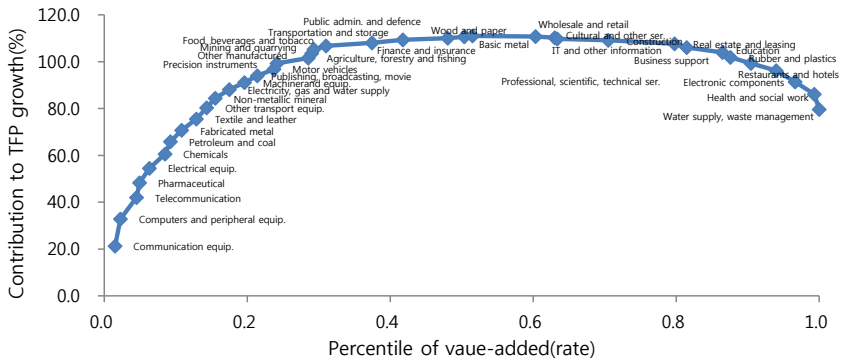
Source: KIP (Korea industrial productivity) database (2015)
( ) notes the contribution to the growth of value-added

manufacturing sector in which the growth rate of TFP declined from 3.69% to 2.60% between two sub-periods. Furthermore, we note the reduction of labor input (-0.11%) in manufacturing and increase in labor input (1.29%) in service, which implies employment switch from manufacturing to service in the Korean economy.

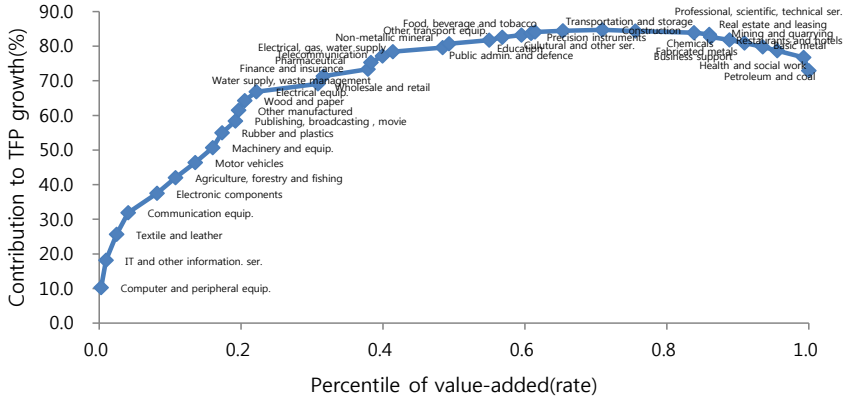
The result of value-added growth accounting by four sub-sectors of service industries is not much different from that of gross output growth accounting. In terms of value-added growth, producer service (4.64%) was followed by distribution service (3.75%), personal service (3.41%), and social service (3.37%). However, in terms of the growth rates of TFP, while distribution service (0.73%) and producer service (0.14%) have recorded positive growth rates, social service (−0.64%) and personal service (−0.66%) have recorded negative growth rates. The relative inefficiency in social service sector appears to be due to lack of competition and regulatory environments in the sector. The relative inefficiency in the personal service sector is due to economies of scale intrinsic in the nature of personal services.

We constructed the Harberger Diagram based on estimated value-added TFP by 38 industrial sectors using the KIP database. The general picture of the diagram in three different time intervals looks similar to Figure 1 based on estimated gross-output TFP. However, as shown in Figure 2, the Harberger Diagram based on value-added TFP appears to have a higher hump than the Harberger Diagram based on gross-output TFP as shown in Figure 1, which implies that value-added is more sensitive at the time of financial crisis, such as 1997 and 2009, than gross-output. For the first sub-period in which the 1997 crisis is included, only approximately 55% of cumulative weights had a positive value-added TFP contribution. During the sub-period, the leaders of TFP contribution were communication equipment, computer and peripheral equipment, telecommunication equipment, and pharmaceutical products, whereas the TFP-losing industries are water supply and waste management, health and social work, electronic components, and restaurants and hotels.

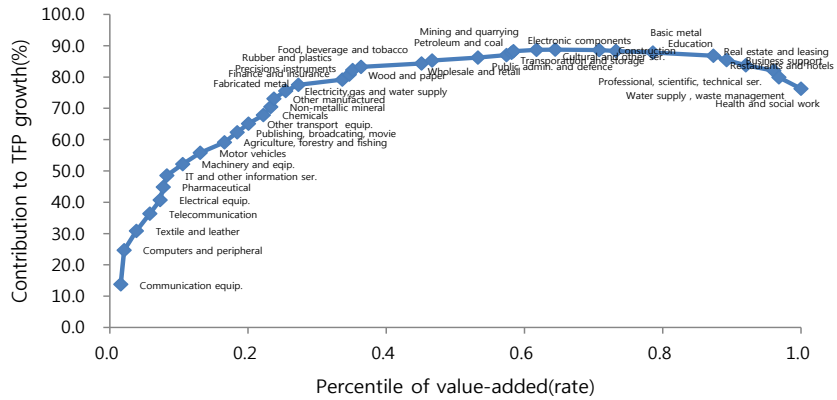
During the second sub-period (2005-2013) which includes the 2007-2008 global financial crisis, the numbers of sectors contributing value-added TFP with positive values increased and approached to approximately 70% of the cumulative weight. The leading industries in terms of value-added TFP contribution are Computer and Peripheral Equipment, IT and Other Information Service, and Textile and Leather.



(1996–2004)



(2005–2013)



(1996–2013)

FIGURE 2

CUMULATIVE CONTRIBUTION OF INDUSTRIES TO TFP GROWTH (1996–2013): ECONOMY-WIDE

TABLE 5

RELATIONSHIP BETWEEN LABOR PRODUCTIVITY AND TFP IN KOREA (1996-2013)

□ $GTFP_{GO} = \alpha + \beta GPL_{GO} + \varepsilon$

	Economy-Wide	Manufacturing	Service	Distribution Service	Producer Service	Social Service	Personal Service
GPL_GO	0.26***	0.04	0.46***	0.34***	0.31***	0.48***	0.31***
	(4.31)	(0.91)	(5.88)	(6.37)	(4.12)	(7.17)	(5.39)
Adj R^2	0.50	0.37	0.66	0.69	0.48	0.74	0.62
D/W	2.07	2.45	2.30	2.06	1.69	2.56	1.79

Notes: The values in parentheses are *t*-values.

□ $GTFP_{VA} = \alpha + \beta GPL_{VA} + \varepsilon$

	Economy-Wide	Manufacturing	Service	Distribution Service	Producer Service	Social Service	Personal Service
GPL_VA	0.81***	0.62**	0.93***	0.78***	0.52***	0.80***	0.83***
	(4.90)	(2.85)	(5.60)	(9.80)	(3.65)	(7.85)	(6.21)
Adj R^2	0.57	0.29	0.64	0.84	0.42	0.78	0.68
D/W	2.34	2.32	2.45	2.70	1.89	2.93	1.85

Notes 1) The values in parentheses are *t*-values.

2) GTFP = growth of total factor productivity; GPL = growth of labor productivity

The negative contribution was made by Petroleum and Coal, Health and Social Work, and Business Support.

C. Relationship Between Labor Productivity and TFP in Korea (1996-2013)

We examined the relationship between labor productivity and TFP in terms of gross-output-based growth accounting and value-added-based growth accounting. The implicit hypothesis is that the rise in labor productivity affects TFP. As shown in Table 5, the effect of labor productivity on TFP is positive and significant in both gross-output-based and value-added-based regression. The degree of fitness is the highest in Social Service (0.74) and Distribution Service (0.69) in the regression of gross-output labor productivity growth on gross-output TFP growth. In the case of the regression of value-added labor productivity growth on value-added TFP growth, Distribution Service (0.84) ranks first followed by Social Service (0.78). We interpreted that this result reflects value-added intensive nature of distribution and social services.

The strong and positive labor productivity on TFP in both gross-output and value-added terms indicate that any structural reform should begin aiming at improving labor productivity first.

IV. Productivity in the Service Sector from Survey of Business Activities

The second source of productivity in the service sector can be found in the Survey of Business Activities (SBA or Survey) which has been conducted by Statistics Korea during the period of 2006-2014, and was first studied in a volume edited by Lee and Pyo (2007) and analyzed by Rhee and Pyo (2015). According to Rhee and Pyo (2015), the survey was conducted on firms with more than 50 full-time employees and capital amount of over 300 million won. The number of surveyed firms in each year was: 10,786 firms in 2006, 10,748 firms in 2007, 10,928 firms in 2008, 10,884 firms in 2009, 11,045 firms in 2010, 11,718 firms in 2011, and 12,008 firms in 2012. For 2012, the number of surveyed firms in manufacturing was 6,163 firms and that in service was 5,087 firms.

A. Value-Added Labor Productivity from Survey

Rhee and Pyo (2015) estimated value-added labor productivity from the survey by deflating value-added in current prices in the survey by the industry's implicit GDP deflator to obtain real value added in 2005 base-year prices and dividing it by total number of employees which includes full-time employees and part-time workers but excludes self-employed and unpaid family workers. As summarized in Table 6, the average value-added per labor during the period of 2006-2012 was 105 million won for economy-wide, 117 million won for manufacturing, and 95 million won for service sector, which confirms that the value-added labor productivity in manufacturing is higher than in service by approximately 23%. The disparity of value-added labor productivity becomes wider when we consider the industry and the size of enterprises. For example, the average per capita value-added in large manufacturing enterprise (150 million won) is more than double the level in SME (67 million won).

In service, the disparity is smaller but still as large as almost double: Large service enterprise (110 million won) and SME service enterprise (63 million won). It is interesting to note that while the disparity

Table 6

The Level of Value-Added Labor Productivity by Industry and Size: Survey of Business Activities (2006-2012)

(million won, index (SME=100))

	Level				Relative Levels (SME = 100)		
Period Average	All	SME	Medium	Large	SME	Medium	Large
				Economy-Wide			
'06-'12	105	64	93	128	100	147	201
				Manufacturing			
'06-'12	117	67	92	150	100	138	224
				Service			
'06-'12	95	63	99	110	100	159	176

Sources: Rhee and Pyo (2015)

between large enterprise and SME in service sector declined from 1.99 in 2006 to 1.59 in 2012, the disparity in manufacturing sector increased from 2.11 to 2.38 during the same period. It should also be noted that the disparity between Manufacturing and Service sector is almost negligible in SME and medium enterprises but still substantial in large enterprises. In summary, Rhee and Pyo (2015) found from the SBA that the labor productivity of the large enterprise is on the average, about double (2.01) the level of SME during the period of 2006-2012. The level of labor productivity in medium enterprises is estimated to be approximately 1.47 times higher than that of SME. Rhee and Pyo (2015) noted that while the growth rate of labor productivity by large enterprises was higher than that of SME in Manufacturing, it was opposite in the Service sector. The relatively rapid increase of labor productivity in the Service sector in Korea has been the prime source of overall efficiency increase in the sector which is evidenced by overall improvement in the TFP growth of the sector.

B. Comparison of Value-Added Labor Productivity Between Industry Data and Firm-Level Data

We compared value-added labor productivity between industry-level data and firm-level data in both level and growth terms. As summarized in Table 7, the levels of the average per capita value-added are relatively

TABLE 7
VALUE-ADDED LABOR PRODUCTIVITY AND GROWTH RATES BY SECTORS (2006-2013)

	KIP DB		Survey of Business Activities	
	Labor Productivity (Million Won)	Growth (%)	Labor Productivity (Million Won)	Growth (%)
Economy-Wide	21	4.0	110	0.9
Manufacturing	33	5.0	125	4.1
Service	19	3.2	99	-2.3
Distribution Service	13	4.6	87	0.9
Producer Service	34	2.9	115	-3.1
Social Service	23	0.3	47	0.5
Personal Service	8	3.9	49	-0.2

lower in the KIP database than in the Survey of Business Activities (SBA). The labor productivity levels estimated from industry-level data (KIP Database) is lower by approximately 80% than those estimated from SBA because the survey covered only sample firms with more than 50 full-time employees and 300 million won as capital. In other words, the level of labor productivity seems to be lower in the macro level than micro level due to the unbalanced coverage. We also noted that the growth rates of value-added productivity from both industry-level data and firm-level data during the period of 2006 -2013 are higher in Manufacturing such as 5.0% in the KIP database and 4.1% in the survey than the Service sector. Moreover, the growth of labor productivity in the Service is positive at 3.2% in the KIP database but is negative at -2.3% in the survey. In particular, the micro firm-level data indicates a rapid decrease in labor productivity in the Personal Service sector, which calls for structural adjustment in these sectors to remain competitive.

C. Determinants of TFP Growth

Lastly, we examined what the determinants are for their overall efficiency measured by the growth rate of TFP from the micro firm-level survey data. As summarized in Table 8, we estimated an insignificant but negative effect of export/value-added ratio and a significant positive effect of R&D expenditure/value added ratio. Several earlier studies included in Lee and Pyo (2007) have found negative effects of export/value-added ratio on TFP. We conjectured that the firms with higher

Table 8
Determinants of TFP Growth from Firm-Level Data

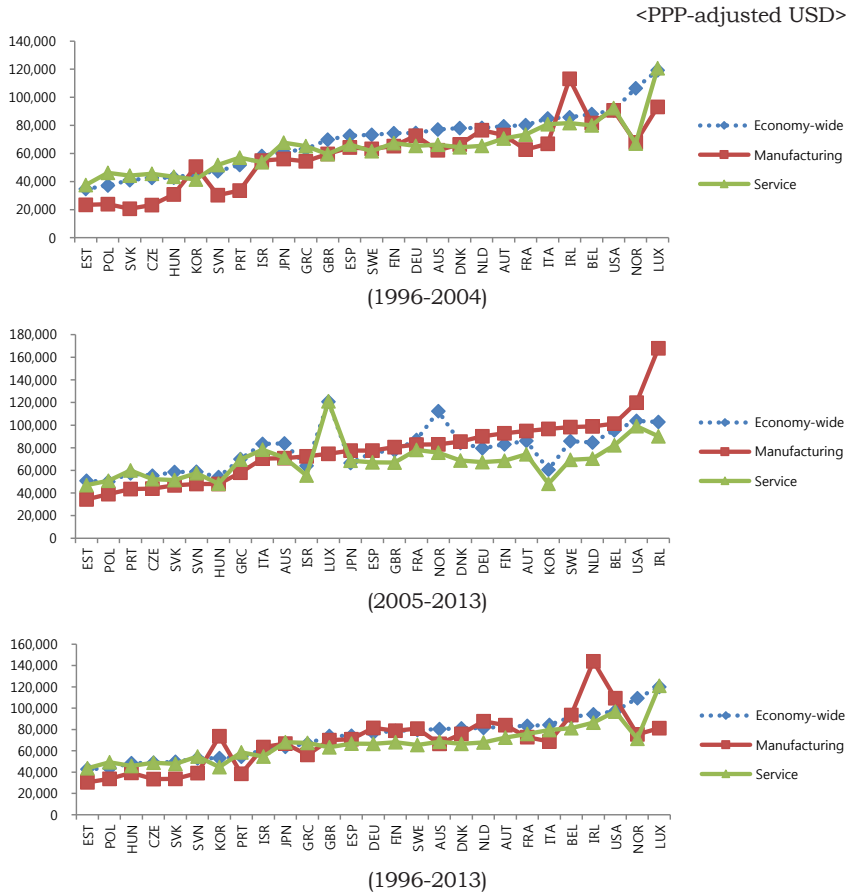
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.677	1.62	-0.41	0.677
Export/VA	-5.801	3.38	-1.71	0.088
R&D Expenditure/VA	332.067	107.68	3.08	0.002
D1	6.854	5.50	1.24	0.215
D2	-7.717	3.20	-2.40	0.017
D3	-8.353	3.50	-2.38	0.018

Notes: 1) Dependent Variable: TFP (%), Sample (adjusted): 2007-2014, Included observations: 32 after adjustments, Cross-sections included: 4, Total pool (balanced) observations: 128, R-squared: 0.11
2) D1, D2, D3: Industry dummy of service sub-sectors

export/value-added ratio may have been more squeezed in their profits than the firms based on higher local demand and therefore, their performance in TFP was not strong. On the other hand, the positive effect of R&D on TFP growth is well-expected and consistent with other earlier studies included in Lee and Pyo (2007). However, the earlier study by Kim and Pyo (2012) found insignificant negative coefficients of R&D/value-added ratio from the four period averages, nine service industries of eight EU-KLEMS member countries, and 72 cross-section data with 4 time series in the regression of TFP-level. The authors conjectured that the volume of R&D expenditure per se may not have exerted significant impact on TFP levels in market services. Since the R&D stock without flow of expenditure can have externality effect, the measurement of R&D expenditure alone may not have captured its positive effect on TFP.

V. An International Comparison of Productivity in Service Sector

We examined an international time profile of labor productivity over the same time interval of 1996-2013 quoted from the National Accounts of OECD STAT (stat.oecd.org). The PPP-adjusted labor productivity level in US dollars is plotted in Figure 3. The data for Korea is only available for the entire period of 1996-2013. In terms of level in the service sector, it is below 50,000 dollars together with low-productivity group of

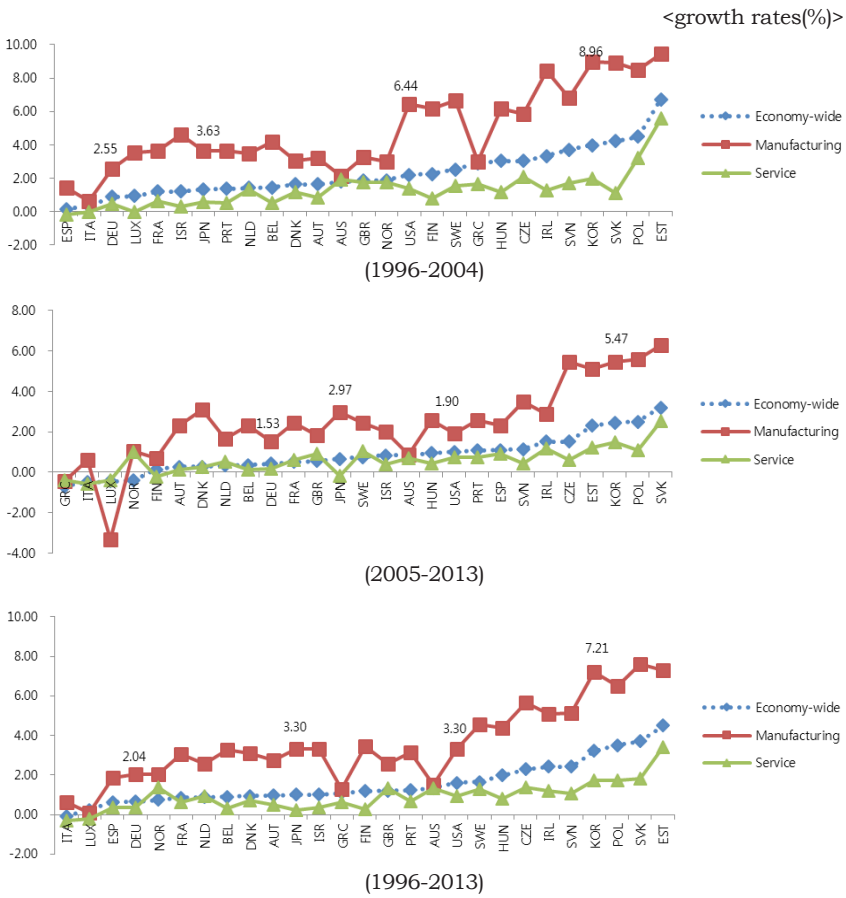


Source: OECD STAT (stat.oecd.org), National Accounts

FIGURE 3
A COMPARATIVE PROFILE OF LABOR PRODUCTIVITY LEVEL

countries such as Estonia, Hungary, and Slovakia.

Only the manufacturing sector's ppp-adjusted labor productivity of Korea is approximately on the 70,000 dollars level equivalent with the mid-level group of Spain, Finland, and Austria. On the other hand, the growth rate data of Korea is only available for the latter period of 2005-2013 and its growth rate in Manufacturing is the second highest next to Slovakia at the 5.47% range (Figure 4). However, the growth rate of the service-sector labor productivity is not as fast as that of manufacturing sector.



Sources: OECD STAT (stat.oecd.org), National Accounts

FIGURE 4
A COMPARATIVE PROFILE OF LABOR PRODUCTIVITY GROWTH RATES

VI. Conclusion

In the present paper, we examined the trend of gross-output and value-added labor productivity in Korea with special attention to its service sector. We decomposed the service sector into four sub-sectors: 1) Distribution Service, (2) Producer Service, (3) Social Service, and (4) Personal Service. We detected that the year 1998 was an outlier in all of economy-wide, manufacturing and service. It should be

TABLE 9
A COMPARATIVE PROFILE OF LABOR PRODUCTIVITY BY SELECTED COUNTRIES

Period: 1996-2004						
	Level (PPP-Adjusted USD)			Growth Rate (%)		
Nation	Economy-Wide	Manufacturing	Service	Economy-Wide	Manufacturing	Service
US	90,738 (100)	90,666 (100)	92,400 (100)	2.20	6.44	1.36
Japan	60,930 (67)	56,063 (62)	67,643 (73)	1.35	3.63	0.59
Korea	45,559 (50)	50,593 (56)	41,415 (45)	3.99	8.96	1.98

Period: 2005-2013						
	Level (PPP-Adjusted USD)			Growth Rate (%)		
Nation	Economy-Wide	Manufacturing	Service	Economy-Wide	Manufacturing	Service
US	103,868 (100)	119,847 (100)	99,174 (100)	1.02	1.90	0.75
Japan	66,462 (64)	77,424 (65)	68,584 (69)	0.67	2.97	-0.16
Korea	60,602 (58)	96,713 (81)	48,141 (49)	2.47	5.47	1.47

Period: 1996-2013						
	Level (PPP-Adjusted USD)			Growth Rate (%)		
Nation	Economy-Wide	Manufacturing	Service	Economy-Wide	Manufacturing	Service
US	97,303 (100)	109,425 (100)	96,755 (100)	1.61	3.30	0.93
Japan	63,696 (65)	66,744 (61)	68,113 (70)	1.01	3.30	0.21
Korea	53,080 (55)	73,653 (67)	44,778 46	3.23	7.21	1.72

noted that the positive labor productivity growth in manufacturing in 1998 reflects the large-scale lay-off by the IMF-mandated corporate restructuring. In the year 2009, the growth rate of gross output labor productivity turned negative in all of economy-wide, manufacturing and service while the growth rate of gross output remained positive. But after 2006, the distribution and producer services caught up with manufacturing in making the economic transformation of the Korean economy from manufacturing-based to service-based more vividly. Yet the continuous sluggish demand for Korean exports and domestic production has slowed down the growth of personal service output and its labor productivity. The magnitude of negative shock on value added labor productivity was deeper in 1998 than in 2009. We also noted that the negative shock was deepest in distribution service. On the other hand, in social service, although the growth rate of value-added labor productivity was negative and deep, the growth rate of value-added itself was positive which reveals the nature of the sector's public function as a social safety net in case of economic crisis.

We also examined the effect of value-added growth on its per capita labor productivity by sector, which is equivalent to the test of Kaldor-Verdoorn Law in its original version by Kaldor (1976) who defined the output growth as value-added growth and labor productivity as value-added per employee. The test was made on macroeconomic data in East Asia by Pyo (2018a). The so-called Verdoorn coefficient was highest in Distribution service (1.14), followed by Manufacturing (1.10), Personal service (0.67), Total service (0.63), and Producer service (0.32). The coefficient of Social service is negative which implies the counter-cyclical nature of social service expenditure by government. Noting that the estimated Verdoorn coefficients from European and US data fell in the range of 0.2-0.6, the estimates of Manufacturing and Distribution services seem high reflecting the strong pro-cyclicality of the two sectors.

The Survey of Business Activity revealed that the growth rate of labor productivity by large enterprises was higher than that of SME in Manufacturing, and was opposite in the Service sector. The relatively rapid increase of labor productivity in the Service sector in Korea has been the prime source of overall efficiency increase in the sector which is evidenced by overall improvement in the its TFP growth.

Furthermore, we constructed the Harberger Diagram to see the cumulative weight of TFP in gross output. Sectors with positive TFP

growth in services were only approximately 44% during the period of 1972-2007, but there was a significant improvement in TFP in service sectors particularly after 2005. However, the dominant sectors of TFP contribution are still IT and Other Information service, Computers and Peripheral Equipment, Agriculture, Forestry and Fishing, Other Manufactured products, Textile and Leather, and Electronic components during the period of 2005-2013.

The Harberger Diagram based on value-added TFP seems to have a higher hump than the Harberger Diagram based on gross-output TFP, which implies that value-added is more sensitive at the time of financial crisis (such as 1997 and 2009) than the gross-output. For the first sub-period in which the 1997 crisis is included, only approximately 55% of cumulative weights had a positive value-added TFP contribution.

In addition, we examined what the determinants are from the micro firm-level survey data for their overall efficiency measured by the growth rate of TFP. We estimated an insignificant but negative effect of export/value-added ratio and a significant positive effect of R&D expenditure/value added ratio. Several earlier studies included in Lee and Pyo (2007) have also found negative effects of export/value-added ratio on TFP. We conjectured that the firms with higher export/value-added ratio may have been more squeezed in their profits than the firms based on higher local demand and therefore, their performance in TFP was not strong. On the other hand, the positive effect of R&D on TFP growth is well-expected and consistent with other earlier studies included in Lee and Pyo (2007).

Finally, we examined an international time profile of labor productivity over quoting from National Accounts of OECD STAT (stat.oecd.org). The PPP-adjusted labor productivity level of Korea in US dollars is below 50,000 together with the low-productivity group of countries such as Estonia, Hungary, and Slovakia. Only the manufacturing sector's ppp-adjusted labor productivity of Korea is approximately on the 70,000 dollars level which is equivalent to the mid-level group of Spain, Finland, and Austria. The growth rate of Korea in Manufacturing is the second highest next to Slovakia at the 5.47% range. However, the growth rate of the service sector labor productivity is not as fast as that of the manufacturing sector.

The major finding of the present paper is that while the growth rate of gross output in the service sector has decelerated more rapidly than that in the manufacturing sector, the growth rate of total factor

productivity (TFP) has improved from near 0% during 1996-2010 to 1.41% during 2011-2013. In particular, the improvement in TFP in distribution and producer services has been impressive, which indicates that the Korean economy is transforming itself toward a more service-oriented growth, and two financial crises have helped such transformation. However, the relative level of TFP in the service sector still seems far behind than that of the US and Japan.

Appendix

Appendix Table 1

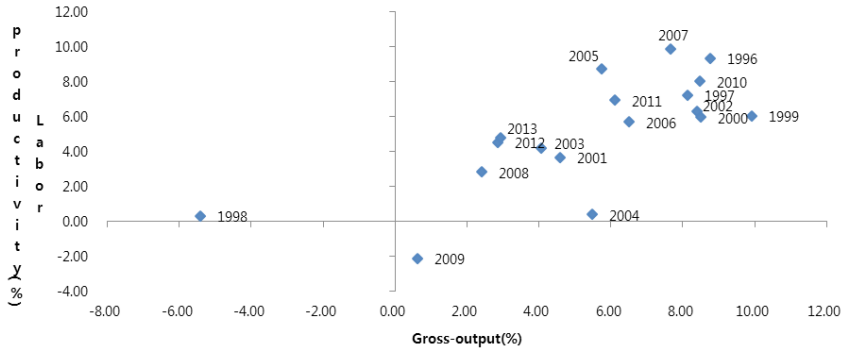
Contribution of inputs and TFP growth to gross output growth in manufacturing

(growth rates(%), contribution rates(%))

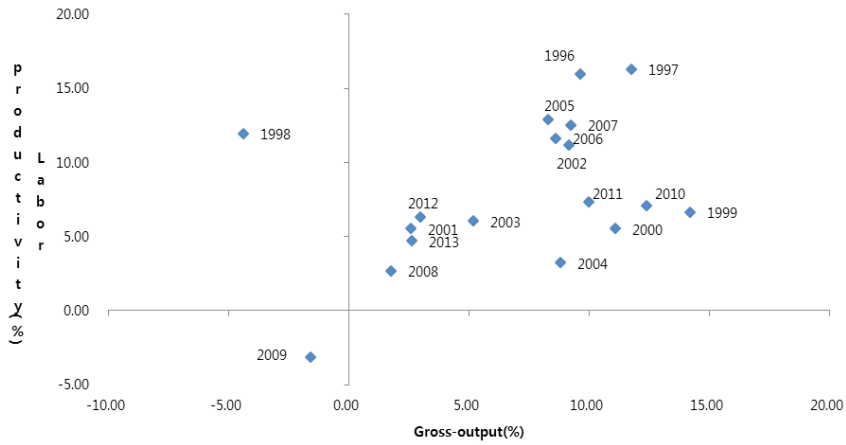
	Gross output	Capital	Labor	Energy	Material	Service	TFP
'96–'04	7.11	0.81	−0.06	0.31	4.15	0.94	0.97
'05–'12	5.70	0.55	0.04	0.52	3.15	0.96	0.48
				Relative contribution to gross output			
'96–'04	100.0	11.4	−0.08	4.3	58.3	13.2	13.7
'05–'12	100.0	9.6	0.6	9.2	55.3	16.8	8.5

Sources: KIP(Korea Industrial Productivity) Database(2014)

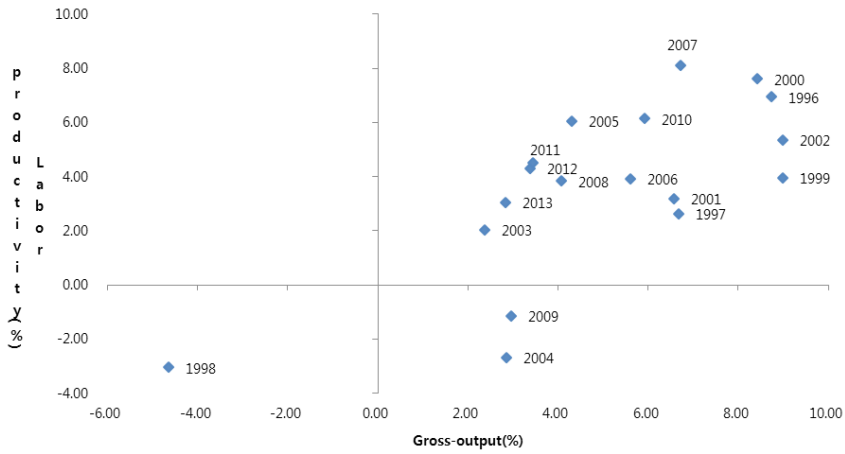
<growth rates(%)>



(Economy-wide)

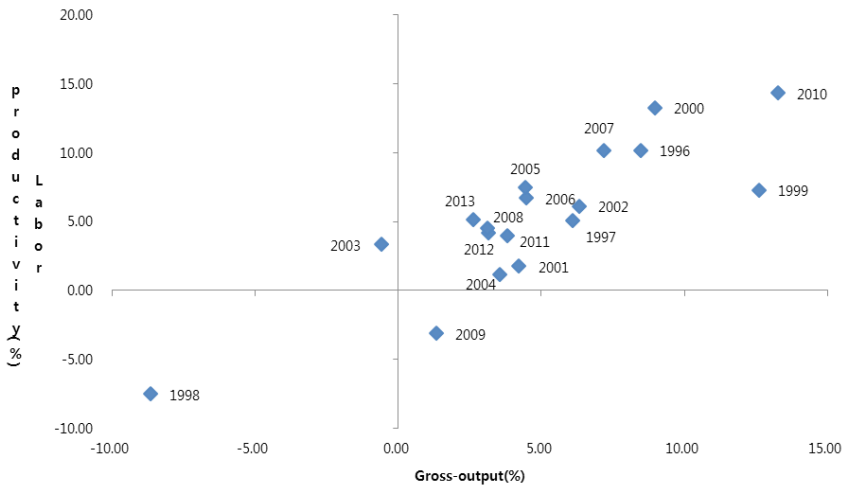


(Manufacturing)

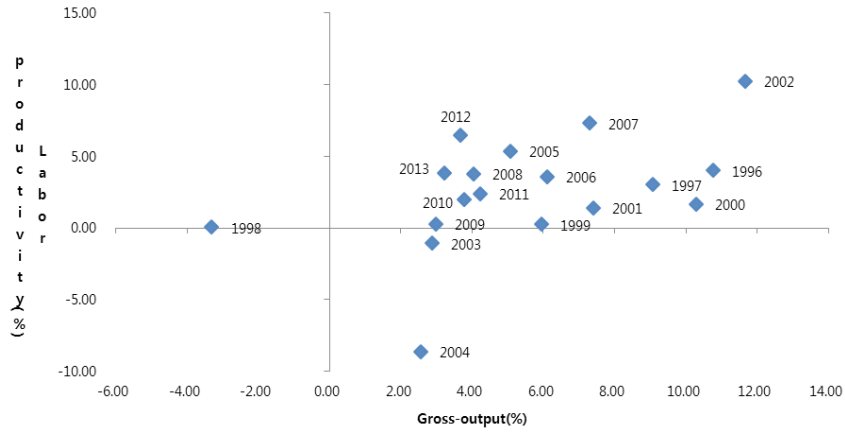


(Service)

(CONTINUED)

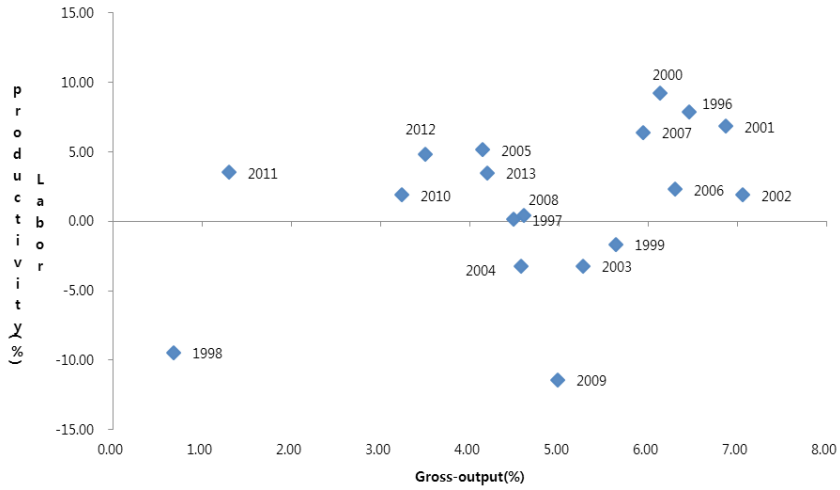


(Distribution service)

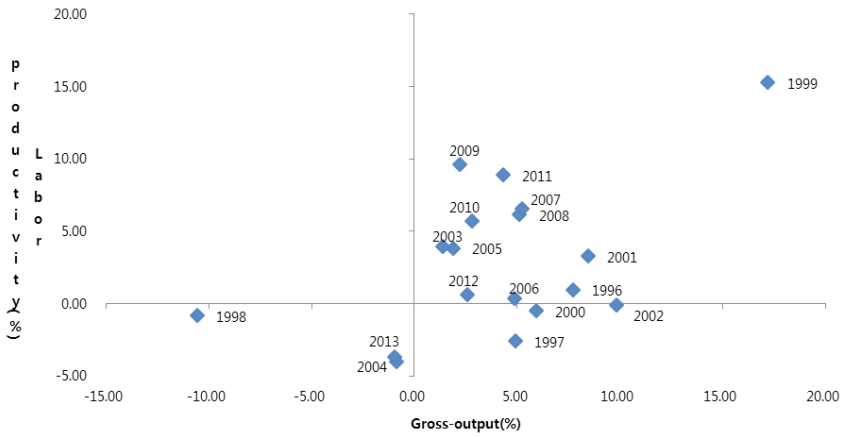


(Producer service)

(CONTINUED)



(Social service)

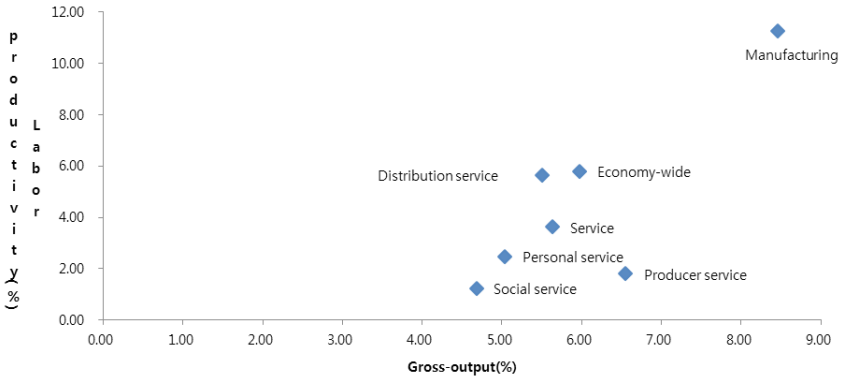


(Personal service)

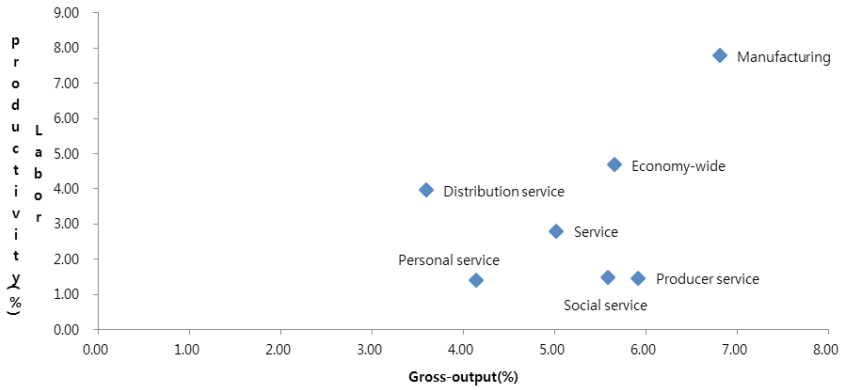
APPENDIX FIGURE 1

TREND IN GROSS OUTPUT LABOR PRODUCTIVITY BY SECTOR (1996–2013)

<growth rates(%)>

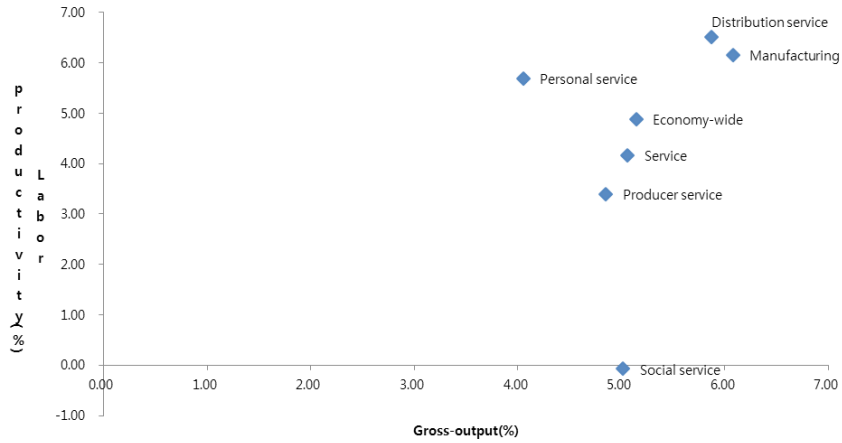


(1996–2000)

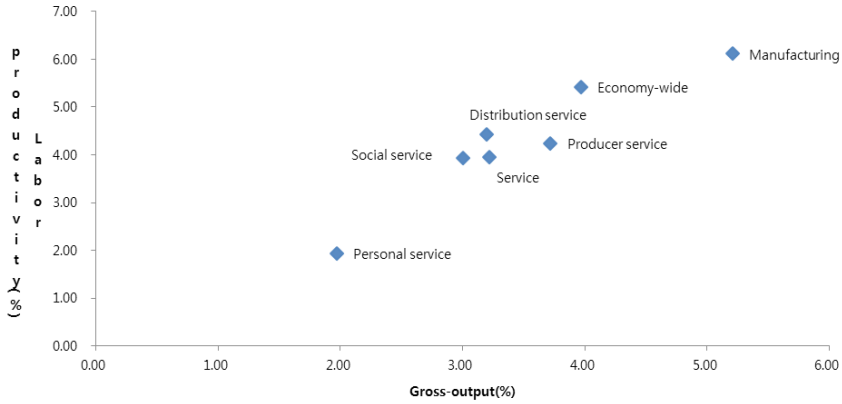


(2001–2005)

(CONTINUED)



(2006–2010)

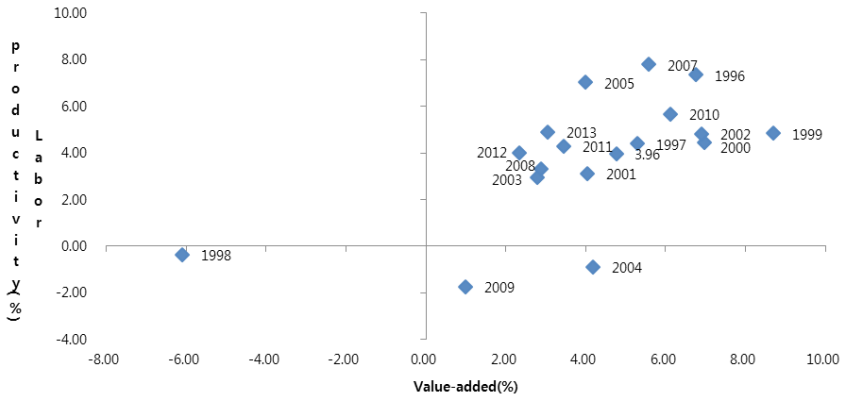


(2011–2013)

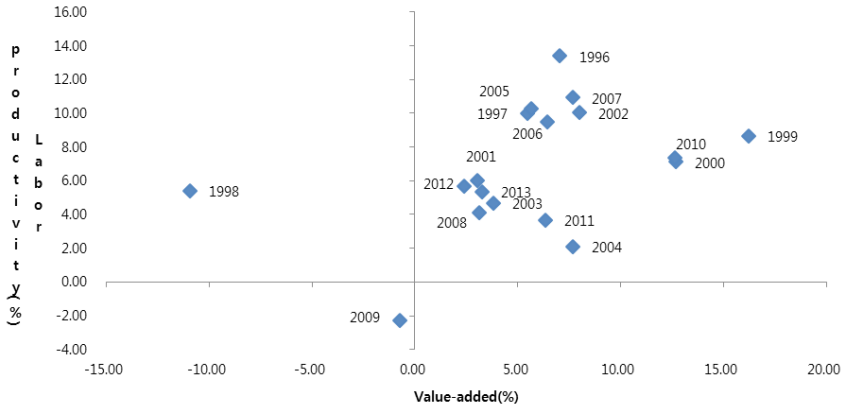
APPENDIX FIGURE 2

GROWTH RATES OF GROSS OUTPUT LABOR PRODUCTIVITY BY SUB-PERIOD

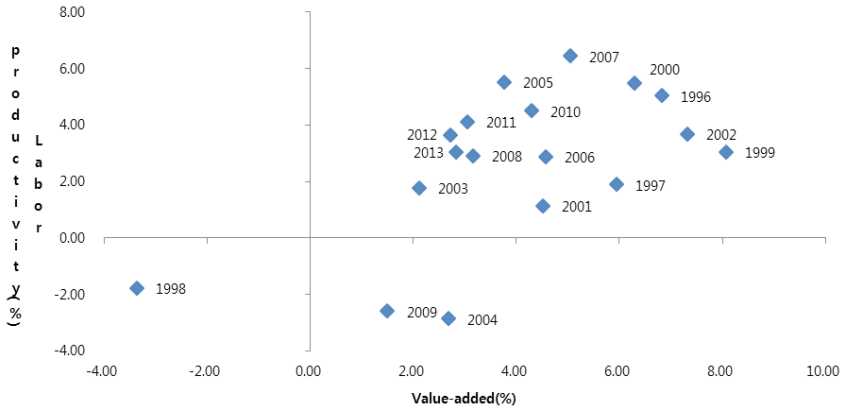
<growth rates(%)>



(Economy-wide)



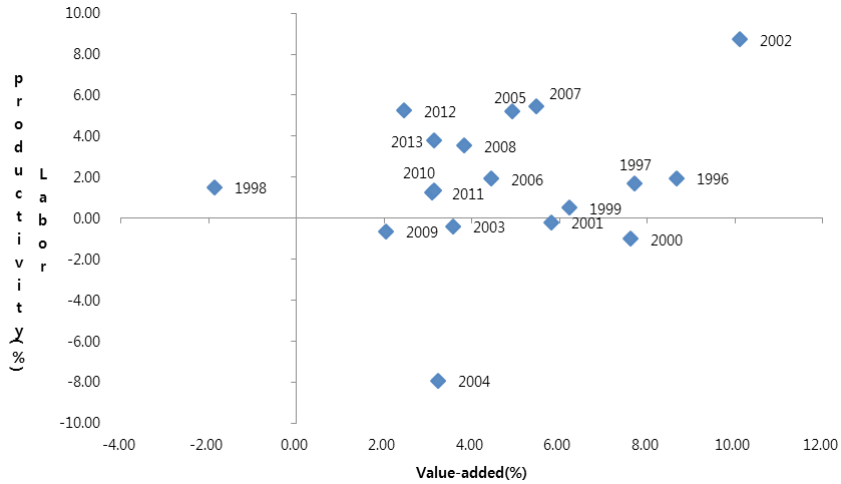
(Manufacturing)



(Service)

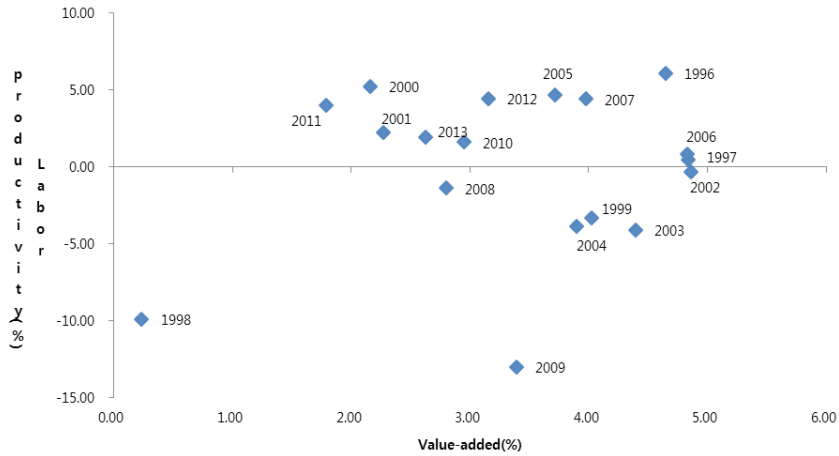
(CONTINUED)

(Distribution service)

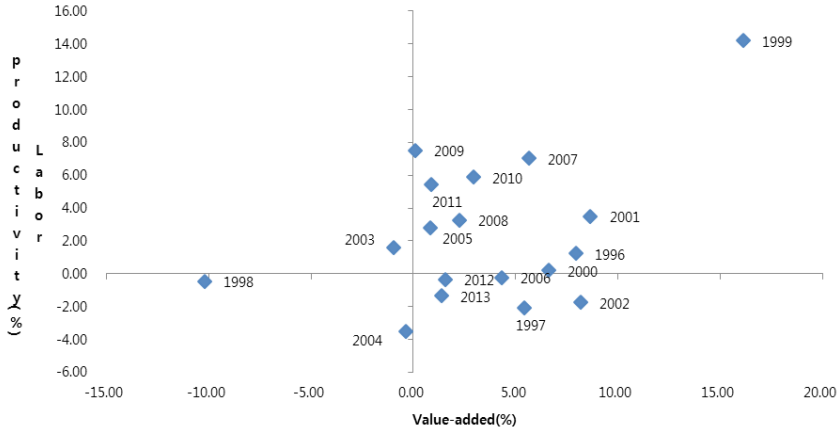


(Producer service)

(CONTINUED)



(Social service)

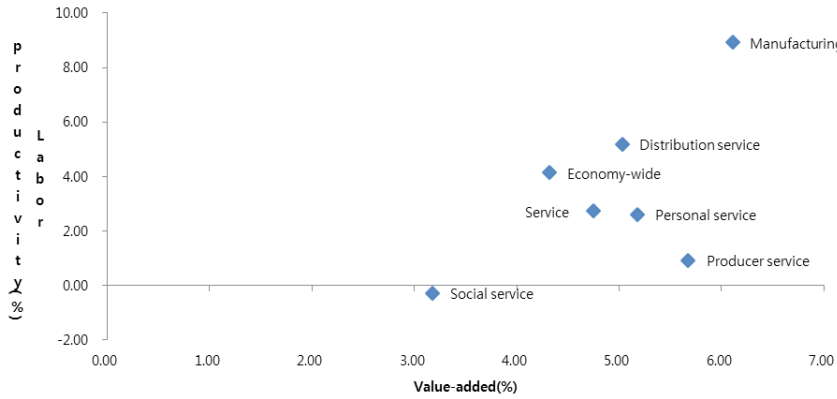


(Personal service)

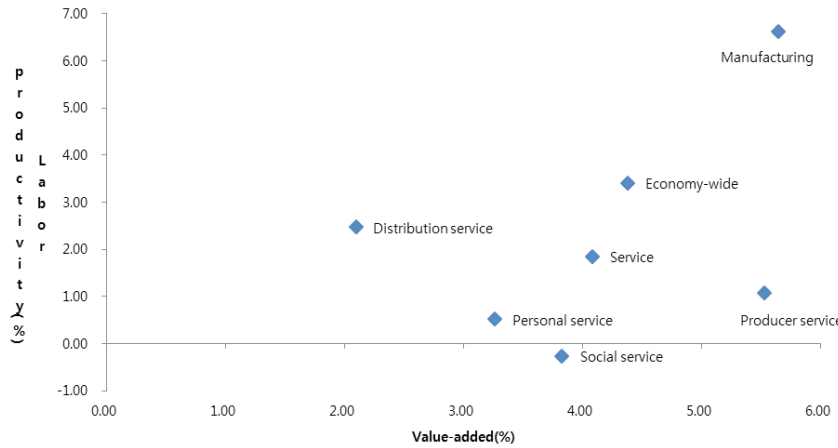
Appendix Figure 3

Trend in Value-Added Labor Productivity by Sector (1996–2013)

<growth rates(%)>

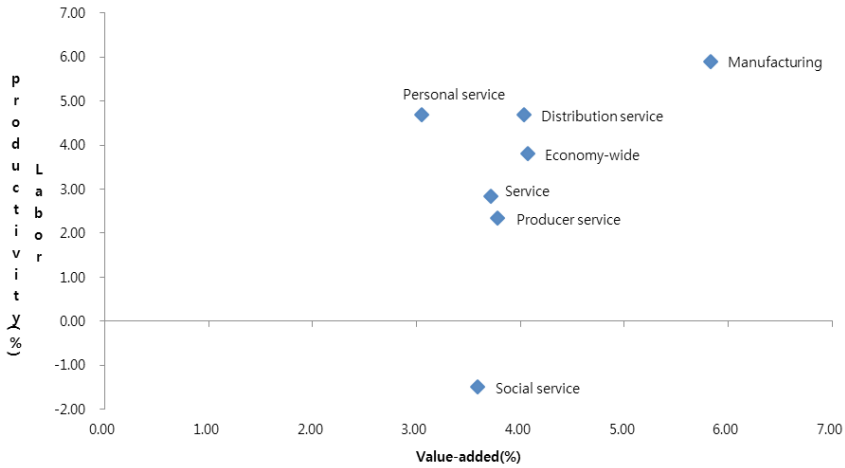


(1996–2000)

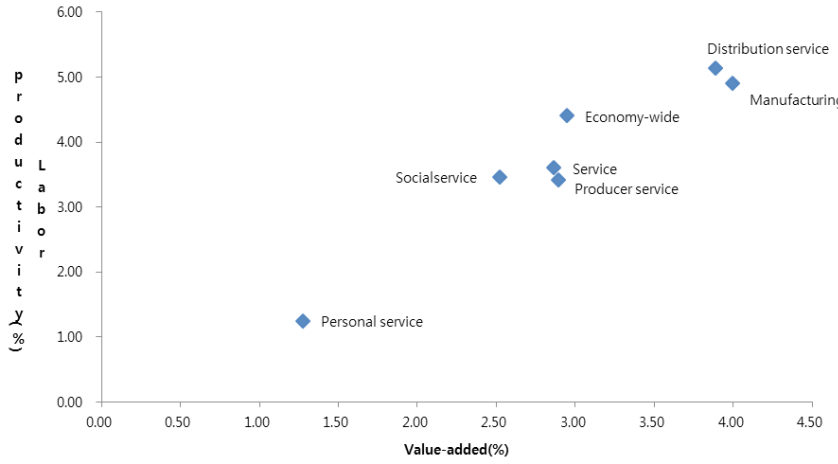


(2001–2005)

(CONTINUED)



(2006–2010)



(2011–2013)

APPENDIX FIGURE 4

GROWTH RATES OF VALUE-ADDED LABOR PRODUCTIVITY BY SUB-PERIOD

References

Chun, H., H. K. Pyo, and K. H. Rhee. "Multifactor Productivity in Korea and an International Comparison: Data and Productivity Estimates of the Korea Industrial Productivity Database." *Seoul Journal of Economics* 21 (No. 4 2008): 551-577.

Farrell, D., M. Baily, and J. Remes. "US Productivity after the Dot Com Bust." McKinsey Global Institute, 2005. Available at http://www.mckinsey.com/global-themes/americas/us-productivity-after-the-dot-com-bust (accessed on January 18, 2017).

Fukao, K., Y. G. Kim, and H. U. Kwon. Plant Turnover and TFP Dynamics in Japanese Manufacturing, CEI Working Paper Series, Hitotsubashi University, No. 2006-17, 2006.

Fukao, K., T. Miyagawa, H. K. Pyo, and K. H. Rhee. "Estimates of Total Factor Productivity, the Contribution of ICT, and Resource Reallocation Effect in Japan and Korea." In M. Mas and R. Stehrer (eds.), *Industrial Productivity in Europe: Growth and Crisis*. Chapter 9, Cheltenham, U.K: Edward Elgar, pp. 264-304, 2012.

Harberger, A. C. "A Vision of the Growth Process." *The American Economic Review* 88 (No. 1 1998): 1-32.

Ha, B. and H. K. Pyo. "The Measurement of IT Contribution by Decomposed Dynamic Input-Output Tables in Korea (1980-2002)." *Seoul Journal of Economics* 17 (No. 4 2004): 511-546.

Hein, E. and A. Tarassow. "Distribution, Aggregate Demand and Productivity Growth: Theory and Empirical Results for Six OECD Countries Based on a Post-Kaleckian Model." *Cambridge Journal of Economics* 34 (No. 4 2010): 727-754.

Kaldor, N. *Strategic Factors in Economic Development*. New York State School of Industrial and Labor Relations, Cornell University, 1967.

_____. "Inflation and Recession in the World Economy." *The Economic Journal* 86 (No. 344 1976): 703-714.

Kim, H. J. and H. K. Pyo. "International Comparison of Productivity in Market Services: Korea with EU KLEMS Member Countries." In M. Mas and R. Stehrer (eds.), Industrial Productivity in Europe: Growth and Crisis, Chapter 9, Cheltenham, U.K.: Edward Elgar, pp. 428-459, 2012.

Kim, H. J. "The Shift to the Service Economy: Causes and Effects."

Quarterly Economic Analysis 12 (No. 4 2006): 35-76 (in Korean).

Lee, Y. and H. K. Pyo. "Productivity Growth and Patterns of Efficiency Changes in Korean Economy: Stochastic Frontier Approach with Industry-panel Data." *Seoul Journal of Economics* 20 (No. 1 2007): 23-58.

McCombie, J. "Increasing Returns and the Verdoorn Law From a Kaldorian Perspective." In J. McCombie, M. Pugno, and B. Soro (eds.), *Productivity Growth and Economic Performance*. London, UK: Palgrave Macmillan, pp. 64-114, 2002.

OECD, National Accounts, OECD STAT Available at http: www.stat.oecd.org.

Pyo, H. K. "Economic Growth in Korea (1911-1999): A Long-term Trend and Perspective." *Seoul Journal of Economics* 14 (No. 1 2001): 59-125.

_____. "The Labor Productivity and a Test of Kaldor-Verdoorn Law in East Asia." In Deb Kusum Das (ed.), *Productivity Dynamics in Emerging and Industrialized Countries*, Taylor & Francis Group, forthcoming, 2018a.

_____. "Productivity and Economic Development." In Emili Grifell-Tatje, C. A. Knox Lovell, and Robin C. Sickles (eds.), *The Oxford Handbook of Productivity Analysis*. Chapter 23, Oxford University Press, forthcoming, 2018b.

Pyo, H. K., and B. Ha. "A Test of Separability and Random Effects in Production Function with Decomposed IT Capital." *Hitotsubashi Journal of Economics* 48 (No. 1 2007): 67-81.

Rhee, K. H. and H. K. Pyo. "Financial Crisis and Relative Productivity Dynamics in Korea: Evidence From Firm-level Data (1992–2003)." *Journal of Productivity Analysis* 34 (No. 2 2010): 111-131.

_____. "Aggregate Total Factor Productivity and Resource Reallocation Effect of ICT Sectors in Korea: A Comparison with the USA, Japan and EU7." *Korean Economic Review* 28 (No. 2 2012): 189-219.

_____. "Firm Dynamics, Resource Reallocation and Determinants of Labor Productivity: A Panel Analysis From the Korean Firm Level Data (2006-2012)." *Journal of Korean Economic Analysis* 21 (No. 3 2015): 43-114 (in Korean).

Storm, S. and C. W. M. Naastepad. "The NAIRU Reconsidered: Why Labour Market Deregulation May Raise Unemployment." *International Review of Applied Economics* 22 (No. 5 2008): 527-

544.

The Bank of Korea, Input-Output Statistics (2013, 2015).

Van Ark, B., E. Monnikhof, and M. Timmer. "Prices, Quantities, and Productivity in Industry: A Study of Transition Economies in a Comparative Perspective." In A. Heston. and R. E. Lipsey (eds.) *International and Interarea Comparisons of Income, Output, and Prices.* Chicago, U.S.A.: University of Chicago Press, pp. 327-367, 1999.

Whitefoot, Kate S. and Walter D. Valdivia with Gina C. Adams, Innovation and Manufacturing Labor: A Value-Chain Perspective. Center for Technology Innovation at Brookings, March, 2015.