Total Factor Productivity of the Korean Firms and Catching up with the Japanese Firms

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This paper measured the Total Factor Productivity (TFP) of all listed firms in Korea from 1984 to 2005 and compared this TFP of Korean firms with that of Japanese firms. This study used the chain-linked index number method developed by Good *et al.* (1999) to find that the average TFP of Korean firms grew about 44.1% between 1984 and 2005, with 2.1% annual growth rates. The catch-up index of Korean firms with Japanese firms is defined at an individual firm level for the first time among existing literature. Through this comparison analysis, the researchers found that there were four patterns of catching up methods practiced by Korean firms in closing in on the Japanese firms. These patterns were over catch-up, just catch-up, under catch-up, and reverse catch-up." Furthermore, the researchers found that the number of under catch-up and reverse catch-up industries was more than 40% of the firms subjected in the study. In contrast, only 10.1% of all the Korean listed firms and 8.7% of total sales of all the listed firms surpassed Japanese firms in terms of TFP in 2004. Also, the catch-up performance was quite better in bigger firms, which is indicative of polarization in TFP catch-up performance.

Keywords: Catch-up, Productivity, Korea, Japan, Polorization

JEL Classification: D24, L25, O53, O57

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I. Introduction

The studies of Copeland (1937), Tinbergen (1941), Kendrick (1955), Solow (1957) among others, which measured the TFP (total factor productivity) of industries propelled other proponents to add new knowledge about TFP using various methodologies.[1] With the availability of micro level data (MLD, firm level or plant level data), firm or plant level TFP analysis has increased dramatically since 1980s (Bartelsman and Doms 2000). According to Bartelsman and Doms, micro level data give a lot of new findings to two sub-fields of TFP research, which are the field related to growth accounting of industry and the national economy and the research that examines the factors underlying changes in productivity.[2]

Total factor productivity is crucial to the competitiveness of any economic unit. Without high productivity, the possibility of any economy reaching high economic welfare or high income levels is low. With Krugman (1994), a band of scholars including Young (1994, 1995), and Rodrik (1995) saying that the rapid growth of several Asian countries including Korea can be explained not by the rapid growth of TFP but by the rapid growth of inputs, productivity of Asian countries has become an important issue. However, obtaining reliable productivity measurement is not easy because of the data required such as more specific industry level deflators (output, material, capital deflators, respectively) and data for calculating capital stock or cost of each input. The reliability of TFP measurement depends directly on the reliability of these data. In fact, if there are no reliable deflators or capital stock data or depreciation data, it is very difficult to make reliable TFP of more specified industry level like the two-digit SIC code.[3] Such scenario makes the study discussed in this paper necessary as it used as accurate data as possible including the studies conducted by Pyo (2002) and Pyo *et al.* (2006) for material deflator of two digit industry level and depreciation data of each capital good. This paper then aimed to compare the TFP of Korean firms with that of Japanese

[1] See the Griliches (1996) for more details about TFP pioneers.

[2] Nadiri (1970) and Nelson (1981) review literatures of two fields, that is, growth accounting literature and evolutionary literature, respectively.

[3] In this aspect, usable data of Korea for TFP measurement is so poor that it is necessary to make these reliable basic data with a remarkable investment.

firms, thereby analyzing the catching-up methods practiced by the Korean firms to close in on Japanese firms.

Aw *et al.* (2000, 2003), Hahn (2000, 2004), Ahn *et al.* (2004), Ahn (2005, 2006), Pyo *et al.* (2006), Kim (2006), Oh *et al.* (2006), and Kwack (2007), among others, have provided literature related to measuring TFP of Korean firms using micro level data. While their papers used plant level data, this paper used individual firm level data to measure the TFP of firms as given by the Korea Productivity Center (2002 and 2006), which used listed and externally audited firm data. In this study, the researchers measured the firm level TFP of Korean firms from 1984 until 2005 and chain-linked index number method developed by Good *et al.* (1999). In the succeeding parts of this paper, the researchers provide the literature used to back up the necessity of the problem, discuss the methodology employed in the conduct of the study, explain the results of the estimation of the TFP of the listed firms, present the methodologies of comparing the TFP of firms from different countries, and present the results of the comparison of TFP between Korean and Japanese firms, including the four patterns practiced by Korean firms in catching up Japanese firms.

II. Related Literature, Methodology, and the Data

A. Methodology in Measuring Total Factor Productivity (TFP)

Many studies have measured Total Factor Productivity (TFP) in a variety of ways. Hulten (2000) explained the development of methodology thoroughly in the biography of research on TFP. More concentrated on methodology, Biesebroeck (2003, 2004) surveyed these numerous methods into five widely-used methods: (1) index numbers by Tinbergen (1941), Kendrick (1955), Solow (1957), Diewert (1976), Caves *et al.* (1982), and Good *et al.* (1999); (2) data envelope analysis or nonparametric frontier estimation (DEA) by Farwell (1957), Charnes *et al.* (1978); (3) parametric estimation or instrumental variables estimation (GMM) by Blundell and Bond (1998, 2000); (4) stochastic frontiers (SF) by Farwell (1957), Aigner and Chu (1968), Aigner *et al.* (1977), Meeusen and van den Broeck (1977), and Cornwell *et al.* (1990), and (5) semi-parametric estimation (OP, LP) by Olley and Pakes (1996), Levinsohn and Petrin (2003).[4] Using all these methods, Biesebroeck (2003, 2004) measured

firm level TFPs and made correlation simulation analysis between different productivity levels and growth estimates. Biesebroeck found that the different methods produced surprisingly similar productivity estimates using data on two developing countries, Colombia and Zimbabwe (2003).[5]

Among the five above-mentioned methods, index number method is the oldest and most widely used method of measuring TFP. Among several index methods, multilateral Tornqvist index which was justified by Diewert (1976) and developed by Caves *et al.* (1982) is also widely used. Good *et al.* (1999) extended this method using chain-link over time.

For its part, this paper chose the index number method basically because it provides a consistent way of the cross-sectional and time series comparison (Caves *et al.* 1982; Aw *et al.* 2001). Furthermore, the equations used in this paper were those extended by Good *et al.* (1999) and used by Aw *et al.* (2001, 2003) and Fukao *et al.* (2007a) among others.[6]

B. Data on Firms and Industries

The researchers used firm data from the Korea Information Service (KIS) and 33 industries based on the International Comparison of Productivity among Asian Countries (ICPA) classification.[7,8] Table 1 shows the ICPA classification and firm year observations, which include all firms listed or delisted in KSE or KOSDAQ market.[9] Table 2 shows ICPA 33 industries matched to KSIC (Korea Standard Industry Classification) code because original firm data of KIS had this code.

[4] The literatures in parentheses refer to the first users of each method in measuring TFP or efficiency. Farwell gives both DEA and SF methodologists pioneering idea of efficient frontier.

[5] For more details on the comparative analysis of each method, see Biesebroeck (2003, 2004).

[6] See Fukao *et al.* (2007a) for the explanations about equations.

[7] Korea Information Service was first established in 1985 as the first credit rating company in Korea.

[8] ICPA project is managed by RIETI (Research Institute of Economy, Trade and Industry), Japan.

[9] 3 sigma outliers of TFP value are excluded in these observations.

TABLE 1

INDUSTRIES AND FIRMS (1984-2005)[10]

Industry Code	Industries	Firm Year Observations
1	Agriculture	124
2	Coal mining	22
3	Metal and non-metallic mining	6
4	Oil and gas extraction	0
5	Construction	1217
6	Food and kindred products	1262
7	Textile mill products	611
8	Apparels	623
9	Lumber and wood	87
10	Furniture and fixtures	95
11	Paper and allied	679
12	Printing, publishing, and allied	173
13	Chemicals	2966
14	Petroleum and coal products	109
15	Leather	204
16	Stone, clay, glass	670
17	Primary metal	1398
18	Fabricated metal	707
19	Machinery, non electric	1607
20	Electrical machinery	4665
21	Motor vehicles	1192
22	Transportation equipment and ordnance	185
23	Instruments	485
24	Rubber and misc. plastics	564
25	Misc. manufacturing	207
26	Transportation	454
27	Communications	149
28	Electric utilities	21
29	Gas utilities	209
30	Trade	1562
31	Finance	0
32	Other private service	2155
33	Public service	0
	Total	24408

[10] Real estate firm is included in industry 31 but in this paper 45 real estate firms were included in industry 32.

TABLE 2

ICPA 33 INDUSTRIES MATCHED TO KSIC CODE

ICPA Code	KSIC Code	Industry Name of KSIC	Firm Year Observations
1	1000	Agriculture	15
1	5000	Fishing	109
2	10000	Mining of Coal, Crude Petroleum and Natural Gas, Uranium and Thorium Ores	22
3	11000	Mining of Metal Ores	6
5	45000	General Construction	1,074
5	46000	Special Trade Construction	143
6	15000	Manufacture of Food Products and Beverages	1,257
6	16000	Manufacture of Tobacco Products	5
7	17000	Manufacture of Textiles, Except Sewn Wearing apparel	611
8	18000	Manufacture of Sewn Wearing Apparel and Fur Articles	623
9	20000	Manufacture of Wood and of Products of Wood and Cork, Except Furniture; Manufacture of Articles of Straw and Plaiting Materials	87
10	36000	Manufacture of Furniture; Manufacturing of Articles n.e.c.	95
11	21000	Manufacture of Pulp, Paper and Paper Products	679
12	22000	Publishing, Printing, and Reproduction of Recorded Media	173
13	24000	Manufacture of Chemicals and Chemical Products	2,966
14	23000	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel	109
15	19000	Tanning and Dressing of Leather , Manufacture of Luggage and Footwear	204
16	26000	Manufacture of Other Non-metallic Mineral Products	670
17	27000	Manufacture of Basic Metals	1,398
18	28000	Manufacture of Fabricated Metal Products, Except Machinery and Furniture	707
19	29000	Manufacture of Other Machinery and Equipment	1,607
20	30000	Manufacture of Computers and Office Machinery	354
20	31000	Manufacture of Electrical Machinery and Apparatuseses n.e.c.	919
20	32000	Manufacture of Electronic Components, Radio, Television and Communication Equipment and Apparatuses	3,392

(Table 2 Continued)

ICPA Code	KSIC Code	Industry Name of KSIC	Firm Year Observations
21	34000	Manufacture of Motor Vehicles, Trailers, and Semitrailers	1,192
22	35000	Manufacture of Other Transport Equipment	185
23	33000	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks	485
24	25000	Manufacture of Rubber and Plastic Products	564
25	36000	Manufacture of Furniture; Manufacturing of Articles n.e.c.	187
25	37000	Recycling	20
26	60000	Land Transport; Transport *via* Pipelines	194
26	61000	Water Transport	109
26	62000	Air Transport	39
26	63000	Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	112
27	64000	Post and Telecommunications	149
28	40000	Electricity, Gas, Steam, and Hot Water Supply	21
29	40000	Electricity, Gas, Steam, and Hot Water Supply	209
30	50000	Sale of Motor Vehicles and Motorcycles; Retail Sale of Automotive Fuel	63
30	51000	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	1,189
30	52000	Retail Trade, Except Motor Vehicles and Motorcycles	278
30	55000	Hotels and Restaurants	32
32	70000	Real Estate Activities	42
32	72000	Computer and Related Activities	1,417
32	73000	Research and Development	5
32	74000	Professional, Scientific, and Technical Services	282
32	75000	Business Support Services	105
32	80000	Education	34
32	87000	Motion Picture, Broadcasting, and Performing Arts Industries	196
32	88000	Other Recreational, Cultural, and Sporting Activities	52
32	90000	Sewage and Refuse Disposal, Sanitation, and Similar Activities	22
		Total	24,408

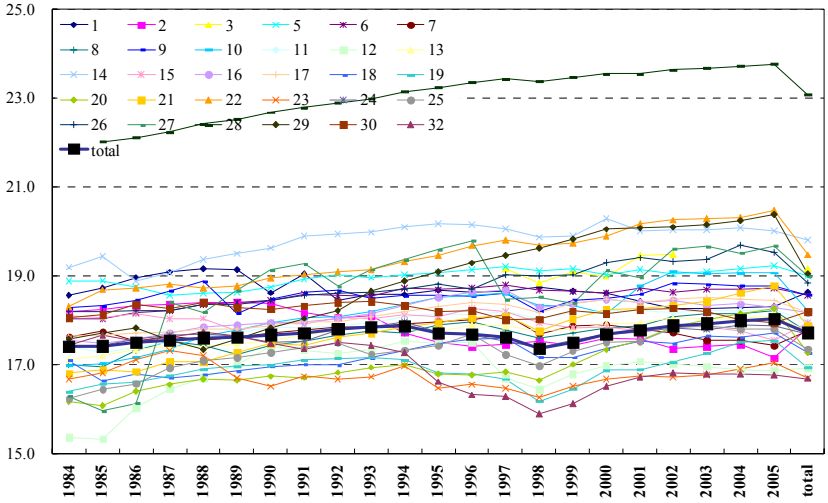


FIGURE 1
AVERAGE FIRM ln(REAL OUTPUT) BY INDUSTRY AND YEAR

Output and Material and Their Deflator

"Sales," in real terms, refers to the output of any firm. Material inputs are calculated using several items in financial statements such as Cost of Sales + Selling and General Administration Expenses — Depreciation — Labor Cost. Instead of using physical material, the proponents of this research used the broad definition of material input including selling and general administration expenses because they used material deflator by industry made by IO table.

The average firm natural log of real output and material by industry and firm is shown in Figure 1 and 2 and in appendix tables. The tables show that the average firm output and material grew by 60% and 50%, respectively, from 1984 to 2005.

The price indices for output was made using PPI (Producer Price Index) in BOK (Bank of Korea). Intermediate input deflators were taken from Pyo *et al.* (2006) from 1984 to 2002 and deflators in 2003, 2004, and 2005 were extended using broadly-defined material and intermediate deflators in BOK.

Labor Input

Total labor hours (determined by the product of the number of

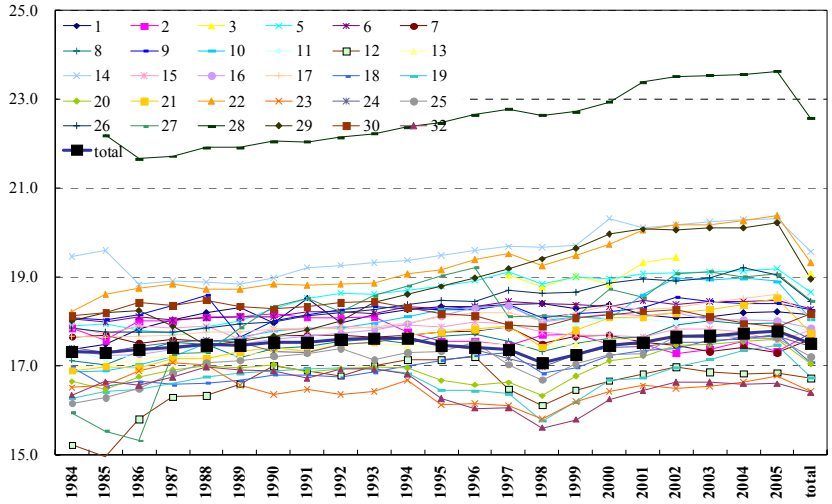


FIGURE 2
AVERAGE FIRM ln(MATERIAL) BY INDUSTRY AND YEAR

employees and industry level yearly working hour) were used as labor input. The labor hours of each industry were taken from the Monthly Labor Survey of Government. The total average monthly labor hour decreased from 233 hours in 1984 to 197 hours in 2005. Total labor input also decreased.

Capital Inputs and Their Price Index and Capital Cost

The six capital goods considered in this study were: (1) buildings, (2) structures, (3) machinery, (4) transportation equipment, (5) instruments and tools, and furniture, and (6) land.

The price indices for buildings and structures were taken from that of materials and intermediate goods for construction of the Bank of Korea (BOK). The price indices for machinery, transportation equipment, and instruments and tools and furniture were taken from fixed capital formation deflator of BOK. For the price index of land, the average of index of Seoul and whole country land prices compiled by the BOK was used. These fixed capital formation deflators in BOK had some shortcomings because they were not stock but flow deflators. Therefore, the researchers used stock

deflators from Korea Development Institute (KDI) and compared the TFP estimation results in Table 6 in Appendix.[11] As a result of comparison, the researchers found that the average gap of annual growth rate during all sample periods was only below 0.1 %.[12]

Capital Stock

In many cases, real capital stock is calculated using perpetual inventory method as follows;

$$K_t=(1-\delta)K_{t-1}+\frac{NOMI_t}{PK_t} \tag{1}$$

where, PK_t is the price index for the capital asset. δ is depreciation rate and $NOMI_t$ is nominal investment and can be calculated using net acquisition in Statement of Changes in Financial Position up to 1993 and Cash Flow Statements from 1994 to Present in Korea.[13] However, the starting point of Korean firm data set was 1980 for the firms having full sample period data. Analysis period was from 1984. The number of firms with full sample period data was very small, which affected the initial value when Perpetual Inventory Method (PIM) was used. While PIM method is fit for balanced panel data set, this paper's data set for TFP analysis was unbalanced panel data.[14] Even if the this sample period problem was disregarded, there still was not enough consistency among net book values in the balance sheet and net acquisition values made by Statement of Changes in Financial Position (CFP) and Cash Flow Statements (CFS); this was because of missing values in CFP and CFS and revaluation of asset in balance sheet. Moreover, there were so many zero value

[11] The researchers wanted to thank Sanghoon Ahn in KDI for good comment and data.

[12] The used sample period was 1990-2003 because of the constraint of stock deflator. By two sample T test result by industry and year respectively, H_0: difference of two means=0 was rejected only in year 1998 (5% level **), industry 18 (1% level ***), industry 20 (10% level *) and total samples (1% level ***). In total samples, H_0 is not rejected in T-test using the growth rates of TFPs.

[13] By the regulation change, Statement of Change of Financial Condition was substituted by Cash Flow Statement in 6^{th} Amendment of Business Accounting Standards in 1994.

[14] Hayashi and Inoue (1991) also used balance panel data set and base year for PIM was 1962 and starting year for analysis was 1977.

observations. If the researchers used the PIM method, the volatility of real capital stock would be large, thus creating more consistency problems. Because of these problems, the researchers made real value of capital using net book value as follows;

$$K_t + \frac{NBV_t}{PK_t} \tag{2}$$

NBV_t is depreciation excluded net book value of year t and was provided by each capital in balance sheet.

Depreciation and Effective Corporate Tax Rate in Capital Cost

To make cost share of each input, the capital cost rates of each capital inputs ck were calculated based on the method by Jorgensen (1963), Fukao *et al.* (2003), and Fukao *et al.* (2007a).[15]

Depreciation rate δ was determined using Pyo (2002). The depreciation rates for each capital goods were (1) 1.796%, (2) 3.413%, (3) 11.3%, (4) 20.51%, and (5) 11.3%.[16]

Corporate tax rate and enterprise tax rate were referred by Kim *et al.* (2003). Labor cost and material cost were directly obtained from Income Statement.

III. Result of the Total Factor Productivity (TFP) Estimation

A. Comparison with Existing Estimates

The researchers' estimates of the average TFP levels are presented in Table 3 and Figure 3.[17] According to these representations, the average TFP of the listed firms grew about 44.1% between 1984 and 2005.[18] If averages weighted were taken by outputs, the average of TFP of all listed firms would have grown to about 39.5%. In terms of the annual growth rate, 2.1% per annum was observed over the same period.

[15] See Fukao *et al.* (2007a) for detail explanations about equations.

[16] For the comparison, Hayashi and Inoue (1991) uses the depreciation rates of (1) 4.7%, (2) 5.64%, (3) 9.489%, (4) 14.70%, and (5) 8.838%.

[17] Base year is not fixed to the first year of time series, but the year 1999 for the convenience of international comparison to Japan in part 2.

[18] The values are natural log value. So the difference means growth rate.

TABLE 3

AVERAGE TFP LEVEL

Year	N	Mean	Output Weighted Mean	S.D.	Min.	Median	Max.	N (Manu-facturing)	Mean (Manu-facturing)
1984	551	-0.41	-0.33	0.40	-1.27	-0.43	0.81	427	-0.51
1985	606	-0.36	-0.31	0.39	-1.24	-0.37	0.91	473	-0.45
1986	650	-0.34	-0.30	0.37	-1.12	-0.35	0.89	514	-0.42
1987	710	-0.33	-0.32	0.36	-1.20	-0.33	0.89	561	-0.40
1988	759	-0.32	-0.30	0.35	-1.21	-0.31	0.99	598	-0.38
1989	790	-0.31	-0.28	0.33	-1.23	-0.30	0.94	621	-0.36
1990	823	-0.29	-0.25	0.29	-1.22	-0.27	0.96	645	-0.33
1991	866	-0.25	-0.20	0.28	-1.40	-0.22	0.92	681	-0.27
1992	877	-0.21	-0.16	0.25	-1.40	-0.19	0.93	690	-0.23
1993	899	-0.18	-0.14	0.23	-1.01	-0.15	0.90	706	-0.18
1994	965	-0.14	-0.09	0.21	-1.18	-0.11	0.92	758	-0.13
1995	1087	-0.12	-0.07	0.20	-1.27	-0.09	0.87	844	-0.11
1996	1153	-0.08	-0.06	0.19	-1.17	-0.06	0.92	880	-0.06
1997	1300	-0.09	-0.06	0.20	-1.25	-0.06	0.79	988	-0.06
1998	1358	-0.08	-0.07	0.23	-1.29	-0.04	0.63	1025	-0.05
1999	1518	-0.07	-0.07	0.18	-1.22	-0.04	0.73	1121	-0.05
2000	1561	-0.09	-0.08	0.20	-1.24	-0.05	0.74	1148	-0.07
2001	1578	-0.04	-0.04	0.22	-1.41	-0.03	0.80	1158	-0.01
2002	1654	-0.04	0.01	0.25	-1.18	-0.03	0.81	1202	0.01
2003	1595	0.00	0.06	0.28	-1.20	-0.03	0.95	1166	0.06
2004	1568	0.03	0.08	0.30	-1.19	-0.01	0.94	1153	0.08
2005	1540	0.03	0.07	0.33	-1.24	-0.01	0.95	1130	0.08
Total	24408	-0.12	-0.13	0.30	-1.41	-0.09	0.99	18489	-0.12

Note: The TFP value of each firm is difference from 1999 industry average. The mean difference from previous year means growth rate of TFP. Manufacturing includes industries with ICPA code 6-25.

Now let us compare our results with those of existing literatures shown in Table 4.

First generation literature which measured the TFP of Korea include studies by Chen (1977) using three sector-level data, and Christensen and Cummings (1975, 1981) using whole country level data based on growth accounting approach.[19] Chen (1977) showed

[19] There were two earlier papers, Lee (1972) and Kim and Roemer (1979), which were not published in Journal but reported in KDI. However, they did

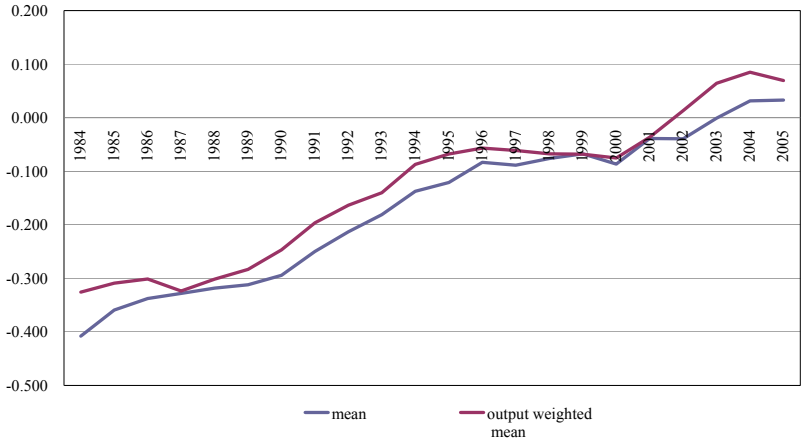


FIGURE 3
TOTAL MEAN AND OUTPUT WEIGHTED MEAN OF AVERAGE TFP LEVEL

that the average annual growth rate of TFP was 4.33% from 1955 to 1970. Christensen and Cummings (1981) showed that the average annual growth rate of TFP from 1960 to 1973 was 4.1%.[20] These rates were higher, relative to those achieved by the major developed countries (except Japan) during the same time period when compared with the results of Christensen, Cummings, and Jorgensen (1980). A high growth rate of TFP of Korea was contrary Nadiri's conclusion (1972), which was that "contribution of factor productivity is small in developing countries as compared to its critical importance in industrialized countries." The Korean experience in this period did not support Nadiri's view (1972), and that of Young (1994, 1995). Christensen and Cummings (1981) said that the acceleration of TFP during the period was consistent with the beneficial effect claimed for the 'liberalization' of prices in the early 1960s and rapid rise of capital use in manufacturing as was found by Kim and Kwon (1977).[21]

Kwon (1986) showed that the annual growth rate of TFP in Korean

not show referable result of TFP measurement.

[20] See Table 12 in Christensen and Cummings (1981).

[21] The aggregate utilization rate is shown to have increased at an annual rate of about 8%.

manufacturing from 1961 to 1980 was 2.95%, which is a considerably larger value than the rates for Japan and U.S. for the same period. Moreover, Kwon decomposed TFP into (a) technical change represented by the proportionate shift in the cost function, (b) increase in capital utilization, and (c) scale economies.

According to these results of early two decades of economic development in Korea, 1960s and 1970s, TFP was far from insignificant as a source of economic growth in Korea as was mentioned by Chen (1997). The World Bank (1993) also showed consistent results using the TFP estimates of 87 economies for the period of 1960-1989. The World Bank said the East Asian economies including South Korea showed outstandingly higher rates of TFP growth than industrial economies consistent with the possibility of large catching-up gains. In this book, annual growth rate of TFP in Korea for the period 1960-1989 was 3.1%. Dollar and Sokoloff (1990) measured TFP growth rate of 25 Korean industries and found that the annual growth rate of TFP in Korean manufacturing for the period 1963-1979 was 6.1%.

However, Young (1995) contradicted existing results and showed TFP growth rate relatively low or similar among developed counties, 1.7%, for the period 1966-1990. After Young's paper, Korean economy experienced the financial crisis in 1997. The period 1997-1998 proved finding paper in literature was difficult.[22] Pyo *et al.* (2006) and other papers shown in Table 4 reported TFP measurements consistent with Young (1995), reconfirming both Krugman's (1994) proposition and empirical findings by Young (1994) and Kim and Lau (1994).

Comparatively, while Young found the 1985-90 TFP growth in manufacturing as 0.8%, this paper found it as 3.1% per annum for the period of 1984-90. As to the level of national economy, Young's paper had higher estimates than this paper's for the same periods. This means that the estimates made by this paper's researchers for the agricultural and service sector growth should have been lower than those made by Young (1995).

Another difference is that the researchers' (3.0% in manufacturing) for the more recent periods, early 1980s to the mid 2000s, for instance, were somewhat larger than the results using industry level

[22] One exceptional paper was Chen's (1997), although it did not measure TFP in his paper and his proposition was based only on existing literature.

TABLE 4
ANNUAL TFP GROWTH RATES (%) IN THE EXISTING LITERATURE

	Period	Economy	Manu-facturing	Input	Level
Chen(1977)	1955-1970*	5.0	3.1	KL	3 industries
	1955-1960	2.0	n.a.		
	1960-1966	4.1	2.6		
	1966-1970	5.1	4.8		
Christensen and Cummings (1981)	1960-1973	4.1	n.a.	KL	economy
Kim and Park (1985)	1963-1982	2.7	n.a.	KL	economy
	1963-1972	4.0	n.a.		
	1972-1982	1.5	n.a.		
Kwon (1986)	1961-1980	n.a.	3.0	KLEM	economy
	1961-1972	n.a.	1.8		
	1972-1978	n.a.	4.8		
Pyo and Kwon (1991)	1960-1989	1.6	n.a.		
Pyo, Kong, Kwon, and Kim (1991)	1970-1990	1.3	1.1		
Moon, Jo, Whang, and Kim (1991)	1971-1989	n.a.	3.7		
Dollar and Sokoloff (1990)	1963-1979	n.a.	6.1	KL	economy
World Bank (1993)	1960-1989	3.1	n.a.	KL	economy
Young (1995)	1966-1990	1.7	3.0	KL	3 industries
	1960-1966	0.5	1.3		
	1966-1970	1.3	4.8		
	1970-1975	1.9	5.3		
	1975-1980	0.2	-0.7		
	1980-1985	2.4	5.1		
	1985-1990	2.6	0.8		
Pyo (2001)	1962-1999	1.2	n.a.	KL	3 industies
	1962-1973	-0.3	n.a.		
	1974-1999	-0.4	n.a.		
KPC (2002)	1987-2001	n.a.	6.4	KL	194 firms
KPC (2005)	1983-2003	n.a.	1.2	KLM	22
	1983-1993	n.a.	1.2		industries
	1993-2003	n.a.	1.4		
KPC (2006)	1985-2003	0.06	0.06	KLM	16669
	1985-1997	0.06	0.04		firms
	1997-2003	0.07	0.08		

(Table 4 Continued)

	Period	Economy	Manu-facturing	Input	Level
Pyo, Rhee, and Ha (2006)	1984-2002	0.6	1.4	KLEM	33 industries
	1984-1997	0.2	1.2		
	1998-2002	1.5	1.7		
Oh *et al.* (2006)	1993-2002	n.a.	1.7	KLM	23 industries
Ahn (2006)	1990-2003	n.a.	3.5	KLM	34 industries
	1990-1997	n.a.	1.7		
	1997-2003	n.a.	4.9		
Kwack (2007)	1982-2004	n.a.	1.7	KLM	12 industries
	1982-1987	n.a.	1.2		
	1988-1996	n.a.	2.2		
	1997-1999	n.a.	0.1		
	2000-2004	n.a.	2.1		
This paper	1984-2005	2.2	3.0	KLM	1769 firms
	1984-1990	1.9	3.1		
	1990-1995	4.3	5.5		
	1995-2000	0.9	1.0		
	2000-2005	3.0	3.7		

Notes: 1) * For manufacturing, period covered is from 1960 to 1970.
2) 'n.a.' means not available.

estimation, such as 1.4% of Pyo, Rhee, and Ha (2006) and 1.7% of Kwack (2007). However, the results of Ahn's study (2006) were consistent with this paper's results, 3.5%, for the period of 1990-2003.[23]

The researcher's estimates were also higher than the other estimates using firm level data, such as Korea Productivity Center (KPC 2006), which provided that the annual TFP growth among Korean firms from 1985-2003 was 0.06%.

The researchers' higher TFP growth rate estimates, compared to the results from sectoral or macro level data, seemed to have to do with the sampling, which used only listed firms which had usually larger size than the business unit used in macro level data or plant level data from the *Report on Mining and Manufacturing Survey of*

[23] The cause of higher growth rate of Ahn (2006) could be explained by the fact that it used "weighted" average when calculating growth rate of all the manufacturing industries.

KNSO (Korea National Statistical Office). In the case of estimation using sectoral level data, measuring capital stock in each industry was very difficult because of the scarcity of reliable data. On the contrary, in the case of firm level data whose original data sources were financial statements and business reports made by firms, categorized capital stocks were directly usable from these official sources. In this sense, the researchers claimed their estimates to be reliable.

As to the estimates using firm level data, KPC (2002) was thought to be somehow biased because in that it evaluated only 194 firms which survived through whole sample period. On the contrary, the researchers use the data of firms that had closed down and those that were new in the business. While the Korea Productivity Center used more extensive data set, the data themselves had a crucial defect — the PPI (Producer Price Index) was used both as an output deflator and as a material deflator. Moreover, the data did not consider the effect of taxes on capital cost and the impact of labor hour effect on labor input. Using the same deflators in output and material, the researchers believed, makes considerable lower growth rates bias in the said data. On the contrary, the estimates by the researchers used PPI only for output and material deflators from Pyo *et al.* (2006) for material input; moreover, it considered labor hour at detail industry level and tax effect on capital cost explicitly.

B. TFP Growth by Firm Size and the Recent "Polarization"

Figure 3 shows that output weighted mean was larger than simple mean. This means that the TFP of large firms grew faster than that of smaller firms. The same figure also shows that after the Asian crisis in 1997 and 1998, the gap between smaller firms and larger firms became bigger. This phenomenon has been so named as "polarization." To illustrate polarization more clearly, the researchers divided the sample into two groups by firm size and then compared the average TFPs of both groups. By "larger firm," the researchers meant a firm whose sales were larger than or the same as the industry median sales in that year. As shown in Table 5 and Figure 4, one can see that after year 2001, the gap between larger firms and smaller firms got bigger and that the gap of average TFP level was over 10%, increasing about two times, compared to the previous periods.

TABLE 5

TFP LEVEL BY FIRM SIZE

Year	Larger firms than median size				Smaller firms than median size				Mean gap
	N	Mean	Min.	Max.	N	Mean	Min.	Max.	
1984	282	-0.39	-1.25	0.81	269	-0.43	-1.27	0.81	0.04
1985	306	-0.34	-1.16	0.76	300	-0.38	-1.24	0.91	0.04
1986	328	-0.33	-1.04	0.70	322	-0.35	-1.12	0.89	0.02
1987	359	-0.31	-1.08	0.89	351	-0.35	-1.20	0.85	0.04
1988	381	-0.30	-1.01	0.99	378	-0.34	-1.21	0.64	0.04
1989	401	-0.29	-1.03	0.94	389	-0.34	-1.23	0.72	0.05
1990	413	-0.27	-1.20	0.96	410	-0.32	-1.22	0.61	0.05
1991	435	-0.23	-1.40	0.92	431	-0.27	-1.25	0.62	0.04
1992	444	-0.20	-1.07	0.93	433	-0.23	-1.40	0.82	0.02
1993	455	-0.16	-0.86	0.90	444	-0.20	-1.01	0.59	0.04
1994	486	-0.12	-0.85	0.92	479	-0.16	-1.18	0.56	0.04
1995	550	-0.09	-0.81	0.87	537	-0.15	-1.27	0.55	0.06
1996	575	-0.06	-1.10	0.92	578	-0.10	-1.17	0.50	0.04
1997	648	-0.07	-1.24	0.65	652	-0.10	-1.25	0.79	0.03
1998	679	-0.07	-1.14	0.48	679	-0.08	-1.29	0.63	0.01
1999	761	-0.06	-0.92	0.73	757	-0.08	-1.22	0.60	0.02
2000	781	-0.07	-1.10	0.74	780	-0.10	-1.24	0.61	0.03
2001	791	-0.01	-1.41	0.80	787	-0.06	-1.28	0.68	0.05
2002	826	0.01	-1.16	0.81	828	-0.09	-1.18	0.75	**0.10**
2003	802	0.06	-0.90	0.95	793	-0.07	-1.20	0.78	**0.13**
2004	789	0.09	-0.69	0.94	779	-0.03	-1.19	0.91	**0.12**
2005	770	0.09	-0.76	0.84	770	-0.03	-1.24	0.95	**0.12**
Total	12262	-0.10	-1.41	0.99	12146	-0.15	-1.40	0.95	0.06

Note: The TFP value of each firm is the difference from 1999 industry average.

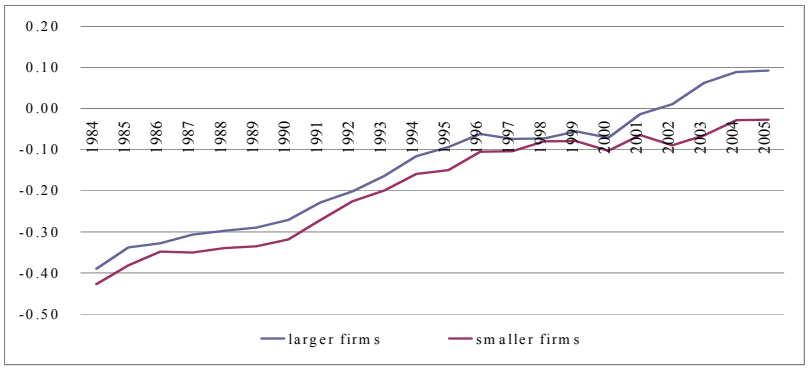


FIGURE 4

AVERAGE TFP LEVEL BY FIRM SIZE

Moreover, the table shows that there existed a consistent size premium of TFP through all the sample period.

C. TFP Level by Industry

Table 6 shows the ranking of the annual TFP growth rates by industry. The table shows high TFP growth in electrical industry (7.7% annual growth), communications (5.2%), and motor industries (3.6%). Specifically, electrical industry showed remarkable performance.

IV. Methodology Used to Compare the TFP of Korean and Japanese Firms

A. Measuring the Internationally Comparable TFP

Using the results of the preceding section, the researchers made international comparison analysis between Korean firms and Japanese firms. The methods and data used in this part were based on the results of the study by Fukao *et al.* (2007a) and Fukao *et al.* (2007b). This TFP database of all the Japanese listed firms is available at the JCER homepage.[24]

Fukao *et al.* (2007a) and Fukao *et al.* (2007b) are based on the international comparison method introduced by Schreyer (2005), an extended version of Good *et al.* (1999)'s chain-linked time index number method and PPP adjusted price index of Motohashi (2006).

B. Data

This part of the methodology excluded non-manufacturing sectors such as agricultural, service or construction industries. This was done since there were numerous small-sized family-owned business units in service or agricultural industries, hence making getting reliable results of comparison difficult when they were to be compared with the listed firms' data. The researchers also believed that a somewhat different and more specified methodology for service or construction industry was necessary for the TFP measurement to be reliable. In addition, firms in trade industry do not make the goods and so there are no material cost defined as cost to make goods. In

[24] http://www.jcer.or.jp/eng/research/database070528.html

TABLE 6

ANNUAL TFP GROWTH RATES BY INDUSTRY

ICPA Code	All industries	Annual growth (1984-2005)
20	Electrical machinery	7.7%
27	Communications	5.2%
29	Gas utilities	4.4%
21	Motor vehicles	3.6%
8	Apparels	3.5%
12	Printing, publishing and allied	3.3%
26	Transportation	3.1%
25	Misc. manufacturing	2.8%
16	Stone, clay, glass	2.3%
7	Textile mill products	2.3%
10	Furniture and fixtures	2.2%
avg	average	2.2%
23	Instruments	2.2%
22	Transportation equipment & ordnance	2.1%
30	Trade	2.0%
6	Food and kindred products	2.0%
2	Coal Mining	1.8%
24	Rubber and misc. plastics	1.8%
13	Chemicals	1.6%
19	Machinery, non electric	1.6%
18	Fabricated metal	1.3%
9	Lumber and wood	1.2%
11	Paper and allied	1.0%
14	Petroleum and coal products	0.2%
17	Primary metal	0.2%
28	Electric utilities	-0.1%
15	Leather	-0.4%
32	Other Private service	-1.7%
5	Construction	-3.2%
1	Agriculture	-3.6%

ICPA Code	Majnufacturing industries	Annual growth (1984-2005)
20	Electrical machinery	7.7%
21	Motor vehicles	3.6%
8	Apparels	3.5%
12	Printing, publishing, and allied	3.3%
avg	average	3.0%
25	Misc. manufacturing	2.8%
16	Stone, clay, glass	2.3%
7	Textile mill products	2.3%
10	Furniture and fixtures	2.2%
23	Instruments	2.2%
22	Transportation equipment & ordnance	2.1%
6	Food and kindred products	2.0%
24	Rubber and misc. plastics	1.8%
13	Chemicals	1.6%
19	Machinery, non electric	1.6%
18	Fabricated metal	1.3%
9	Lumber and wood	1.2%
11	Paper and allied	1.0%
14	Petroleum and coal products	0.2%
17	Primary metal	0.2%
15	Leather	-0.4%

Note: Annual growth rate is average annual difference between the TFP level of 1984 and 2005.

measuring the TFP of the firms in financial industry, the researchers concluded that defining output and input was difficult. Because of these problems, firms in industry 1-5 (agriculture, mining, and construction), 25-33 (service) in ICPA code were excluded in this part.

The firm observations in comparison included all the listed firms and delisted firms during the sample periods. This firm sample also included also the firm observations found in the periods before the firm was listed.[25] The sources of Korean data were almost the same as those used in the preceding section. Data of Japanese firms were taken from the study of Fukao *et al.* (2007a).

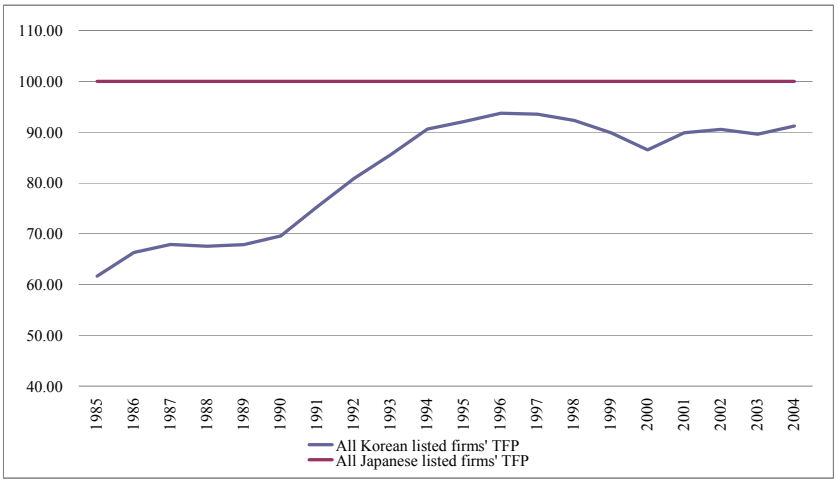
C. Defining Catch-up Index

In this part, the researchers conceptualized the TFP gap as the TFP catch-up index. The TFP catch-up index of each firm f of Korea in year t has two components. The first was the distance of each (Korean) firm distance from the industry average in Korea; the second was the distance between the industry average levels of TFP in each of the two countries. In the context of this research, therefore, catch-up index is defined as the TFP distance of each firm from the industry average TFP in Korea plus the industry TFP gap between Korea and Japan. The equation below shows the TFP catch-up index of each Korean firm with the average Japanese firm in the same industry.

$$\begin{aligned} Catchupindex_{f,t,K} = \{ & (\ln Q_{f,t,K} - \overline{\ln Q_{t,K}}) \\ & - \sum_{i=1}^{n} \frac{1}{2} (S_{i,f,t,K} + \overline{S_{i,t,K}})(\ln X_{i,f,t,K} - \overline{\ln X_{i,t,K}}) \\ & + INDTFPGAP_{t,Korea/Japan} \} \times 100 + 100 \end{aligned} \tag{3}$$

The first two items of equation measure the TFP distance from the industry average TFP of Korean firms. The last part of the equation, that is $INDTFPGAP_{KOREA/JAPAN}$, measures the industry TFP gap between Korea and Japan.

[25] However, this firm sample does not include the firm observations found in the periods after the firm was delisted.



Note: The TFP level of all Japanese listed firms in each year was set at 100. The difference can be regarded as percentage gap of TFP between the two countries because the values are natural log value of TFP.

FIGURE 5
TFP CATCH-UP INDEX OF ALL MANUFACTURING LISTED FIRMS
(SIMPLE AVERAGE)

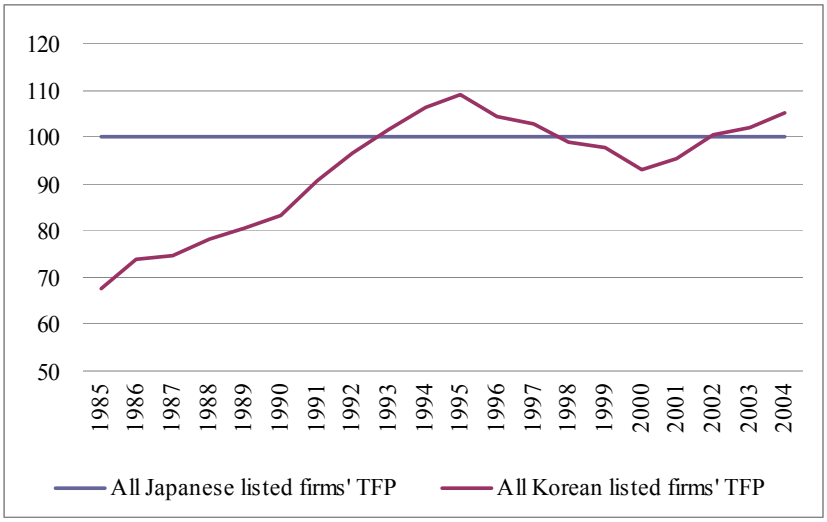
V. Results of the TFP Catch-up and the Four Patterns of Catch-up

A. Overall Results and Polarization by Firm Size

The TFP catch-up index of all listed manufacturing firms is shown in Figure 5. The averages of these catch-up indexes by industry and year are shown in the Table 7. The values in the table are the average of the Korean firms' differences from Japanese industry average TFP. This difference can be regarded as percentage difference of TFP between the two countries because the values are natural log value of TFP.

Figure 5 shows that Korean manufacturing firms caught up rapidly until early 1990s and through the crisis the gap slightly increased while after year 2000 the gap had been sustained.

Figure 6 shows the average of catch-up index weighted by size of firm. Through weighted average, it can be verified that the TFP of



Note: The TFP level of all Japanese listed firms in each year was set at 100. The difference can be regarded as percentage gap of TFP between the two countries because the values are natural log value of TFP.

FIGURE 6
TFP CATCH-UP INDEX OF ALL MANUFACTURING LISTED FIRMS
(FIRM SIZE-WEIGHTED AVERAGE)

listed Korean firms already surpassed that of the Japanese listed firms. Through this result, it can be inferred that Korean large firm's TFP had already caught up Japanese industry average before the crisis. Table 7 verifies this polarization of TFP catch-up by firm size directly.

The average TFP catch-up index of the top 5% firms (58 firms in 2004) was 101.4 while that of the top 10% firms (115 firms in 2004) was 99.2. However, the average TFP catch-up index of the lower 50% was only 85.4 in 2004. This means that TFP catch-up with Japanese industry level of Korean firms was made mainly by larger firms, especially top firms. These results are well consistent with the "polarization" results discussed in the third section of this paper.

B. Four Patterns of Catch-up

Based on the results shown in Table 8, one can identify the

TABLE 7
TFP CATCH-UP INDEX BY FIRM SIZE

Year	Total			Top 50%		Bottom 50%		Top 25%		Top 10%		Top 5%	
	N	Mean	Weighted Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
1985	511	61.6	67.7	257	68.1	254	55.1	128	68.7	52	66.1	26	67.5
1986	567	66.3	73.8	285	71.2	282	61.4	142	73.4	57	72.5	29	71.8
1987	612	67.9	74.8	306	73.3	306	62.5	153	74.3	62	73.6	31	72.4
1988	660	67.6	78.3	331	73.3	329	61.8	166	77.0	66	75.2	33	75.2
1989	696	67.9	80.7	349	74.6	347	61.1	174	77.5	71	76.2	36	77.7
1990	725	69.5	83.3	367	76.6	358	62.3	182	78.5	73	77.4	38	80.4
1991	747	75.3	90.7	376	81.9	371	68.7	188	81.8	76	82.5	39	85.2
1992	781	80.8	96.6	391	86.5	390	75.1	197	86.6	81	86.8	40	90.9
1993	799	85.6	101.7	401	90.7	398	80.4	200	91.0	81	91.2	40	95.0
1994	820	90.6	106.2	411	94.4	409	86.7	205	95.8	82	96.3	41	100.1
1995	867	92.1	108.9	435	95.3	432	88.9	219	96.2	88	97.3	44	101.0
1996	943	93.7	104.2	476	96.4	467	91.0	236	96.5	95	96.6	48	96.4
1997	994	93.5	102.6	497	95.5	497	91.6	251	96.6	100	98.3	51	97.2
1998	1052	92.3	99.0	529	93.9	523	90.6	263	91.9	106	92.3	53	95.4
1999	1084	89.9	97.6	542	92.6	542	87.2	271	93.4	109	94.7	55	93.6
2000	1125	86.5	93.0	572	89.1	553	83.8	281	90.3	113	92.2	57	93.7
2001	1171	89.9	95.3	588	93.2	583	86.6	293	94.4	119	95.9	60	96.8
2002	1188	90.5	100.4	595	95.4	593	85.6	300	96.8	122	99.3	61	99.9
2003	1182	89.6	102.0	594	95.1	588	84.1	296	96.1	118	99.5	59	100.7
2004	1154	91.2	105.1	578	97.0	576	85.4	289	98.4	115	99.2	58	101.4

Note: N means number of firms. Mean and weighted mean are averages of TFP catch-up indices adjusted assuming TFP level of all Japanese listed firms in each year was 100.

following four patterns of catch-up, which are "Over catch-up," "Just catch-up," "Under catch-up," and "Reverse catch-up." Nineteen industries were classified into the four above-mentioned patterns as shown in Table 9. Tables 10 and 11 show firm numbers, sales shares, and largest firms in each pattern and industry.

Pattern 1: The "Over Catch-up"

The first pattern of catch-up defined in this paper is "Over catch-up." "Over Catch-up" means that the TFP of the Korean firms in that industry was over than that of Japanese firms. The TFP gap between the two countries in 2004 was over 10% with the Koreans firms getting the upper hand in this pattern, which included the following sectors: food and kindred products, lumber and wood, furniture and fixtures, and stone clay glass industries. Specifically,

TABLE 8

AVERAGE OF TFP CATCH-UP INDEX BY INDUSTRY

ICPA Code	Industry Name	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
6	Food and kindred products	81.7	86.3	99.2	104.4	106.4	110.3	113.6	112.5	114.0	118.2	116.7	116.1	114.9	106.5	110.5	111.2	108.2	110.6	106.0	110.9
7	Textile mill products	48.8	52.6	52.9	49.4	50.6	57.1	61.8	72.2	79.2	82.7	81.3	83.5	83.4	77.9	84.7	87.8	92.2	96.1	88.0	82.4
8	Apparel	7.7	12.7	19.5	18.0	15.1	19.4	25.5	32.3	40.5	49.1	53.2	56.4	54.1	52.4	56.1	57.5	62.6	56.5	52.1	59.6
9	Lumber and wood	124.5	127.8	130.5	129.6	138.0	141.1	146.3	143.7	114.9	122.1	131.8	126.2	130.3	113.6	135.6	137.9	141.1	148.4	148.3	150.9
10	Furniture and fixtures	87.0	90.3	92.7	93.2	92.5	99.6	105.0	111.6	108.3	110.0	119.2	122.3	122.6	123.8	128.9	125.0	125.1	128.8	128.5	129.1
11	Paper and allied	72.5	71.1	67.8	68.4	71.6	75.6	84.4	89.5	98.3	102.0	92.2	91.4	95.9	82.1	82.4	74.0	78.7	83.9	78.9	86.6
12	Printing publishing and allied	81.6	86.1	85.7	72.1	82.7	98.4	97.1	101.0	104.1	105.1	106.4	96.3	85.4	94.8	113.0	111.1	106.6	88.3	85.6	88.3
13	Chemicals	72.7	75.5	77.9	77.8	78.3	78.7	81.1	86.2	90.6	93.7	91.0	95.2	98.0	89.9	91.6	90.0	92.7	91.6	86.4	80.9
14	Petroleum and coal products	73.7	117.1	121.3	155.3	169.0	163.7	174.2	177.7	185.2	195.0	195.3	171.5	153.8	142.6	142.4	114.0	106.0	107.7	102.9	102.7
15	Leather	108.5	107.6	108.6	105.7	101.3	104.3	106.7	113.9	118.9	125.2	128.0	134.0	131.2	126.6	117.8	121.1	113.7	105.9	103.4	104.2
16	Stone clay glass	80.0	89.7	91.2	98.4	97.6	92.2	90.9	94.1	100.0	107.6	108.9	111.1	109.7	103.8	111.5	108.6	107.0	108.8	107.7	112.6
17	Primary metal	67.2	70.8	69.4	66.8	67.9	70.0	76.2	80.8	87.8	90.2	89.2	88.9	85.3	81.8	83.6	78.8	82.2	83.2	76.9	61.3
18	Fabricated metal	90.7	95.1	95.8	98.0	99.1	100.0	109.3	115.3	121.3	125.9	128.5	129.3	127.1	125.3	114.2	110.0	111.6	110.3	107.5	96.3
19	Machinery non-elect	91.8	96.2	95.2	90.6	89.1	92.5	97.0	103.7	109.1	114.3	122.0	122.1	117.8	117.6	112.0	110.2	104.9	100.2	102.3	108.5
20	Electrical machinery	24.0	34.5	34.8	32.1	33.0	30.8	43.0	53.8	59.5	67.8	75.0	77.3	78.6	83.8	77.2	73.1	84.0	88.2	90.9	96.6
21	Motor Vehicles	38.6	40.3	42.8	43.0	43.9	54.5	60.2	62.7	66.5	71.1	75.1	81.7	81.9	91.0	85.2	78.8	80.1	78.0	78.5	88.0
22	Transportation equipment and ordnance	74.8	79.2	75.4	72.0	76.2	84.0	92.2	98.1	99.1	100.0	103.8	105.9	114.5	126.5	109.0	92.5	96.3	96.4	100.7	97.0
23	Instruments	33.9	41.1	48.2	41.2	38.1	40.7	50.8	62.1	64.9	68.2	73.1	72.5	73.0	74.2	65.0	60.2	51.5	54.7	56.4	61.0
24	Rubber and misc plastics	55.6	57.7	59.8	55.2	57.8	61.6	68.2	72.7	77.6	82.4	80.5	83.0	88.0	86.4	84.1	81.7	83.4	82.3	78.8	76.0
	Total	61.6	66.3	67.9	67.6	67.9	69.5	75.3	80.8	85.6	90.6	92.1	93.7	93.5	92.3	89.9	86.5	89.9	90.5	89.6	91.2

Note : The values in the table are the average of the TFP gap of Korean firms from the TFP of Japanese firms. The values can be regarded as percentage gap of TFP between the two countries because the values are natural log value of TFP.

TABLE 9

4 PATTERNS OF CATCH-UP

ICPA Code	Industry Name	1985	1990	1995	2000	2004	Catch-up Pattern
6	Food and kindred products	81.7	110.3	116.7	111.2	110.9	Over Catch-up
9	Lumber and wood	124.5	141.1	131.8	137.9	150.9	Over Catch-up
10	Furniture and fixtures	87.0	99.6	119.2	125.0	129.1	Over Catch-up
16	Stone clay glass	80.0	92.2	108.9	108.6	112.6	Over Catch-up
14	Petroleum and coal products	73.7	163.7	195.3	114.0	102.7	Just Catch-up
15	Leather	108.5	104.3	128.0	121.1	104.2	Just Catch-up
18	Fabricated metal	90.7	100.0	128.5	110.0	96.3	Just Catch-up
19	Machinery non-elect	91.8	92.5	122.0	110.2	108.5	Just Catch-up
20	Electrical machinery	24.0	30.8	75.0	73.1	96.6	Just Catch-up
22	Transportation equipment and ordnance	74.8	84.0	103.8	92.5	97.0	Just Catch-up
7	Textile mill products	48.8	57.1	81.3	87.8	82.4	Under Catch-up
8	Apparel	7.7	19.4	53.2	57.5	59.6	Under Catch-up
11	Paper and allied	72.5	75.6	92.2	74.0	86.6	Under Catch-up
21	Motor Vehicles	38.6	54.5	75.1	78.8	88.0	Under Catch-up
23	Instruments	33.9	40.7	73.1	60.2	61.0	Under Catch-up
12	Printing publishing and allied	81.6	98.4	106.4	111.1	88.3	Reverse Catch-up
13	Chemicals	72.7	78.7	91.0	90.0	80.9	Reverse Catch-up
17	Primary metal	67.2	70.0	89.2	78.8	61.3	Reverse Catch-up
24	Rubber and misc plastics	55.6	61.6	80.5	81.7	76.0	Reverse Catch-up
	Total	61.6	69.5	92.1	86.5	91.2	

Note: The values in the table are the average of the TFP gap of Korean firms from the TFP of Japanese industry. The values also refer to the percentage differences of TFP because they are natural log difference.

the TFPs of lumber and wood industry and furniture and fixtures industry were outstanding. However, most industries in this sector were low-tech. Moreover, the share of this pattern measured by firm number and sales is 10.1% and 8.7% and relatively small.

Pattern 2: The "Just Catch-up"

The second pattern is called "Just catch-up," which means that the TFPs of Korean firms in that industry converged on those of Japanese firms. The TFP gap between the two countries in 2004 in this pattern was under 10%. Grouped in this pattern are those industries involved in petroleum and coal products, leather, fabricated metal, machinery non-elect, and electrical machinery, and transportation equipment and ordnance (ship industry). The last three industries — machinery non-elect, and electrical machinery, and transportation equipment and ordnance (ship industry) were the major industries in Korea that year. Furthermore, these sectors were high-tech industries. These results show that Korean firms' TFP had caught up with that of Japanese firms considerably in considerable sectors based on more advanced resources (or capabilities) like technology ability, brand ability, among others.

Pattern 3: The "Under Catch-up"

The third pattern of catch-up is "Under catch-up," which means that the TFPs of the Korean firms in that industry had made some catching-up but failed to converge on those of Japanese firms substantially given the more than 10% gap between the two countries. textile mill products, apparel, paper and allied, motor vehicles, and instruments industries were classified into "Under catch-up" industries.

Pattern 4: The "Reverse Catch-up"

The last of the four patterns is called "Reverse catch-up," which refers to the idea that the TFPs of the Korean firms did some catching-up during the early period but had experienced the gap getting big recently, especially after 2000. Industries that were classified under this pattern included printing publishing and allied, chemicals, primary metal, and rubber and misc plastics.

TABLE 10

FIRM NUMBER, SALES, AND LARGEST FIRM IN EACH CATCH-UP PATTERN (KOREA)

ICPA Code	Catch-up Pattern	Industry Name	Number of Firms in Each Ind, 2004		Ind Sum of Sales in 2004		Largest Sales Firm in Each Industry	Sales of Top Firm	
			Number	Ind sum /Total	Bil. Won 2004 price	Ind sum /Total		Bil. Won 2004 price	Each Firm /Ind sum
6	Over Catch-up	Food and kindred products	62	5.4%	24,365	**6.1%**	**CJ CORP.**	**2,544**	**10.4%**
9	Over Catch-up	Lumber and wood	5	0.4%	806	0.2%	HANSOL HOME DECO	226	28.0%
10	Over Catch-up	Furniture and fixtures	14	1.2%	1,682	0.4%	DAEWON SANUP	370	22.0%
16	Over Catch-up	Stone clay glass	36	3.1%	8,129	2.0%	KCC CORPORATION	1,863	22.9%
	Sum		**117**	**10.1%**	**34,983**	**8.7%**		**5,003**	**14.3%**
14	Just Catch-up	Petroleum and coal products	5	0.4%	28,504	7.1%	SK CORPORATION	17,406	61.1%
15	Just Catch-up	Leather	11	1.0%	901	0.2%	SAMYANG TONGSANG	212	23.6%
18	Just Catch-up	Fabricated metal	42	3.6%	4,946	1.2%	DOOSAN HEAVY INDUSTRY & CONSTRUCTION	2,456	49.7%
19	Just Catch-up	Machinery non-elect	118	10.2%	10,042	2.5%	DOOSAN INFRACORE	2,861	28.5%
20	Just Catch-up	Electrical machinery	360	31.2%	116,384	**29.0%**	**SAMSUNG ELECTRONICS**	**57,632**	**49.5%**
22	Just Catch-up	Transportation equipment and ordnance	10	0.9%	23,207	5.8%	HYUNDAI HEAVY INDUSTRIES	9,084	39.1%
	Sum		**546**	**47.3%**	**183,983**	**45.8%**		**89,651**	**48.7%**
7	Under Catch-up	Textile mill products	29	2.5%	2,411	0.6%	ILSHIN SPINNING	301	12.5%
8	Under Catch-up	Apparel	36	3.1%	4,310	1.1%	SHINWON CORPORATION	367	8.5%
11	Under Catch-up	Paper and allied	33	2.9%	5,391	1.3%	HANSOL PAPER	1,176	21.8%
21	Under Catch-up	Motor Vehicles	69	6.0%	62,120	**15.5%**	**HYUNDAI MOTOR COMPANY**	**27,472**	**44.2%**
23	Under Catch-up	Instruments	34	2.9%	2,820	0.7%	SAMSUNG TECHWIN	1,981	70.2%
	Sum		**201**	**17.4%**	**77,052**	**19.2%**		**31,298**	**40.6%**
12	Reverse Catch-up	Printing publishing and allied	16	1.4%	465	0.1%	JEONG MOON INFORMATION	64	13.8%
13	Reverse Catch-up	Chemicals	166	14.4%	51,836	12.9%	LG CHEM	7,127	13.7%
17	Reverse Catch-up	Primary metal	74	6.4%	47,685	**11.9%**	**POSCO**	**19,792**	**41.5%**
24	Reverse Catch-up	Rubber and misc plastics	34	2.9%	5,737	1.4%	HANKOOK TIRE	1,856	32.3%
	Sum		**290**	**25.1%**	**105,724**	**26.3%**		**28,840**	**27.3%**
Total			1154	**100.0%**	**401,742**	**100.0%**		**154,791**	**38.5%**

TABLE 11

FIRM NUMBER, SALES, AND LARGEST FIRM IN EACH CATCH- UP PATTERN (JAPAN)

ICPA Code	Catch-up pattern (Korean Firm's)	Industry Name	Number of Firms in Each Ind, 2004		Ind Sum of Sales in 2004		Largest Sales Firm in Each Industry	Sales of Top Firm	
			Number	Ind sum /Total	Bil. Yen 1999 price	Ind sum /Total		Bil. Yen 1999 price	Each Firm /Ind sum
6	Over Catch-up	Food and kindred products	156	**9.8%**	17,832	**9.1%**	ASAHI BREWERIES	**1,120**	**6.3%**
9	Over Catch-up	Lumber and wood	9	0.6%	402	0.2%	DAIKEN TRADE & INDUSTRY	172	42.8%
10	Over Catch-up	Furniture and fixtures	12	0.8%	604	0.3%	OKAMURA	181	30.0%
16	Over Catch-up	Stone clay glass	77	4.9%	4,376	2.2%	ASAHI GLASS	580	13.3%
	Sum		**254**	**16.0%**	**23,214**	**11.8%**		2,053	**8.8%**
14	Just Catch-up	Petroleum and coal products	9	0.6%	4,584	2.3%	TONEN GENERAL SEKIYU K.K.	2,370	51.7%
15	Just Catch-up	Leather	3	0.2%	69	0.0%	REGAL	36	51.8%
18	Just Catch-up	Fabricated metal	93	5.9%	2,868	1.5%	TOYO SEIKAN KAISHA	362	12.6%
19	Just Catch-up	Machinery non-elect	232	14.6%	20,658	10.5%	CANON	2,280	11.0%
20	Just Catch-up	Electrical machinery	281	**17.7%**	58,349	**29.8%**	MATSUSHITA ELECTRIC	**4,080**	**7.0%**
22	Just Catch-up	Transportation equipment and ordnance	26	1.6%	1,181	0.6%	HITACHI ZOSEN	201	17.0%
	Sum		**644**	**40.6%**	**87,708**	**44.7%**		**9,329**	**10.6%**
7	Under Catch-up	Textile mill products	43	2.7%	2,550	1.3%	TORAY INDUSTRIES	459	18.0%
8	Under Catch-up	Apparel	28	1.8%	602	0.3%	WACOAL	128	21.3%
11	Under Catch-up	Paper and allied	30	1.9%	2,274	1.2%	OJI PAPER	616	27.1%
21	Under Catch-up	Motor Vehicles	111	**7.0%**	40,720	**20.8%**	TOYOTA MOTOR	**8,960**	**22.0%**
23	Under Catch-up	Instruments	56	3.5%	3,033	1.5%	OLYMPUS	425	14.0%
	Sum		**268**	**16.9%**	**49,179**	**25.1%**		**10,588**	**21.5%**
12	Reverse Catch-up	Printing publishing and allied	41	2.6%	3,360	1.7%	DAI NIPPON PRINTING	1,120	33.3%
13	Reverse Catch-up	Chemicals	218	13.7%	17,315	8.8%	FUJI PHOTO FILM	771	4.5%
17	Reverse Catch-up	Primary metal	93	**5.9%**	10,793	**5.5%**	NIPPON STEEL	**1,860**	**17.2%**
24	Reverse Catch-up	Rubber and misc plastics	68	4.3%	4,526	2.3%	BRIDGESTONE	789	17.4%
	Sum		**420**	**26.5%**	**35,994**	**18.4%**		**4,540**	**12.6%**
Total			**1,586**	**100.0%**	**196,095**	**100.0%**		**26,510**	**13.5%**

Note: The largest firm in Food and Kindred industry is Japan Tobacco, but this study chose Asahi, the second largest firm, for the comparison with CJ.

VI. Summary and Concluding Remarks

This paper measured the Total Factor Productivity (TFP) of all the listed firms in Korea from 1984 to 2005 and then compared the TFP of Korean firms with those of Japanese firms. The study used the chain-linked index number method developed by Good *et al.* (1999).

On one note, the researchers concluded that the average TFP of the listed firms in Korea grew about 44.1% between 1984 and 2005, with an annual growth rate of 2.1%. Furthermore, they figured that after the Asian crisis in 1997 and 1998, the TFP gap between large and small firm became two times wider, which shows what has been known as the polarization.

Delving more into the details of the study, the researchers found that this productivity growth varied depending on the type of industry. In fact, electrical industry, motor industry, apparel, and textile industry, and trade industry showed steady growth, with the electrical industry performing very remarkably.

This paper defined catch-up index of Korean firms with Japanese firms at individual firm level for the first time among existing literatures. Through this comparison analysis four patterns of catch-up of the Korean with the Japanese firms were arrived at — the "Over catch-up," "Just catch-up," "Under catch-up," and "Reverse catch-up." The researchers also found that the share of the firm number or the sales share of "Under Catch-up" and "Reverse Catch-up" industries were more than 40%. So to speak, 42.5% of all the listed firms and 45.5% of total sales of all the Korean listed firms could not catch up with the Japanese firms considered in this study. On the contrary, only 10.1% of all the listed Korean firms and 8.7% of total sales of all the listed firms' sales surpassed the Japanese firms in TFP in year 2004. However, the catch-up performance was quite better in larger firms, which is indicative of the phenomenon called polarization.

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Appendix

APPENDIX TABLE 1

AVERAGE FIRM ln (REAL OUTPUT) BY INDUSTRY AND YEAR

	Year																						
33 Code	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
1	18.6	18.7	19.0	19.1	19.2	19.1	18.6	19.1	18.5	18.6	18.6	18.7	18.6	18.7	18.8	18.7	18.6	18.4	18.3	18.3	18.3	18.3	18.6
2	18.2	18.3	18.3	18.4	18.4	18.4	18.4	18.2	18.1	18.1	17.7	17.5	17.4	17.5	17.5	17.4	17.6	17.6	17.4	17.4	17.5	17.2	17.8
3														19.2	18.8	19.1	19.0	19.5	19.5				19.2
5	18.9	18.9	18.7	18.6	18.6	18.6	18.7	18.9	19.0	19.0	19.0	19.1	19.1	19.2	19.1	19.2	19.0	19.1	19.0	19.1	19.2	19.2	19.0
6	18.0	18.0	18.2	18.2	18.4	18.4	18.5	18.6	18.6	18.5	18.7	18.7	18.7	18.8	18.7	18.7	18.6	18.7	18.6	18.7	18.7	18.7	18.6
7	17.6	17.8	17.5	17.7	17.6	17.6	17.7	17.8	17.9	17.9	17.9	18.0	18.0	18.1	17.7	17.9	17.9	17.8	17.7	17.6	17.6	17.4	17.8
8	17.0	17.0	17.3	17.5	17.4	17.2	17.5	17.5	17.7	17.8	17.7	17.9	18.0	17.8	17.6	17.7	17.8	17.9	18.1	18.2	18.1	18.2	17.7
9	18.3	18.3	18.5	18.7	18.9	18.2	18.5	18.6	18.7	18.5	18.6	18.6	18.5	18.6	18.2	18.5	18.5	18.6	18.8	18.8	18.8	18.8	18.6
10	17.0	17.0	17.2	17.3	17.7	17.8	17.9	18.1	18.1	18.2	18.4	18.5	18.6	18.6	18.3	18.3	18.2	18.8	19.1	19.1	19.1	19.1	18.2
11	17.4	17.3	17.4	17.5	17.6	17.7	17.9	17.8	17.9	17.9	18.1	18.2	18.1	18.2	18.0	18.2	18.2	18.2	18.2	18.2	18.2	18.3	18.0
12	15.4	15.3	16.0	16.5	16.7	17.0	17.4	17.3	17.3	17.3	17.5	17.5	17.5	16.7	16.5	16.8	17.0	17.1	17.0	17.0	16.9	16.9	16.9
13	17.1	17.2	17.4	17.4	17.4	17.5	17.6	17.7	17.8	17.9	17.8	17.8	17.9	17.9	17.8	17.8	17.9	18.0	18.1	18.0	18.0	18.1	17.8
14	19.2	19.4	18.9	19.1	19.4	19.5	19.6	19.9	19.9	20.0	20.1	20.2	20.2	20.1	19.9	19.9	20.3	20.0	20.0	20.0	20.1	20.0	19.8
15	18.1	18.1	18.2	18.0	18.0	17.8	17.9	17.9	18.1	18.0	18.1	18.1	18.3	18.2	18.0	17.8	17.9	17.8	17.9	17.9	17.8	17.6	18.0
16	17.6	17.5	17.6	17.7	17.9	17.9	18.0	18.0	18.0	18.2	18.3	18.5	18.6	18.7	18.3	18.4	18.5	18.4	18.5	18.3	18.4	18.3	18.2
17	17.6	17.7	17.7	17.7	17.8	17.8	17.9	18.0	18.0	18.1	18.2	18.3	18.4	18.4	18.2	18.4	18.5	18.4	18.5	18.5	18.5	18.4	18.2
18	17.1	16.6	16.8	16.7	16.8	16.9	17.0	17.0	17.0	17.2	17.3	17.5	17.6	17.6	17.2	17.2	17.4	17.5	17.5	17.6	17.6	17.7	17.3
19	16.4	16.6	16.6	16.8	16.9	17.0	17.0	17.1	17.1	17.2	17.1	16.8	16.8	16.7	16.2	16.5	16.9	16.9	17.1	17.3	17.5	17.6	16.9
20	16.2	16.1	16.4	16.6	16.7	16.7	16.7	16.7	16.8	16.9	17.0	16.8	16.8	16.8	16.7	17.0	17.3	17.6	17.9	18.0	18.2	18.3	17.3
21	16.8	16.9	16.8	17.1	17.1	17.3	17.5	17.4	17.6	17.7	17.9	17.9	18.1	18.1	17.8	18.0	18.3	18.3	18.3	18.4	18.6	18.8	17.9
22	18.3	18.7	18.7	18.8	18.7	18.8	19.0	19.0	19.1	19.1	19.3	19.5	19.7	19.8	19.7	19.7	19.9	20.2	20.3	20.3	20.3	20.5	19.5
23	16.7	16.8	17.1	17.3	17.2	16.7	16.5	16.7	16.7	16.7	17.0	16.5	16.6	16.5	16.3	16.5	16.7	16.8	16.7	16.8	16.9	17.1	16.7
24	17.4	17.4	17.6	17.7	17.7	17.7	17.5	17.5	17.8	17.9	18.0	17.7	17.7	17.5	17.4	17.6	17.7	17.8	17.8	17.8	17.9	17.9	17.7
25	16.2	16.4	16.6	16.9	17.1	17.2	17.3	17.4	17.5	17.2	17.3	17.4	17.7	17.2	17.0	17.3	17.5	17.5	17.8	17.9	17.8	17.8	17.4
26	18.2	18.2	18.2	18.2	18.4	18.4	18.5	18.6	18.6	18.6	18.7	18.8	18.7	19.0	19.0	19.0	19.3	19.4	19.3	19.4	19.7	19.5	18.8
27	16.3	16.0	16.1	18.4	18.2	18.7	19.1	19.3	18.8	19.1	19.4	19.6	19.8	18.5	18.5	18.4	19.1	19.0	19.6	19.7	19.5	19.7	19.0
28		22.0	22.1	22.2	22.4	22.5	22.7	22.8	22.9	23.0	23.1	23.2	23.4	23.4	23.4	23.5	23.5	23.5	23.6	23.7	23.7	23.8	23.1
29	17.6	17.7	17.8	17.6	17.4	17.6	17.8	18.1	18.2	18.7	18.9	19.1	19.3	19.5	19.6	19.8	20.1	20.1	20.1	20.1	20.2	20.4	19.1
30	18.1	18.1	18.4	18.3	18.4	18.3	18.3	18.3	18.4	18.4	18.3	18.2	18.2	18.0	18.0	18.2	18.1	18.2	18.3	18.2	18.0	17.9	18.2
32	17.5	17.7	17.5	17.6	17.7	17.7	17.5	17.4	17.5	17.4	17.3	16.6	16.3	16.3	15.9	16.1	16.5	16.7	16.8	16.8	16.8	16.8	16.7
Total	17.4	17.4	17.5	17.6	17.6	17.6	17.7	17.7	17.8	17.8	17.9	17.7	17.7	17.6	17.4	17.5	17.7	17.8	17.9	17.9	18.0	18.0	17.7

APPENDIX TABLE 2

AVERAGE FIRM ln (MATERIAL) BY INDUSTRY AND YEAR

	Year																						
33 Code	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
1	17.4	17.5	17.8	18.1	18.2	18.3	18.0	18.5	18.0	18.2	18.3	18.3	18.3	18.4	18.4	18.3	18.4	18.1	18.1	18.1	18.2	18.2	18.2
2	17.9	17.6	18.0	18.0	18.1	18.1	18.2	18.1	18.1	18.1	17.8	17.6	17.6	17.5	17.7	17.7	17.5	17.5	17.3	17.4	17.6	17.3	17.7
3														19.0	18.8	19.0	18.8	19.3	19.4				19.1
5	17.9	17.9	17.8	17.7	17.9	18.0	18.3	18.5	18.6	18.6	18.7	18.8	18.9	19.1	18.8	19.0	19.0	19.1	19.1	19.1	19.1	19.2	18.7
6	18.1	18.0	18.1	18.0	18.1	18.1	18.1	18.2	18.2	18.2	18.3	18.3	18.3	18.5	18.4	18.4	18.3	18.5	18.4	18.5	18.4	18.5	18.3
7	17.7	17.7	17.5	17.6	17.6	17.6	17.7	17.7	17.7	17.6	17.7	17.8	17.8	17.9	17.5	17.7	17.7	17.5	17.5	17.3	17.4	17.3	17.6
8	17.1	17.0	17.3	17.5	17.5	17.2	17.4	17.5	17.6	17.6	17.5	17.7	17.7	17.6	17.3	17.5	17.6	17.6	17.9	18.0	17.9	18.0	17.6
9	18.1	18.0	18.2	18.4	18.6	17.6	18.0	18.2	18.3	18.3	18.3	18.3	18.3	18.4	18.1	18.2	18.2	18.3	18.6	18.5	18.4	18.4	18.3
10	16.9	16.9	17.0	17.2	17.5	17.6	17.8	17.9	17.9	18.0	18.1	18.3	18.3	18.4	18.0	18.1	18.1	18.6	19.0	18.9	19.0	18.9	18.1
11	17.4	17.1	17.3	17.4	17.5	17.6	17.7	17.6	17.6	17.6	17.7	17.8	17.8	17.9	17.9	18.0	18.1	18.1	18.0	18.0	18.0	18.1	17.8
12	15.2	14.9	15.8	16.3	16.3	16.6	17.0	16.9	16.8	17.0	17.1	17.1	17.2	16.5	16.1	16.5	16.7	16.8	17.0	16.9	16.8	16.9	16.7
13	17.0	17.0	17.2	17.2	17.2	17.2	17.3	17.4	17.5	17.5	17.5	17.4	17.5	17.5	17.4	17.5	17.6	17.6	17.7	17.7	17.8	17.9	17.5
14	19.5	19.6	18.8	18.9	18.9	18.9	19.0	19.2	19.3	19.3	19.4	19.5	19.6	19.7	19.7	19.7	20.3	20.1	20.2	20.2	20.3	20.3	19.6
15	17.9	17.7	17.9	17.9	17.9	17.6	17.8	17.8	17.9	17.8	17.9	17.9	18.0	17.9	17.8	17.7	17.7	17.6	17.8	17.8	17.8	17.6	17.8
16	17.4	17.2	17.3	17.4	17.5	17.5	17.6	17.7	17.7	17.8	18.0	18.1	18.3	18.4	18.0	18.1	18.2	18.1	18.2	18.0	18.0	18.0	17.9
17	17.7	17.6	17.7	17.7	17.8	17.8	17.8	17.8	17.8	17.9	18.0	18.1	18.2	18.2	18.0	18.2	18.4	18.3	18.3	18.4	18.5	18.6	18.1
18	17.0	16.5	16.7	16.6	16.6	16.7	16.8	16.8	16.8	16.9	17.0	17.1	17.2	17.3	16.8	17.0	17.2	17.3	17.4	17.6	17.6	17.7	17.1
19	16.3	16.4	16.5	16.6	16.8	16.8	16.9	16.9	17.0	16.9	16.8	16.5	16.4	16.4	15.8	16.2	16.7	16.7	17.0	17.2	17.4	17.5	16.7
20	16.7	16.5	16.8	16.9	17.0	17.0	17.0	16.9	16.9	17.0	17.0	16.7	16.6	16.6	16.3	16.8	17.1	17.2	17.5	17.5	17.6	17.6	17.0
21	16.9	17.0	17.0	17.2	17.2	17.3	17.4	17.3	17.5	17.5	17.7	17.8	17.8	17.9	17.4	17.8	18.1	18.1	18.2	18.3	18.4	18.5	17.7
22	18.2	18.6	18.7	18.8	18.7	18.7	18.8	18.8	18.8	18.9	19.1	19.2	19.4	19.5	19.3	19.5	19.7	20.1	20.2	20.2	20.3	20.4	19.3
23	16.5	16.6	16.9	17.1	17.0	16.6	16.4	16.5	16.4	16.4	16.7	16.1	16.1	16.1	15.8	16.2	16.4	16.6	16.5	16.5	16.6	16.8	16.4
24	17.4	17.3	17.4	17.5	17.6	17.5	17.3	17.3	17.5	17.5	17.7	17.5	17.4	17.2	17.0	17.3	17.4	17.4	17.5	17.5	17.6	17.7	17.4
25	16.2	16.3	16.5	16.8	17.1	17.1	17.2	17.3	17.4	17.1	17.3	17.3	17.5	17.0	16.7	17.0	17.2	17.3	17.7	17.7	17.6	17.6	17.2
26	17.8	17.8	17.8	17.8	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.4	18.7	18.6	18.7	18.9	18.9	18.9	19.0	19.2	19.1	18.4
27	16.0	15.5	15.3	17.3	17.3	17.9	18.4	18.5	18.2	18.6	18.8	19.0	19.2	18.1	18.1	18.1	18.7	18.5	19.1	19.1	19.0	19.1	18.5
28		22.2	21.7	21.7	21.9	21.9	22.1	22.0	22.1	22.2	22.4	22.5	22.7	22.8	22.6	22.7	22.9	23.4	23.5	23.5	23.6	23.6	22.6
29	18.0	18.2	18.2	17.9	17.5	17.5	17.7	17.8	18.0	18.4	18.6	18.8	19.0	19.2	19.4	19.7	20.0	20.1	20.1	20.1	20.1	20.2	19.0
30	18.1	18.2	18.4	18.4	18.5	18.3	18.3	18.3	18.4	18.5	18.3	18.2	18.1	17.9	17.9	18.1	18.1	18.2	18.3	18.1	18.0	17.9	18.2
32	16.3	16.7	16.6	16.8	17.0	16.9	16.9	16.7	16.9	16.9	16.8	16.3	16.1	16.1	15.6	15.8	16.3	16.5	16.6	16.6	16.6	16.6	16.4
Total	17.3	17.3	17.4	17.4	17.5	17.5	17.5	17.5	17.6	17.6	17.6	17.5	17.4	17.4	17.1	17.3	17.5	17.5	17.7	17.7	17.7	17.8	17.5

APPENDIX TABLE 3

AVERAGE FIRM ln (LABOR INPUT) BY INDUSTRY AND YEAR

	Year																						
33 Code	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
1	14.8	15.0	15.0	15.1	15.2	15.3	15.0	15.4	14.9	14.7	14.6	14.6	14.5	14.5	14.3	14.4	14.2	14.2	14.1	14.1	14.0	14.0	14.6
2	15.8	15.8	15.8	15.9	16.0	15.5	16.0	15.7	15.9	15.1	14.8	14.6	14.4	14.9	14.1	14.2	14.0	13.8	13.9	13.8	13.6	11.7	14.8
3														13.7	12.9	14.0	14.0	13.8	14.0				13.7
5	14.0	13.8	13.8	13.7	13.5	13.6	13.7	13.7	13.8	13.9	13.9	14.0	14.0	13.9	13.8	13.8	13.7	13.7	13.5	13.5	13.5	13.5	13.7
6	14.4	14.4	14.4	14.4	14.4	14.4	14.3	14.2	14.2	14.3	14.3	14.2	14.1	14.1	13.9	13.9	13.9	13.9	13.8	13.7	13.7	13.7	14.1
7	15.0	15.1	14.8	14.8	14.6	14.6	14.6	14.5	14.4	14.3	14.3	14.2	14.1	13.9	13.6	13.8	13.8	13.6	13.4	13.1	12.9	12.7	14.0
8	14.4	14.4	14.5	14.5	14.3	14.2	14.2	14.0	14.0	14.0	13.8	13.8	13.7	13.5	13.4	13.4	13.4	13.3	13.4	13.4	13.3	13.3	13.7
9	15.2	15.2	15.3	15.4	15.4	14.7	14.6	14.5	14.5	14.4	14.3	14.3	14.2	14.2	14.0	14.0	14.0	13.9	13.8	13.8	13.7	13.7	14.3
10	14.6	14.5	14.5	14.6	14.6	14.6	14.6	14.7	14.7	14.7	14.6	14.7	14.6	14.5	14.2	14.1	13.8	14.0	14.2	14.0	13.9	13.8	14.4
11	13.8	13.8	13.8	13.8	13.8	13.6	13.7	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.3	13.4	13.3	13.3	13.3	13.2	13.2	13.2	13.5
12	13.3	12.8	13.3	13.4	13.3	13.4	13.3	13.2	13.1	13.0	13.0	13.0	13.0	12.0	11.8	12.3	12.4	12.6	12.6	12.6	12.4	12.3	12.6
13	14.0	14.0	14.0	14.0	14.0	13.9	13.9	13.8	13.8	13.9	13.8	13.7	13.6	13.5	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.6
14	14.0	14.0	13.5	13.4	13.8	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.8	13.8	13.9	13.8	13.9	13.8	13.8	13.8	13.8
15	14.6	14.7	14.5	14.3	14.2	14.0	13.9	13.8	13.8	13.6	13.5	13.4	13.3	13.3	13.3	13.4	13.2	13.2	12.9	12.9	12.8	12.7	13.5
16	14.6	14.5	14.4	14.5	14.5	14.4	14.4	14.3	14.3	14.4	14.4	14.3	14.3	14.2	13.9	13.8	13.8	13.7	13.6	13.5	13.5	13.5	14.1
17	14.2	14.1	14.0	13.9	13.8	13.7	13.7	13.6	13.6	13.6	13.5	13.6	13.5	13.4	13.2	13.3	13.4	13.2	13.3	13.3	13.3	13.2	13.5
18	14.3	13.9	13.9	13.7	13.7	13.6	13.6	13.4	13.3	13.3	13.4	13.3	13.3	13.2	13.0	13.0	13.1	13.1	13.0	13.0	12.9	12.9	13.3
19	13.7	13.7	13.7	13.7	13.8	13.7	13.6	13.4	13.5	13.4	13.2	12.9	12.8	12.6	12.3	12.5	12.6	12.6	12.6	12.7	12.8	12.8	12.9
20	14.2	14.0	14.1	14.2	14.2	14.0	13.9	13.7	13.6	13.6	13.5	13.2	13.0	12.9	12.6	12.8	12.9	12.9	12.9	12.8	12.9	12.9	13.1
21	14.6	14.5	14.4	14.4	14.3	14.3	14.4	14.2	14.3	14.3	14.2	14.2	14.1	14.1	13.7	13.9	14.0	13.7	13.8	13.9	13.8	13.9	14.1
22	15.4	15.6	15.3	15.4	15.3	15.3	15.3	15.2	15.3	15.2	15.3	15.3	15.4	15.3	15.1	15.1	15.4	15.4	15.3	15.3	15.3	15.3	15.3
23	14.2	14.3	14.3	14.5	14.4	13.8	13.4	13.2	13.1	13.2	13.1	12.7	12.6	12.3	12.2	12.3	12.5	12.5	12.5	12.4	12.5	12.6	12.8
24	14.5	14.6	14.6	14.5	14.4	14.3	14.0	13.9	14.0	13.9	14.0	13.7	13.5	13.4	13.3	13.4	13.5	13.5	13.4	13.5	13.5	13.5	13.7
25	14.2	14.1	13.8	14.0	14.1	14.0	14.0	13.8	13.7	13.4	13.5	13.4	13.4	13.4	13.1	13.2	13.2	13.1	13.2	13.0	12.9	12.9	13.4
26	14.8	14.8	14.7	14.7	14.7	14.8	14.7	14.6	14.7	14.7	14.7	14.8	14.7	14.7	14.6	14.5	14.5	14.4	14.2	14.1	14.2	14.2	14.6
27	14.5	14.3	14.1	15.7	14.7	14.9	15.1	15.1	14.8	14.9	15.0	15.3	15.4	14.3	13.7	13.5	13.9	13.5	14.0	14.0	14.0	14.0	14.2
28		18.2	18.2	18.2	18.2	18.3	18.3	18.2	18.2	18.3	18.3	18.4	18.3	18.4	18.3	18.2	18.2	17.6	17.5	17.6	17.6	17.6	18.1
29	13.7	13.7	13.7	13.5	13.3	13.3	13.3	13.2	13.3	13.4	13.4	13.5	13.6	13.7	13.7	13.8	13.8	13.8	13.8	13.8	13.7	13.6	13.6
30	14.3	14.4	14.4	14.3	14.3	14.2	14.0	13.9	13.8	13.7	13.6	13.4	13.2	13.0	12.8	12.8	12.8	12.8	12.8	12.8	12.6	12.5	13.3
32	13.5	13.6	13.5	13.5	13.5	13.5	13.6	13.5	13.6	13.5	13.3	12.6	12.3	12.2	12.0	12.1	12.2	12.3	12.4	12.4	12.4	12.4	12.5
Total	14.3	14.2	14.2	14.2	14.1	14.0	14.0	13.9	13.9	13.8	13.8	13.6	13.4	13.3	13.0	13.1	13.1	13.1	13.1	13.0	13.1	13.1	13.4

APPENDIX TABLE 4

WEIGHTED AVERAGE OF INDUSTRY TFP LEVEL

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.50	0.53	0.46	0.43	0.34	0.19	0.05	-0.02	-0.07	-0.07	-0.12	-0.06	-0.09	-0.08	0.01	-0.07	-0.10	-0.13	-0.21	-0.18	-0.27	-0.23
2	0.27	0.49	0.33	0.30	0.20	0.36	0.17	0.06	-0.09	0.04	-0.07	-0.07	-0.09	-0.03	0.09	0.00	0.36	0.39	0.29	0.31	0.47	0.63
3														0.07	0.05	0.00	0.08	0.12	0.01			
5	0.46	0.49	0.46	0.39	0.31	0.19	0.08	0.07	0.07	0.04	0.03	0.00	-0.03	-0.11	0.03	-0.03	-0.09	-0.11	-0.14	-0.16	-0.08	-0.06
6	-0.41	-0.34	-0.34	-0.07	0.02	0.06	0.09	0.13	0.12	0.13	0.13	0.14	0.14	0.11	-0.01	0.03	0.01	0.04	0.07	0.07	0.13	0.09
7	-0.46	-0.39	-0.33	-0.27	-0.33	-0.34	-0.31	-0.29	-0.18	-0.13	-0.09	-0.12	-0.06	0.04	-0.03	-0.03	-0.03	0.08	0.09	0.13	0.07	0.08
8	-0.58	-0.51	-0.46	-0.41	-0.41	-0.38	-0.37	-0.31	-0.28	-0.22	-0.14	-0.07	-0.01	-0.04	-0.03	-0.05	0.00	0.07	0.03	-0.02	0.08	0.16
9	-0.12	-0.06	-0.02	-0.01	-0.04	0.03	0.04	0.07	0.04	-0.19	-0.10	-0.07	-0.02	-0.01	-0.16	-0.03	-0.04	-0.02	0.02	0.09	0.13	0.11
10	-0.35	-0.36	-0.35	-0.31	-0.29	-0.26	-0.24	-0.21	-0.19	-0.13	-0.10	-0.06	-0.01	0.00	0.05	0.00	-0.04	0.00	0.01	0.00	-0.01	0.07
11	-0.20	-0.15	-0.15	-0.18	-0.14	-0.13	-0.07	-0.05	0.00	0.04	0.11	0.06	0.03	0.04	-0.11	-0.09	-0.14	-0.15	-0.04	-0.06	-0.02	-0.02
12	-0.98	-0.75	-0.62	-0.51	-0.05	-0.04	0.01	-0.01	0.01	-0.10	-0.05	-0.05	-0.10	-0.17	-0.02	-0.08	-0.12	-0.14	-0.24	-0.24	-0.18	-0.16
13	-0.45	-0.36	-0.35	-0.33	-0.33	-0.32	-0.30	-0.27	-0.23	-0.18	-0.11	-0.12	-0.05	-0.01	-0.10	-0.06	-0.04	-0.01	0.05	-0.01	-0.09	-0.10
14	-0.49	-0.38	-0.17	-0.08	0.18	0.34	0.39	0.38	0.39	0.41	0.49	0.47	0.31	0.20	-0.12	-0.09	-0.25	-0.30	-0.34	-0.39	-0.33	-0.45
15	-0.03	0.02	-0.07	-0.08	-0.08	-0.12	-0.11	-0.10	-0.05	0.02	0.08	0.11	0.18	0.12	-0.03	0.04	0.08	0.05	0.00	-0.04	-0.02	0.00
16	-0.41	-0.36	-0.30	-0.23	-0.15	-0.11	-0.21	-0.20	-0.23	-0.16	-0.10	-0.06	-0.03	-0.02	-0.16	-0.05	0.02	0.03	0.08	0.10	0.13	0.03
17	-0.42	-0.23	-0.18	-0.17	-0.19	-0.27	-0.28	-0.16	-0.16	-0.03	0.03	0.03	0.05	0.00	-0.06	-0.02	-0.04	-0.02	0.01	0.03	-0.14	-0.22
18	-0.48	-0.39	-0.31	-0.43	-0.32	-0.24	-0.18	-0.06	0.01	0.16	0.17	0.18	0.09	0.17	0.13	0.06	0.02	0.04	0.01	0.02	0.00	-0.02
19	-0.42	-0.36	-0.34	-0.31	-0.34	-0.28	-0.26	-0.19	-0.16	-0.13	-0.07	0.01	0.04	-0.01	0.03	-0.04	-0.08	-0.05	-0.07	-0.03	0.04	0.01
20	-1.06	-0.99	-0.92	-0.91	-0.89	-0.75	-0.72	-0.62	-0.52	-0.41	-0.26	-0.06	-0.13	-0.10	-0.04	-0.03	0.02	0.14	0.30	0.44	0.52	0.53
21	-0.53	-0.55	-0.53	-0.50	-0.47	-0.44	-0.31	-0.24	-0.22	-0.19	-0.11	-0.06	0.00	-0.01	-0.04	-0.02	-0.02	0.03	0.02	0.06	0.05	0.05
22	-0.42	-0.38	-0.40	-0.45	-0.40	-0.33	-0.23	-0.08	-0.07	-0.08	-0.07	-0.02	-0.01	0.06	0.16	0.05	-0.07	-0.06	-0.07	-0.03	-0.08	-0.05
23	-0.52	-0.42	-0.39	-0.43	-0.42	-0.41	-0.34	-0.26	-0.18	-0.19	-0.13	-0.07	-0.03	-0.02	-0.03	0.02	-0.07	-0.10	-0.12	-0.06	-0.01	0.00
24	-0.39	-0.27	-0.30	-0.24	-0.27	-0.26	-0.20	-0.15	-0.13	-0.07	-0.04	-0.05	0.01	0.04	0.05	0.00	0.01	0.07	0.05	0.08	0.11	0.03
25	-0.48	-0.42	-0.40	-0.38	-0.38	-0.38	-0.29	-0.28	-0.24	-0.22	-0.17	-0.12	-0.11	-0.07	-0.05	-0.05	0.00	0.02	-0.01	0.01	0.02	0.06
26	-0.43	-0.43	-0.46	-0.47	-0.45	-0.49	-0.46	-0.45	-0.50	-0.49	-0.47	-0.46	-0.46	-0.35	-0.35	-0.36	-0.23	-0.13	-0.09	-0.01	0.10	0.17
27	-0.96	-0.56	-0.22	-1.06	-0.91	-0.99	-0.92	-1.34	-0.89	-0.82	-0.80	-0.75	-0.64	-0.81	-0.83	-0.49	-0.32	-0.11	-0.02	-0.01	0.10	0.17
28		-0.72	-0.45	-0.36	-0.27	-0.20	-0.05	0.12	0.16	0.15	0.25	0.21	0.17	0.10	0.09	0.00	-0.03	-0.03	-0.05	-0.04	-0.02	-0.03
29	-0.76	-0.79	-0.70	-0.68	-0.59	-0.48	-0.33	-0.24	-0.23	-0.17	-0.09	-0.09	-0.13	-0.12	-0.18	-0.21	-0.26	-0.27	-0.27	-0.23	-0.13	-0.09
30	-0.37	-0.32	-0.33	-0.36	-0.32	-0.28	-0.24	-0.19	-0.18	-0.19	-0.15	-0.17	-0.10	-0.06	-0.01	-0.06	-0.11	-0.09	-0.04	0.05	0.02	0.02
32	0.29	0.37	0.22	0.30	0.26	0.21	0.08	0.03	0.01	-0.04	-0.08	-0.06	-0.11	-0.18	-0.14	-0.07	-0.09	-0.08	-0.08	-0.07	-0.03	-0.02
Total	-0.33	-0.31	-0.30	-0.32	-0.30	-0.28	-0.25	-0.20	-0.16	-0.14	-0.09	-0.07	-0.06	-0.06	-0.07	-0.07	-0.08	-0.04	0.01	0.06	0.08	0.07

APPENDIX TABLE 5

SIMPLE AVERAGE OF INDUSTRY TFP LEVEL

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.49	0.52	0.49	0.42	0.33	0.17	0.05	-0.06	-0.12	-0.08	-0.12	-0.07	-0.08	-0.10	-0.01	-0.02	-0.11	-0.11	-0.19	-0.20	-0.23	-0.23
2	0.27	0.49	0.33	0.30	0.20	0.36	0.17	0.06	-0.09	0.04	-0.07	-0.07	-0.09	-0.03	0.09	0.00	0.36	0.39	0.29	0.31	0.47	0.63
3														0.07	0.05	0.00	0.08	0.12	0.01			
5	0.55	0.57	0.54	0.46	0.38	0.29	0.16	0.15	0.14	0.08	0.07	0.02	-0.01	-0.12	0.03	-0.06	-0.12	-0.10	-0.19	-0.18	-0.11	-0.09
6	-0.41	-0.35	-0.33	-0.21	-0.12	-0.10	-0.06	0.00	-0.03	-0.02	0.04	0.03	0.03	0.03	-0.07	-0.04	-0.05	-0.05	-0.04	-0.03	0.01	0.00
7	-0.43	-0.36	-0.36	-0.32	-0.36	-0.34	-0.31	-0.26	-0.16	-0.11	-0.09	-0.10	-0.04	0.02	-0.05	-0.03	-0.03	0.04	0.04	0.07	0.03	0.02
8	-0.59	-0.54	-0.45	-0.42	-0.43	-0.44	-0.41	-0.34	-0.29	-0.24	-0.17	-0.10	-0.04	-0.08	-0.05	-0.07	-0.05	0.01	-0.04	-0.05	0.04	0.10
9	-0.13	-0.06	-0.02	-0.01	-0.04	-0.16	0.03	0.12	0.10	-0.13	0.00	-0.02	-0.01	0.00	-0.16	-0.02	-0.01	0.00	0.04	0.09	0.12	0.11
10	-0.37	-0.34	-0.33	-0.32	-0.28	-0.24	-0.20	-0.16	-0.17	-0.12	-0.08	-0.06	-0.01	0.00	0.05	-0.02	-0.11	0.00	0.00	-0.01	-0.01	0.07
11	-0.22	-0.18	-0.17	-0.20	-0.18	-0.13	-0.09	-0.03	0.03	0.07	0.13	0.08	0.04	0.04	-0.10	-0.04	-0.10	-0.10	-0.03	-0.05	-0.01	-0.02
12	-0.98	-0.75	-0.66	-0.72	-0.54	-0.47	-0.29	-0.30	-0.26	-0.24	-0.14	-0.13	-0.22	-0.23	-0.09	-0.08	-0.13	-0.18	-0.35	-0.32	-0.31	-0.32
13	-0.43	-0.35	-0.33	-0.31	-0.30	-0.29	-0.26	-0.22	-0.18	-0.14	-0.10	-0.12	-0.04	-0.01	-0.06	-0.06	-0.05	-0.02	0.01	-0.05	-0.10	-0.12
14	-0.51	-0.38	-0.18	-0.05	0.24	0.38	0.41	0.43	0.43	0.43	0.49	0.47	0.33	0.15	-0.04	-0.03	-0.22	-0.28	-0.31	-0.38	-0.36	-0.46
15	-0.01	0.07	0.03	-0.02	-0.05	-0.07	-0.07	-0.06	-0.01	0.02	0.07	0.09	0.17	0.13	0.05	-0.01	0.04	0.00	-0.04	-0.07	-0.07	-0.09
16	-0.43	-0.40	-0.33	-0.27	-0.20	-0.17	-0.21	-0.22	-0.23	-0.18	-0.11	-0.05	-0.03	-0.03	-0.10	-0.06	-0.02	-0.02	0.00	0.02	0.08	0.03
17	-0.35	-0.27	-0.23	-0.22	-0.22	-0.25	-0.21	-0.16	-0.13	-0.05	-0.01	-0.02	0.00	-0.04	-0.09	-0.05	-0.08	-0.05	-0.05	-0.07	-0.21	-0.31
18	-0.36	-0.33	-0.26	-0.25	-0.21	-0.18	-0.17	-0.11	-0.07	0.00	0.05	0.11	0.12	0.09	0.05	-0.05	-0.07	-0.01	-0.08	-0.05	-0.09	-0.10
19	-0.40	-0.36	-0.35	-0.33	-0.33	-0.31	-0.30	-0.24	-0.21	-0.17	-0.11	-0.04	0.00	-0.03	-0.01	-0.06	-0.09	-0.11	-0.15	-0.10	-0.03	-0.09
20	-1.07	-1.01	-0.92	-0.90	-0.87	-0.83	-0.78	-0.67	-0.57	-0.48	-0.39	-0.28	-0.20	-0.16	-0.07	-0.07	-0.07	0.07	0.16	0.31	0.40	0.46
21	-0.63	-0.61	-0.60	-0.54	-0.53	-0.47	-0.36	-0.32	-0.26	-0.23	-0.16	-0.13	-0.06	-0.07	0.01	-0.03	-0.06	-0.01	-0.05	-0.02	0.07	0.09
22	-0.48	-0.41	-0.42	-0.44	-0.40	-0.35	-0.29	-0.18	-0.15	-0.13	-0.09	-0.05	-0.03	0.00	0.11	-0.02	-0.15	-0.10	-0.09	-0.06	-0.11	-0.05
23	-0.54	-0.45	-0.41	-0.40	-0.46	-0.48	-0.41	-0.25	-0.18	-0.20	-0.14	-0.17	-0.08	-0.05	-0.03	-0.05	-0.15	-0.17	-0.18	-0.15	-0.11	-0.11
24	-0.42	-0.30	-0.30	-0.28	-0.30	-0.28	-0.26	-0.18	-0.12	-0.04	-0.04	-0.06	-0.01	-0.01	0.02	-0.03	-0.03	0.00	-0.01	-0.03	-0.02	-0.06
25	-0.53	-0.44	-0.42	-0.38	-0.41	-0.37	-0.30	-0.25	-0.20	-0.27	-0.29	-0.20	-0.11	-0.14	-0.07	-0.05	-0.01	0.02	-0.04	0.00	0.00	0.03
26	-0.44	-0.44	-0.44	-0.46	-0.40	-0.48	-0.44	-0.40	-0.41	-0.43	-0.43	-0.42	-0.41	-0.28	-0.25	-0.17	-0.07	0.02	0.03	0.05	0.20	0.19
27	-0.96	-0.59	-0.40	-0.90	-0.87	-0.70	-0.69	-0.79	-0.81	-0.70	-0.68	-0.66	-0.59	-0.57	-0.40	-0.29	-0.26	-0.25	-0.10	-0.04	-0.05	0.07
28		-0.72	-0.45	-0.36	-0.27	-0.20	-0.05	0.12	0.16	0.15	0.25	0.21	0.17	0.10	0.09	0.00	-0.03	-0.03	-0.05	-0.04	-0.02	-0.03
29	-0.87	-0.89	-0.79	-0.76	-0.68	-0.60	-0.46	-0.31	-0.28	-0.18	-0.12	-0.03	-0.03	-0.03	-0.06	-0.06	-0.12	-0.19	-0.16	-0.14	-0.03	0.00
30	-0.50	-0.48	-0.46	-0.47	-0.44	-0.44	-0.41	-0.38	-0.36	-0.34	-0.30	-0.28	-0.19	-0.19	-0.13	-0.08	-0.19	-0.16	-0.16	-0.09	-0.11	-0.09
32	0.19	0.29	0.23	0.24	0.18	0.14	-0.02	-0.08	-0.08	-0.13	-0.15	-0.16	-0.19	-0.23	-0.24	-0.12	-0.13	-0.12	-0.20	-0.21	-0.16	-0.16
Total	-0.41	-0.36	-0.34	-0.33	-0.32	-0.31	-0.29	-0.25	-0.21	-0.18	-0.14	-0.12	-0.08	-0.09	-0.08	-0.07	-0.09	-0.04	-0.04	0.00	0.03	0.03

APPENDIX TABLE 6

TFP RESULT COMPARISON USING STOCK DEFLATOR FROM KDI

		Year														
Industry		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
6	flow deflator	-0.10	-0.02	-0.05	-0.04	0.02	0.03	0.01	0.03	-0.07	-0.04	-0.05	-0.05	-0.02	-0.03	-0.03
	stock deflator	-0.11	-0.03	-0.06	-0.05	0.02	0.03	0.01	0.03	-0.08	-0.04	-0.06	-0.05	-0.02	-0.03	-0.03
	diff	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01
7	flow deflator	-0.31	-0.26	-0.16	-0.11	-0.09	-0.10	-0.04	0.02	-0.05	-0.03	-0.03	0.06	0.04	0.07	-0.06
	stock deflator	-0.31	-0.27	-0.16	-0.12	-0.10	-0.10	-0.04	0.02	-0.07	-0.04	-0.03	0.06	0.03	0.06	-0.07
	diff	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.01	0.01	0.01
8	flow deflator	-0.41	-0.34	-0.29	-0.24	-0.17	-0.10	-0.04	-0.08	-0.02	-0.07	-0.05	0.01	-0.04	-0.05	-0.12
	stock deflator	-0.43	-0.36	-0.31	-0.25	-0.17	-0.09	-0.04	-0.08	-0.05	-0.08	-0.06	0.00	-0.04	-0.06	-0.12
	diff	0.02	0.02	0.02	0.01	0.00	-0.01	0.00	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.01
9	flow deflator	0.03	0.12	0.10	-0.13	0.00	-0.02	-0.01	0.00	-0.16	-0.02	-0.01	0.00	0.04	0.09	0.00
	stock deflator	0.03	0.12	0.10	-0.12	0.01	-0.01	0.01	0.01	-0.17	-0.02	-0.01	0.00	0.05	0.10	0.01
	diff	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.01	0.01	0.00	0.00	0.00	0.00	-0.01	0.00
10	flow deflator	-0.20	-0.16	-0.17	-0.12	-0.08	-0.06	-0.01	0.00	0.05	-0.02	-0.11	0.00	0.00	-0.01	-0.06
	stock deflator	-0.19	-0.16	-0.17	-0.12	-0.08	-0.05	0.00	0.00	0.04	-0.02	-0.11	0.00	0.00	0.00	-0.06
	diff	-0.01	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	0.00
11	flow deflator	-0.09	-0.03	0.03	0.07	0.13	0.08	0.04	0.04	-0.07	-0.04	-0.10	-0.10	-0.03	-0.05	-0.01
	stock deflator	-0.08	-0.03	0.04	0.07	0.14	0.09	0.06	0.06	-0.09	-0.05	-0.10	-0.10	-0.02	-0.04	0.00
	diff	-0.01	-0.01	-0.02	0.00	-0.01	-0.01	-0.01	-0.01	0.02	0.01	0.00	0.00	-0.01	-0.01	-0.01
12	flow deflator	-0.29	-0.08	-0.26	-0.24	-0.14	-0.13	-0.22	-0.23	-0.09	-0.08	-0.13	-0.18	-0.31	-0.32	-0.20
	stock deflator	-0.32	-0.11	-0.35	-0.26	-0.16	-0.14	-0.23	-0.25	-0.11	-0.07	-0.14	-0.18	-0.31	-0.33	-0.21
	diff	0.04	0.03	0.10	0.02	0.02	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.01	0.01	0.01
13	flow deflator	-0.26	-0.21	-0.18	-0.14	-0.10	-0.12	-0.04	-0.01	-0.06	-0.06	-0.05	-0.01	0.01	-0.04	-0.08
	stock deflator	-0.28	-0.24	-0.21	-0.14	-0.10	-0.13	-0.05	-0.01	-0.08	-0.06	-0.05	-0.01	0.01	-0.04	-0.09
	diff	0.02	0.02	0.03	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01
14	flow deflator	0.41	0.43	0.43	0.43	0.49	0.47	0.33	0.15	-0.04	-0.03	-0.22	-0.28	-0.31	-0.38	0.13
	stock deflator	0.38	0.40	0.40	0.41	0.47	0.46	0.31	0.13	-0.05	-0.03	-0.22	-0.27	-0.30	-0.38	0.12
	diff	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01
15	flow deflator	-0.07	-0.06	-0.01	0.02	0.07	0.09	0.17	0.13	0.05	-0.01	0.04	0.00	-0.04	-0.07	0.02
	stock deflator	-0.05	-0.04	0.00	0.02	0.07	0.09	0.18	0.13	0.04	-0.02	0.03	0.00	-0.04	-0.06	0.03
	diff	-0.01	-0.01	-0.01	0.00	0.00	0.00	-0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00
16	flow deflator	-0.21	-0.22	-0.23	-0.18	-0.11	-0.05	-0.03	-0.03	-0.10	-0.06	-0.02	-0.02	0.00	0.02	-0.09
	stock deflator	-0.22	-0.23	-0.24	-0.18	-0.11	-0.05	-0.01	-0.02	-0.13	-0.07	-0.02	-0.02	0.01	0.03	-0.09
	diff	0.01	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	0.03	0.01	0.00	0.00	0.00	-0.01	0.00
17	flow deflator	-0.21	-0.15	-0.13	-0.05	-0.01	-0.02	0.00	-0.04	-0.08	-0.05	-0.08	-0.05	-0.04	-0.07	-0.07
	stock deflator	-0.23	-0.21	-0.14	-0.06	-0.01	-0.03	0.00	-0.04	-0.09	-0.06	-0.08	-0.05	-0.03	-0.06	-0.07
	diff	0.01	0.07	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	-0.01	-0.01	0.01
18	flow deflator	-0.17	-0.11	-0.07	0.00	0.05	0.11	0.12	0.09	0.08	-0.02	-0.07	-0.01	-0.06	-0.05	-0.01
	stock deflator	-0.20	-0.16	-0.11	-0.04	0.02	0.08	0.10	0.06	0.03	-0.05	-0.10	-0.03	-0.08	-0.07	-0.04
	diff	0.03	0.05	0.05	0.04	0.03	0.03	0.02	0.03	0.05	0.03	0.03	0.02	0.02	0.02	0.03
19	flow deflator	-0.30	-0.24	-0.21	-0.17	-0.11	-0.04	0.00	-0.03	-0.01	-0.06	-0.08	-0.11	-0.14	-0.09	-0.09
	stock deflator	-0.32	-0.25	-0.22	-0.18	-0.11	-0.04	0.00	-0.04	-0.04	-0.06	-0.09	-0.12	-0.14	-0.10	-0.10
	diff	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.03	0.01	0.01	0.01	0.01	0.00	0.01
20	flow deflator	-0.76	-0.64	-0.56	-0.48	-0.38	-0.27	-0.20	-0.16	-0.07	-0.06	-0.06	0.09	0.16	0.31	-0.10
	stock deflator	-0.80	-0.69	-0.59	-0.52	-0.42	-0.29	-0.21	-0.17	-0.08	-0.07	-0.07	0.08	0.16	0.30	-0.12
	diff	0.04	0.05	0.03	0.04	0.04	0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01

(Appendix Table 6 Continued)

		Year														
Industry		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
21	flow deflator	-0.36	-0.29	-0.26	-0.23	-0.16	-0.13	-0.06	-0.07	0.01	-0.03	-0.06	-0.01	-0.05	-0.02	-0.11
	stock deflator	-0.37	-0.30	-0.28	-0.24	-0.16	-0.14	-0.06	-0.08	-0.03	-0.03	-0.07	-0.03	-0.05	-0.02	-0.12
	diff	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.01	0.03	0.00	0.01	0.01	0.01	0.01	0.01
22	flow deflator	-0.29	-0.18	-0.15	-0.13	-0.09	-0.05	-0.03	0.00	0.11	-0.02	-0.15	-0.10	-0.09	-0.06	-0.09
	stock deflator	-0.29	-0.18	-0.15	-0.13	-0.09	-0.06	-0.05	0.00	0.10	-0.02	-0.15	-0.10	-0.09	-0.06	-0.09
	diff	0.00	0.00	0.00	-0.01	-0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
23	flow deflator	-0.41	-0.25	-0.18	-0.20	-0.14	-0.13	-0.08	-0.05	-0.03	-0.05	-0.11	-0.17	-0.17	-0.15	-0.13
	stock deflator	-0.40	-0.24	-0.17	-0.18	-0.13	-0.12	-0.07	-0.05	-0.07	-0.08	-0.14	-0.19	-0.19	-0.18	-0.15
	diff	-0.01	-0.01	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.01
24	flow deflator	-0.22	-0.18	-0.12	-0.04	-0.04	-0.06	-0.01	-0.01	0.02	-0.03	-0.03	0.00	-0.01	-0.03	-0.04
	stock deflator	-0.23	-0.20	-0.14	-0.06	-0.05	-0.07	-0.01	-0.01	0.00	-0.03	-0.03	-0.01	-0.01	-0.03	-0.05
	diff	0.01	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.01
25	flow deflator	-0.30	-0.25	-0.20	-0.27	-0.18	-0.20	-0.11	-0.14	-0.07	-0.05	-0.01	0.02	-0.04	0.00	-0.11
	stock deflator	-0.31	-0.26	-0.21	-0.29	-0.18	-0.20	-0.11	-0.15	-0.09	-0.05	-0.01	0.02	-0.03	0.00	-0.11
	diff	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Total	flow deflator	-0.32	-0.26	-0.23	-0.18	-0.13	-0.10	-0.06	-0.05	-0.04	-0.05	-0.06	0.00	0.02	0.06	-0.08
	stock deflator	-0.34	-0.29	-0.24	-0.20	-0.14	-0.11	-0.06	-0.06	-0.06	-0.06	-0.07	-0.01	0.01	0.05	-0.09
	diff	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.01

Note: The study used sample period 1990-2003 because of the constraint of stock deflator. By two sample T test results by industry and year, respectively, H_0, H_0: difference of two means = 0 was rejected only in year 1998 (5% level **), industry 18 (1% level ***), industry 20 (10% level *) and total samples (1% level ***). In total samples, H_0 was not rejected in T-test using the growth rates of TFPs.

APPENDIX TABLE 7

STANDARD DEVIATION OF TFP DIFFERENCE FROM INDUSTRY AVERAGE (KOREA)

ICPA Code	Industry Name	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
6	Food and kindred products	0.06	0.06	0.07	0.08	0.07	0.06	0.08	0.07	0.07	0.08	0.09	0.10	0.09	0.12	0.13	0.12	0.17	0.14	0.16	0.17	0.13	0.11
7	Textile mill products	0.07	0.09	0.11	0.10	0.06	0.07	0.08	0.09	0.12	0.11	0.11	0.13	0.20	0.20	0.15	0.10	0.14	0.11	0.18	0.14	0.19	0.13
8	Apparel	0.06	0.06	0.06	0.06	0.11	0.09	0.09	0.09	0.12	0.10	0.14	0.10	0.13	0.34	0.20	0.24	0.23	0.15	0.16	0.22	0.12	0.17
9	Lumber and wood	0.01	0.02	0.05	0.05	0.07	0.06	0.11	0.13	0.19	0.30	0.11	0.13	0.16	0.23	0.06	0.04	0.06	0.04	0.03	0.02	0.03	0.13
10	Furniture and fixtures	0.05	0.06	0.05	0.07	0.09	0.06	0.08	0.06	0.15	0.17	0.08	0.06	0.05	0.13	0.09	0.16	0.32	0.14	0.09	0.09	0.11	0.12
11	Paper and allied	0.06	0.10	0.08	0.11	0.11	0.08	0.11	0.13	0.13	0.09	0.08	0.11	0.11	0.16	0.14	0.12	0.11	0.07	0.08	0.08	0.09	0.11
12	Printing publishing and allied	0.16	0.15	0.14	0.12	0.10	0.10	0.13	0.14	0.13	0.08	0.08	0.04	0.14	0.36	0.19	0.15	0.13	0.23	0.15	0.25	0.17	0.18
13	Chemicals	0.09	0.09	0.09	0.09	0.10	0.10	0.13	0.12	0.11	0.10	0.10	0.10	0.11	0.16	0.14	0.21	0.17	0.25	0.15	0.16	0.13	0.14
14	Petroleum and coal products	0.02	0.02	0.04	0.05	0.04	0.04	0.07	0.04	0.03	0.03	0.04	0.04	0.05	0.08	0.05	0.06	0.04	0.05	0.04	0.05	0.04	0.05
15	Leather	0.04	0.03	0.03	0.02	0.02	0.03	0.06	0.04	0.03	0.03	0.04	0.04	0.05	0.06	0.16	0.08	0.08	0.07	0.06	0.12	0.12	0.07
16	Stone clay glass	0.12	0.09	0.10	0.11	0.17	0.18	0.21	0.18	0.15	0.14	0.11	0.08	0.09	0.17	0.30	0.14	0.13	0.14	0.13	0.12	0.11	0.15
17	Primary metal	0.07	0.06	0.06	0.08	0.06	0.07	0.10	0.11	0.12	0.12	0.13	0.13	0.15	0.19	0.16	0.09	0.06	0.08	0.11	0.08	0.07	0.11
18	Fabricated metal	0.10	0.07	0.15	0.10	0.13	0.14	0.15	0.12	0.11	0.10	0.10	0.10	0.11	0.24	0.27	0.19	0.26	0.19	0.16	0.53	0.12	0.20
19	Machinery non-elect	0.20	0.14	0.13	0.13	0.14	0.16	0.14	0.16	0.14	0.12	0.12	0.10	0.13	0.33	0.27	0.25	0.32	0.29	0.28	0.37	0.28	0.25
20	Electrical machinery	0.19	0.12	0.10	0.10	0.13	0.21	0.13	0.11	0.15	0.10	0.11	0.12	0.14	0.33	0.32	0.25	0.28	0.26	0.35	0.34	0.31	0.25
21	Motor Vehicles	0.09	0.09	0.08	0.11	0.08	0.08	0.07	0.08	0.09	0.08	0.08	0.07	0.08	0.17	0.10	0.08	0.06	0.10	0.11	0.06	0.05	0.09
22	Transportation equipment and ordnance	0.16	0.08	0.08	0.11	0.10	0.12	0.14	0.14	0.11	0.05	0.09	0.08	0.06	0.12	0.10	0.12	0.06	0.06	0.07	0.08	0.05	0.10
23	Instruments	0.07	0.06	0.09	0.07	0.13	0.17	0.10	0.09	0.09	0.11	0.14	0.15	0.12	0.15	0.15	0.16	0.28	0.19	0.18	0.22	0.24	0.18
24	Rubber and misc plastics	0.10	0.11	0.10	0.06	0.08	0.09	0.08	0.12	0.10	0.15	0.15	0.14	0.08	0.11	0.09	0.11	0.16	0.13	0.16	0.43	0.11	0.16
	Total	0.11	0.09	0.09	0.10	0.11	0.13	0.12	0.11	0.12	0.11	0.11	0.11	0.12	0.25	0.23	0.20	0.23	0.22	0.24	0.28	0.22	0.18

APPENDIX TABLE 8

STANDARD DEVIATION OF TFP DIFFERENCE FROM INDUSTRY AVERAGE (JAPAN)

ICPA Code	Industry Name	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
6	Food and kindred products	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.19	0.13	0.12	0.12	0.09
7	Textile mill products	0.05	0.06	0.05	0.05	0.07	0.08	0.07	0.07	0.08	0.09	0.08	0.09	0.08	0.10	0.10	0.11	0.15	0.11	0.11	0.14	0.09
8	Apparel	0.07	0.06	0.05	0.06	0.06	0.07	0.06	0.09	0.08	0.08	0.08	0.07	0.06	0.08	0.07	0.08	0.09	0.09	0.10	0.13	0.08
9	Lumber and wood	0.04	0.03	0.03	0.06	0.02	0.12	0.13	0.14	0.12	0.09	0.09	0.10	0.10	0.11	0.08	0.10	0.09	0.09	0.08	0.08	0.09
10	Furniture and fixtures	0.03	0.02	0.02	0.06	0.07	0.07	0.05	0.05	0.06	0.07	0.08	0.07	0.07	0.08	0.07	0.07	0.06	0.06	0.07	0.37	0.11
11	Paper and allied	0.06	0.04	0.05	0.04	0.03	0.04	0.06	0.06	0.06	0.05	0.04	0.03	0.04	0.05	0.05	0.04	0.56	0.44	0.47	0.52	0.24
12	Printing publishing and allied	0.04	0.03	0.05	0.09	0.06	0.06	0.05	0.05	0.06	0.07	0.07	0.07	0.09	0.09	0.09	0.11	0.10	0.11	0.09	0.21	0.10
13	Chemicals	0.06	0.07	0.07	0.08	0.07	0.08	0.08	0.08	0.09	0.09	0.08	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.16	0.21	0.10
14	Petroleum and coal products	0.07	0.06	0.07	0.09	0.09	0.12	0.11	0.10	0.08	0.08	0.05	0.05	0.05	0.04	0.07	0.08	0.07	0.05	0.06	0.07	0.08
15	Leather	0.00	0.00	0.04	0.03	0.02	0.03	0.02	0.03	0.04	0.05	0.04	0.02	0.03	0.02	0.07	0.04	0.04	0.04	0.02	0.01	0.03
16	Stone clay glass	0.07	0.06	0.07	0.07	0.06	0.05	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.08	0.08	0.08	0.07	0.10	0.11	0.11	0.07
17	Primary metal	0.05	0.07	0.07	0.06	0.05	0.06	0.06	0.07	0.08	0.07	0.06	0.05	0.05	0.06	0.06	0.05	0.05	0.26	0.19	0.23	0.11
18	Fabricated metal	0.04	0.06	0.06	0.06	0.05	0.05	0.05	0.06	0.07	0.07	0.07	0.07	0.07	0.09	0.07	0.07	0.11	0.08	0.17	0.16	0.09
19	Machinery non-elect	0.07	0.08	0.10	0.08	0.07	0.07	0.07	0.10	0.12	0.11	0.08	0.07	0.07	0.08	0.11	0.11	0.10	0.12	0.11	0.09	0.09
20	Electrical machinery	0.08	0.08	0.07	0.07	0.07	0.07	0.08	0.09	0.08	0.08	0.08	0.09	0.08	0.09	0.10	0.10	0.17	0.21	0.23	0.20	0.13
21	Motor Vehicles	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04
22	Transportation equipment and ordnance	0.08	0.09	0.11	0.10	0.07	0.08	0.07	0.08	0.10	0.08	0.07	0.06	0.06	0.07	0.07	0.06	0.06	0.08	0.08	0.10	0.08
23	Instruments	0.09	0.09	0.11	0.12	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.14	0.16	0.14	0.17	0.16	0.19	0.13
24	Rubber and misc plastics	0.06	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.10	0.06
	Total	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.08	0.09	0.09	0.14	0.15	0.16	0.18	0.10

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Comments and Discussion

*Comments by Hyeog Ug Kwon**

Summary of the Findings

Authors find

1) The gap of productivity level between small and large firms has increased in Korea after the Asian financial crisis.

2) Four patterns exist in changes of productivities over time among Japanese and Korean firms.

Four patterns are classified as "surpass (productivity of Korean firms is higher than that of Japanese firms)," "convergence (productivity of Korean firms converge on that of Japanese firms)," "slow-down (Korean firms increased their productivity but gap between two countries still profound)" and "new divergence (Korean firms had made catch-up but productivity gap enlarged)."

Two Tales of Economic Growth

Convergence Hypothesis: Less productive countries (industries/firms) catch up with more productive ones.

This hypothesis is based on the Solow growth model, which emphasizes the role of capital accumulation in the long-run economic growth.

There has been a large body of literature that investigated cross-country productivity convergence both at the country level (Dorwick and Nguyen 1989; Wolff 1991) and Industry level (Bernard and Jones 1996; Pascual and Westermann 2002).

Many studies obtained evidences supporting productivity convergence among countries, except Bernard and Jones, 1996.

Two Tales of Economic Growth

Divergence Hypothesis: More productivity in more developed

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countries' (industries/firms) tends to grow faster than the productivity in the less developed ones.

This hypothesis is based on endogenous growth models, which emphasize the contribution of R&D, human capital, globalization (export and FDI), R&D spillover etc.

There is evidence on the persistence of productivity gap, even within very narrowly defined industries (Syverson 2004). However, there is almost no empirical evidence on the acceleration of productivity dispersion in advanced economies, except Fuako and Kwon (2006).

Contributions

- There have been few studies on productivity convergence using firm level data at international level. This paper compares the productivity level between Japan and Korea at firm-level.

International comparisons of the productivity level at firm-level help to reveal the variations in relative productivity across firms. This is a valuable research agenda.

- More importantly, this paper finds that convergence patterns of productivity vary by industry characteristics rather than comparative advantages of countries.

Limitations

- This paper does not answer that what has driven the acceleration of productivity gaps between small and large firms in Korea, and why there exist differential patterns in catch-up mechanism. More research on this respects are expected.
- This paper does not consider the characteristics of workers such as level of skills, and share of part-time workers.
- This paper does not include activities of domestic and foreign subsidiaries in measurements of output and inputs.

Next Steps

- It is necessary to measure all inputs more accurately. In particular, measurements and coordination of capital stock and labor input between two countries need more effort.
- In order to make catch-up mechanism clearer, studies including more countries not only Japan and Korea are expected.