National Productivity Measurement and International Comparisons

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Abstract

Productivity is defined in many different ways. It is sometimes confusing to understand productivity, and to compare productivity among different countries. In this paper, first of all, the definitions of national productivity are summarized. Secondly, the productivity measurements officially used in Korea are defined. Thirdly, additional productivity measurements which are often calculated worldwide are introduced. Lastly, international comparison is made for the value added labor productivity which is well known as a national productivity. The basis of comparison is on the currency exchange rate to US dollars as well as the purchasing power parity (PPP) announced by OECD.

Ⅰ. Introduction

An appropriate and standardized definition of productivity is required if

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productivity enhancement and international comparison are to be achieved. Not many people have a sufficient understanding of what productivity means and the many variables that must be considered. The major definitions with regard to productivity are as follows.

1.1 Wikipedia, the free encyclopedia

Productivity: The amount of output created (in terms of goods produced or services rendered) per unit input used.

Labour productivity: The amount of output per worker, or per labour-hour.

Capital productivity: The amount of output per unit of capital goods employed.

Total factor productivity (Multi-factor productivity): The amount of output per unit of labour and capital goods. Usually the labour and capital goods are weighted by their incomes.

1.2 Toru Sase (2001) in his book published by Asian Productivity Organization (APO)

Productivity: Function of the output performance of the individual firm (nation) compared with its input.

National productivity: GDP / Population

1.3 EPA (European Productivity Agency), 1958

Productivity: The degree of effective utilization of each element of production

1.4 Melkote Ramsay in APO (2004)

Economic productivity: The units of monetary value achieved as output or added value using a production system for a unit of monetary value for the input of any specific resource, set of resources, or aggregate of all input resources consumed by the system.

$$Labor\ force\ productivity = \frac{[Monetary\ \ value\ of\ output]}{[Man-hours\ consumed]}$$

$$Labor\ wage\ productivity = \frac{[Monetary\ \ value\ of\ output]}{[\ Expenditure\ on\ wages]}$$

All kinds of productivities such as labor productivity, capital productivity and total factor productivity are all dependent on a number of doubtful assumptions as well as on a number of each country's national statistics. Therefore, in order to calculate the comparable productivity statistics, we need to check the assumptions and the basis of related national statistics.

Productivity, quality and competitiveness are the key policies and statistical indices that should be checked and pursued at the highest level with a belief in human progress. These polices increase markets, attract local and overseas investment, and expand business. They comprise a state of mind that aims at perpetual improvement for the welfare and happiness of mankind and determine whether a nation will achieve high productivity, quality and competitiveness and an affluent life or low productivity and poverty.

Ⅱ. Productivity Measurement in Korea

The government of Korea officially publishes 3 national statistics for productivity measurement such as indices of physical resource labor productivity, indices of value added labor productivity, and indices of unit labor costs in manufacturing. They are all computed by Korean Productivity Center (KPC) which publishes the statistics. These statistics can be seen in "Quarterly Productivity Review" made by KPC, and can be found in http://www.kpc.or.kr.

2.1 Indices of physical resource labor productivity (PLPI): (Based on regular employees, 2000 = 100)

The PLPI is defined as follows, and is announced quarterly by KPC.

$$PLPI = \frac{Industrial\ production\ index}{Labor\ input\ index} \times 100$$

$$Industrial\ production\ index = \frac{\sum(commodity\ index \times commodity\ weight)}{\sum(commodity\ weight)}$$

$$Labor\ input\ index = \frac{Labor\ input\ (MH)\ of\ the\ current\ year}{Labor\ input\ (MH)\ of\ the\ base\ year} \times 100$$

(1) Industrial Production Index (IPI)

The "Industrial Production Index (IPI)" is obtained from "Current Mining and Manufacturing Survey" of KNSO (The National Statistical Office of Korea) which is monthly held as a sample survey. About 8,400 establishments nationwide are selected for the survey. The survey covers major 647 commodities (items) in mining, manufacturing, electricity and gas. Data on production and shipment are collected and compiled for the past month, and data on inventory are collected and compiled at the end of the previous month. The monthly IPI can be found in "Monthly Industrial Production Statistics" published by KNSO. One can see the results in KOSIS of http://www.nso.go.kr.

The IPI is divided into 3 categories as follows as of 2005. The total number of items is 647, and the total weight is 1,000.

Mining (12 items, weight = 36.2), 3 subcategories
Manufacturing (631 items, weight = 9,362.9), 22 subcategories
Electricity and gas (4 items, weight = 600.9), 2 subcategories

(2) Labor input index

The labor input index is obtained from the following sources.

(a) For 5 or more persons (regular employees):
"Monthly Labor Survey" published by the Ministry of Labor
(see http://laborstat.molab.go.kr).

(b) For 1-4 persons (regular employees):
"The Census on Basic Characteristics of Establishments" published by

KNSO annually.

(c) For all irregular employees:

"The Economically Active Population Survey" published by KNSO monthly.

2.2 Indices of value added labor productivity (VLPI): (Based on constant prices, 2000 = 100)

The VLPI is defined as follows, and is announced quarterly by KPC.

$$VLPI = \frac{Real\ GDP\ index}{Labor\ input\ index\ (MH)} \times 100$$

$$Real\ GDP\ index = \frac{Real\ GDP\ of\ the\ current\ year}{Real\ GDP\ of\ the\ base\ year} \times 100$$

Labor input index (MH) = same as in PLP.

The real (constant) GDP is obtained from "National Accounts" statistics made by The Bank of Korea quarterly (see http://www.bok.or.kr).

2.3 Indices of unit labor costs in manufacturing (ULCI): (2000 = 100)

The ULCI is defined as follows, and is announced quarterly by KPC.

$$ULCI = \frac{Wage\ cost\ index}{Labor\ productivity\ index} \times 100$$

Labor productivity index = The indices of physical resource labor productivity (PLP) is used.

$$Wage = \frac{Total\ wage}{Total\ working\ hours}$$

Wage cost index = The wage is obtained from "Survey Report on Labor Cost of Enterprise" published annually by the Ministry of Labour, http://laborstat.molab.go.kr. The data is compiled from "Survey on Labour Cost of Enterprise" annually.

Ⅲ. Additional Productivity Measurement

In addition to the 3 productivity measures described in Section 2, capital productivity, total factor productivity and green productivity are often used internationally. Korea does not compute these statistics officially. In particular APO(2001-2004) books deal with these productivity measurements, and APO recommends to its member countries to use it. In APO, there are total 19 member countries including Korea.

3.1 Capital productivity growth

The capital productivity growth is the growth in real GDP per unit of capital stock input. The real (constant) GDP is obtained from "National Accounts" statistics made by the Bank of Korea quarterly (see http://www.bok.or.kr). The capital stock input is obtained from "National Wealth Survey" statistics made by KNSO (see http://www.nso.go.kr). However, this survey is done every 10 years (last time in 1997), hence we cannot get yearly data from this survey. Therefore, the capital stock input for each year is estimated by Korea Institute of Public Finance and used by these estimates. Since there is no yearly survey for the capital stock input, the capital productivity growth can have some significant error. Because of this fact, KNSO is not willing to publish the capital productivity growth officially.

3.2 Total factor productivity (TFP) growth

The TFP growth is the growth in real GDP per unit of labor working ours and real fixed capital stock combined. The real (constant) GDP is obtained from "National Accounts" statistics made by The Bank of Korea quarterly (see http://www.bok.or.kr). For references for TFP, see Lee (2003), Pyo (1998) and Pyo et al. (2005).

The labor working ours is obtained from the following sources.

(a) For 5 or more persons (regular employees):

"Monthly Labor Survey" published by the Ministry of Labor (see http://laborstat.molab.go.kr).

(b) For 1-4 persons (regular employees):

"The Census on Basic Characteristics of Establishments" published by KNSO annually.

(c) For all irregular employees:

"The Economically Active Population Survey" published by KNSO monthly.

The real fixed capital stock input is obtained from "National Wealth Survey" statistics made by KNSO (see http://www.nso.go.kr). However, this survey is done every 10 years (last time in 1997), hence we cannot get yearly data from this survey. Therefore, the capital stock input for each year is estimated by Korea Institute of Public Finance and used by these estimates.

(1) TFP growth calculation

For TFP growth calculation, the Cobb-Douglas production function is used. The Cobb-Douglas production function (see APO(2003)) can be written as

$$Q = TL^{w}K^{r}$$

where Q is real GDP, L is the input for labor, K is the input for capital, and w and r are the shares (weights) of value-added received by L and K. Here, T transforms L and K into value added. Taking the natural logarithm of the function gives

$$\ln Q = \ln T + w \ln L + r \ln K.$$

and rearranging yields

$$\ln T = \ln Q - w \ln L - r \ln K.$$

Then the ratio between the time 1 (current year) and the time 0 (base year) becomes

$$\ln (T_1/T_0) = \ln (Q_1/Q_0) - w \ln (L_1/L_0) - r \ln (K_1/K_0).$$

The factor shares are taken to be the average of the share in each year, with $w = (w_0 + w_1)/2$, and $r = (r_0 + r_1)/2$. Then the growth formulae used are:

TFP logarithmic growth = GDP logarithmic growth - Input logarithmic growth

$$\text{GDP logarithmic growth} = \ln (Q_1/Q_0)$$

$$\text{Input logarithmic growth} = 0.5(w_0 + w_1) \ln(L_1/L_0) + 0.5 [(1-w_0) + (1-w_1)] \ln(K_1/K_0).$$

This gives a set of logarithmic growth rates, which are then converted to percentage annual growth rates by exponentiation.

The share (weight) w_i is the weight of labor (wage) cost from the total of the labor cost and the capital stock for the ith year.

3.3 Green productivity growth

The green productivity growth is measured by three sources which are as follows (see APO (2001-2004)).

(a) Number of firms with ISO 14000 certifications (added each year)

(b) Percentage of population with access to portable water (%)

(c) Percentage of sources of energy: coal, oil, and natural gas (%)

However, there is no aggregated index for the green productivity growth. Hence, at the present time, the green productivity growth is not a statistical index to reflect the green productivity.

Ⅳ. Comparison of Value Added Labor Productivity Among OECD Countries

As we have introduced the productivity measurement, there are several different productivities. Since the value added labor productivity in terms of money is most widely used in the world, the value added labor productivity is only compared here among all OECD countries. The value added labor productivity (VALP) used here for comparison is defined as

$$VALP = \frac{Real\ GDP(\$)}{Total\ Number\ of\ Workers}.$$

When we compare the value added labor productivity among different countries, we have to consider two important factors (see KPC(2005)).

(1) The way to compute GDP in each country. It should be standardized.

(2) GDP is computed in the currency unit of each country. GDP of each country should be converted by a common value scale to be compared.

As for the common value scale, two scales can be used. The first is the official currency exchange rate to US dollars, and the second is the PPP(Purchasing Power Parity) index made by OECD. For the first case, the official currency exchange rate can be directly used in the above equation for VALP. However, when we use the PPP, we have to modify the VALP equation as follows.

$$VALP = \frac{Real\ GDP(\$) * Ratio}{Total\ Number\ of\ Workers}$$

where the factor Ratio = (the currency exchange rate / PPP).

Table 1 shows the average PPPs and the average currency exchange rates of OECD countries based on the constant value of 2000.

〈Table 1〉 Average PPP and currency exchange rate during 1996-2003 for the 28 OECD countries (2000, constant)

country	currency unit	Average PPP (Purchasing Power Parity)	Average currency exchange rate to US $
Austria	1999 ATS euro	0.914	1.0854
Australia	Austrian $	1.310	1.7173
Belgium	1000 BEF euro	0.921	1.0854
Canada	Canadian $	1.230	1.4851
Czech	Koruny	14.36	38.598
Denmark	Kroner	8.410	8.0830
Finland	1999 FIM euro	0.979	1.0854
France	1999 FRF euro	0.915	1.0854
Germany	1999 DEM euro	0.981	1.0854
Greece	2001 GDD euro	0.684	1.0854
Hungry	Forint	107.3	282.179
Ireland	1999 IEP euro	0.953	1.0854
Italy	1999 ITL euro	0.808	1.0854
Japan	Yen	155.0	107.77
Korea	Won	753.0	1,130.96
Luxemburg	1999 LUF euro	0.990	1.0854
Mexico	Peros	6.120	9.4556
Netherlands	1999 NLG euro	0.925	1.0854
New Zealand	New Zealand $	1.450	2.1863
Norway	Kroner	9.010	8.8018
Poland	Zlotys	1.820	4.3461
Portugal	1999 PTE euro	0.650	1.0854
Slovakia	Koruny	16.06	46.035
Spain	1999 ESP euro	0.742	1.0854
Sweden	Kronor	9.190	9.1622
Swiss	Francs	1.900	1.6888
United Kingdom	Pounds	0.632	0.6596
USA	US $	1.000	1.0000

Data source: KPC(2005), OECD (www.oecd.org),
KNSO 「International Statistics Yearbook, 2005」

4.1 Basis of currency exchange rate to US dollars

If we use the average currency exchange rate to US dollars in Table 1, we can find the value added labor productivities and growth rates for the 28 OECD countries, which can be found in Table 2. The value added labor productivities of Korea during 1996-2003 based on the currency exchange rate were $21,207(1996), $21,814(1997), $21,625(1998), $23,262(1999), $24,207 (2000), $24,646(2001), $25,657(2002), and $26,493(2003). The average was $23,624 as shown in Table 2. Note that the productivity of 1998, which is the year of IMF crisis, was slightly lower than that of 1997. Korea was ranked in 22 which is rather low in productivity. However, several countries such as Greece, Hungry, Ireland, Korea, Poland, and Slovakia have more than 3.0 average growth rate, which is a promising sign for the countries. However, the growth rate is relatively low in Italy, Netherlands, Spain and Swiss which have the growth rate below 1.0%.

〈Table 2〉 Average value added labor productivity and average growth rate during 1996-2003 based on the currency exchange rate of 2000 for the 28 OECD countries

country	average value added labor productivity (US $)	rank	average growth rate (%)
Austria	46,164	14	1.3
Australia	43,046	18	1.9
Belgium	54,886	7	1.2
Canada	45,913	15	1.6
Czech	11,234	27	2.3
Denmark	56,235	6	1.4
Finland	50,903	11	1.8
France	53,811	10	1.2
Germany	48,622	12	1.1
Greece	28,337	21	3.3
Hungry	12,033	25	3.0
Ireland	54,775	8	3.4
Italy	45,700	16	0.2

〈Table 2〉 Average value added labor productivity and average growth rate during 1996-2003 based on the currency exchange rate of 2000 for the 28 OECD countries

country	average value added labor productivity (US $)	rank	average growth rate (%)
Japan	70,665	2	1.3
Korea	23,624	22	3.3
Luxemburg	70,324	3	1.6
Mexico	14,080	24	2.3
Netherlands	44,798	17	0.5
New Zealand	37,002	19	1.0
Norway	71,464	1	1.6
Poland*	11,992(01-03)	26	11.0
Portugal	21,127	23	1.0
Slovakia	9,806	28	4.3
Spain	35,553	20	0.3
Sweden	54,447	9	1.8
Swiss	58,697	5	0.9
United Kingdom	47,746	13	1.8
USA	69,137	4	2.0

*: The data of Poland were only available for 2001-2003.
Data source: KPC(2005), KNSO 「International Statistics Yearbook, 2005」

4.2 Basis of purchasing power parity

However, if we use the PPP instead of the currency exchange rate, we can find different labor productivities and growth rates. Table 3 shows the results.

The value added labor productivities of Korea during 1996-2003 based on PPP were $31,852(1996), $32,763(1997), $32,479(1998), $34,938(1999), $36,357 (2000), $37,016(2001), $38,535(2002), and $39,791(2003). The average of these figures is $35,466 as shown in Table 3. Note that because of the IMF financial crisis in 1998, the productivity growth becomes negative, which is $32,479 - $32,763 = -$284.

From Table 3, we can see that Korea was ranked in 22 which is rather low among 28 OECD countries. The value added productivity of Korea is roughly

1/2 of U.S.A. and 3/4 of Japan, which means that we still need to improve the productivity as much as we can in the near future.

〈Table 3〉 Average value added labor productivity and average growth rate during 1996-2003 based on PPP for 28 OECD countries

country	average value added labor productivity (US $)	rank	average growth rate (%)
Austria	54,821	12	1.3
Australia	56,430	9	1.9
Belgium	64,684	4	1.2
Canada	55,435	11	1.6
Czech	30,196	25	2.3
Denmark	54,048	14	1.4
Finland	56,436	8	1.8
France	63,832	5	1.2
Germany	53,797	15	1.1
Greece	44,966	21	3.3
Hungry	31,634	24	3.0
Ireland	62,384	6	3.4
Italy	61,390	7	0.2
Japan	49,135	20	1.3
Korea	35,466	22	3.3
Luxemburg	77,101	1	1.4
Mexico	21,754	28	2.3
Netherlands	52,566	16	0.5
New Zealand	55,791	10	1.0
Norway	69,812	2	1.6
Poland	28,636	26	11.0
Portugal	35,278	23	1.0
Slovakia	28,107	27	4.3
Spain	52,007	18	0.3
Sweden	54,282	13	1.8
Swiss	52,172	17	0.9
United Kingdom	49,830	19	1.8
USA	69,137	3	2.0

Data source: KPC (2005), KNSO 「International Statistics Yearbook, 2005」

Note that the ranks become different depending whether the bases are PPP or currency exchange rate. The top 3 countries by the currency exchange rate are Norway, Japan and Luxemburg, and the bottom 3 countries are Slovakia, Czeck and Poland. However, by PPP, the top 3 countries are Luxemburg, Norway and U.S.A., and the bottom 3 countries are Mexico, Slovakia and Poland. In particular, Japan is ranked number 2 in the currency exchange rate, but only number 7 in PPP.

4.3 International comparison of productivity for 2004 based on PPP (Korea = 100.0)

We have compared the average value added labor productivity during 1996-2003 for 28 OECD countries based on both PPP and currency exchange rate. Now it is of interest to compare the productivities of OECD countries on the basis of Korean productivity. Since the PPP is changing, Table 4 shows the PPPs of OECD countries for 2004. Note that the PPPs are significantly changed for some OECD countries. Table 4 includes two more countries which are Iceland and Turkey. However, Netherlands was not included because of lack of data.

In Table 4, we can observe several important statistics.

(1) Among 29 OECD countries, the Korean productivity is still low, and only 7 countries such as Czech, Hungry, Poland, Portugal, Slovakia and Turkey. Table 3 shows that the average productivity of USA was 1.949 times (69,137 / 35,466) to that of Korea during 1996-2003, and it became 1.891 times in 2004 as shown in Table 4. Even though the productivity becomes better for Korea, the difference is still big enough.

(2) Table 3 shows that the average productivity of Japan was 1.385 times (49,135 / 35,466) to that of Korea during 1996-2003, and it became 1.330 times in 2004 as shown in Table 4. Even though the productivity becomes better for Korea, the productivity of Korea is 3/4 of that of Japan.

〈Table 4〉 Productivities of 2004 for 29 OECD countries based on PPP, and indices based on Korea = 100.0

country	currency unit	PPP (Purchasing Power Parity)	Value added labor productivity based on PPP (US $)	Index
Austria	1999 ATS euro	0.908	69,277	155.5
Australia	Austrian $	1.370	63,432	142.3
Belgium	1000 BEF euro	0.883	77,653	174.2
Canada	Canadian $	1.270	63,619	142.8
Czech	Koruny	14.58	40,064	89.9
Denmark	Kroner	8.460	62,823	141.0
Finland	1999 FIM euro	0.936	67,005	150.4
France	1999 FRF euro	0.897	74,626	167.5
Germany	1999 DEM euro	0.939	65,100	146.1
Greece	2001 GDD euro	0.697	54,746	122.8
Hungry	Forint	126.19	41,325	92.7
Iceland	Kronur	90.08	61,046	137.0
Ireland	1999 IEP euro	1.01	79,076	177.4
Italy	1999 ITL euro	0.839	71,870	161.3
Japan	Yen	133.0	59,889	134.4
Korea	Won	774.0	44,565	100.0
Luxemburg	1999 LUF euro	0.980	86,652	194.4
Mexico	Peros	7.290	25,360	56.9
New Zealand	New Zealand $	1.49	48,260	108.3
Norway	Kroner	9.48	78,116	175.3
Poland	Zlotys	1.83	34,827	78.1
Portugal	1999 PTE euro	0.662	39,829	89.4
Slovakia	Koruny	17.21	35,360	79.3
Spain	1999 ESP euro	0.768	60,720	136.3
Sweden	Kronor	9.320	64,816	145.4
Swiss	Francs	1.770	60,014	134.7
Turkey	Liras	0.780	24,757	55.6
United Kingdom	Pounds	0.619	66,952	150.2
USA	US $	1.000	84,272	189.1

Data source: KPC(2005), OECD (www.oecd.org),
OECD, 「National Accounts of OECD Countries, 2005」

(3) The productivities of most European countries such as Belgium, Denmark, Finland, Germany and France are much higher than that of Korea.

(4) The countries that whose productivity is more than 70% higher than Korea are Belgium, Ireland, Luxemburg, Norway and USA. We have to analyze these countries to know why the productivities are high, and we have to learn the way that they have worked to improve productivity.

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