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Bongchan Ha
Hak K. Pyo

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Hitotsubashi University Research Unit for Statistical Analysis in Social Sciences
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Institute of Economic Research
Hitotsubashi University
Kunitachi, Tokyo, 186-8603 Japan
http://hi-stat.ier.hit-u.ac.jp/

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Bongchan Ha[1] Hak K. Pyo[2]

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[1]Researcher, Institute of Economic Research, Seoul National University (Korea) and Visiting Scholar, Institute of Economic Research, Hitotsubashi University (Japan)
[2]Professor, Department of Economics, Seoul National University (Korea)

1 Introduction

In recent years, especially since the 1997 economic crisis in the East Asian countries including Korea, considerable changes have taken place in the Korean economy, such as investment stagnation (see e.g. Pyo and Ha (2005)), changes in production input patterns, and so on. One of the most important changes is the demand for high productivity which would compensate the recent slowdowns of growth rates in capital and labor inputs. As Krugman (1994), Young (1994), and Lau and Kim (1994)'s studies showed, the East Asian economic miracle may be summarized by 'input-led' growth. However, both the stagnation in investment and the decrease in average working hours require a productivity surge for long-term growth in Korea. In addition, a sharp decrease in the fertility rate in Korea necessitates productivity increase in order to maintain the present income and facilitate the support of the large elderly population by the small numbers of working age adults. For those reasons, 'productivity-driven' growth is indispensible for Korea. According to Lewis (2004), the fast economic growth in Korea is the result of both large labor input and capital accumulation: The average working hours is 40% highter than that of the U.S., and almost a third of GDP has been allocated to investment, while GDP per capital in Korea is about half of the U.S. GDP per capita. The focus is changing from how much inputs are put into production to how well those are organized.

The purpose of this paper is to explain the data structure of Korea for the estimation of procutivities by industry in KLEMS model. We have used 72 industry classifcations according to the EU KLEMS project for the future comparability among the participants such as EU countries, the U.S., Japan, and so on. Therefore, an analysis based on detailed industrial classification gives us better views on productivity and growth, which is difficult to grasp in a broad industrial classification. Industries in an economy have shown different productivities and growth patterns according to their characteristics of production, competition policies, and other economic and non-economic circumstances.

KLEMS model is a kind of gross output growth accounting in which output is measured by gross output and inputs by capital (K), labor (L), energy (E), material (M), and service (S). Since this methodology is basically based on gross output, it has the advantage of eliminating effects of intermediate inputs from other industries on productivity, therefore allowing productivities by industry to be more accurate. Moreover, the assumption on real value-added production function (the separability assumption) is not usually guaranteed[1], which also gives legitimacy to gross output growth accounting. However, gross output growth accounting requries more information on in-

[1] See Berndt and Christensen (1973,1974), Berndt and Wood (1974), Denny and Fuss (1977), and Yuhn (1991) for the U.S., and Pyo and Ha (2004) for Korea

termediate inputs than value-added growth accounting. Therefore, the data structures for estimating productivity have to be understood carefully, and the estimation methodologies for unavailable data should be investigated extensively.

This paper is organized as follows. Section 2 examines the methodology for Input-Output analysis, and Section 3 and 4 present the measurement of capital and labor, repectively. Section 5 shows the classification of energy, material, service inputs from total intermediate inputs. Section 6 examines those input shares, and Section 7 concludes the paper.

2 Gross Output from National Accounts and Input-Output Tables

2.1 Data

National Accounts by the Bank of Korea (1999, 2004) reports annual series (1970-2002) of nominal gross outputs at basic prices, both nominal and real value-added at basic prices, nominal compensation of employees, and nominal operating surplus of 21 industries including 9 manufacturing industries. Those data can be extended to the year 2005 from ECOS (Economic Statistics System) in the Bank Of Korea website[2]. National Accounts (1987, 1994, 1999, 2004) also reports annual series (1985-2002) of both nominal and real Make Tables (V-Tables) and real Used Tables (U-Tables). In addition to nominal gross output and both nominal and real value-added, real gross output at basic prices and real intermediate inputs at purchase prices can be obtained from Used Tables. However, since Make Tables and Used Tables for the years 1970-1984 and 2003-2004 are unavailable, we have generated them through RAS using annual data from National Accounts and Input-Output Tables, and benchmark tables of 1985 and 2002, respectively. As the published Used Tables of National Accounts in Korea present the Domestic and Import Used Tables combined, we have not been able to isolate them into two separate tables. In the case of Used Tables before 1995, all the intermediate commodity inputs by industry are measured at purchase prices. Since 1995, those inputs have been measured at incomplete basic prices in the sense that those inputs include trade and transportation margins but isolate net production tax to the last row of intermediate input matrix. Because we have no information for transformation of the Used Tables from purchase prices to basic prices before 1995 and the Used Tables after 1995 hae been measured at incomplete basic prices, we have changed the Used Table at basic price after 1995 into purchase priced Used Tables inputs allocating net production tax to each commodity proportional to each volume.

[2] http://www.bok.or.kr

The Bank of Korea has also published Input-Output Tables (commodity-by-commodity) since 1960. Its most recent 2000 Input-Output Table is the 19th Table. The detailed description of Input-Output Tables during 1970-2000 is summarized in Table 1. Input-Output Tables of Korea have relatively detailed information, even though they are restricted to commodity-by-commodity tables. For example, the table for 2000 has 28, 77, 168, 404 commodities in large, medium, small, and basic classifications, respectively.

Table 1. Input-Output Tables in Korea

Year	Basic	Small	Medium	Large
1970		153	56	
1973		153	56	
1975	392	164	60	
1978		164	60	
1980	396	162	64	
1983	396	162	64	19
1985	402	161	65	19
1986		161	65	20
1987		161	65	20
1988		161	65	20
1990	405	163	75	26
1993		163	75	26
1995	402	168	77	28
1998		168	77	28
2000	404	168	77	28

(Number of commodity classification)

2.2 Estimation of Used Tables

2.2.1 Reclassification of Industries

While National Accounts do not contain detailed information about industries (21 industries), our industrial classification is 72 industries according to EU KLEMS classification (See Appendix Table A-1). In order to reconcile the National Accounts data to our industrial classification, we have used other data sources, such as Mining & Manufacturing Census and Surveys, Wholesale and Retail Surveys, and so on. Since we do not have detailed information on intermediate input structures, we have assumed the same intermediate input structures for the industries belonging to the same category of National Accounts classification. As for Input-Output Tables, they have detailed commodity classifications enough to match the 21 commoditiy classifications in National Accounts. However, since they are not annually published, we have used interpolation method for the missing years. We have attached reclassification of National Accounts into 72 industries in Appendix Table A-2.

2.2.2 Commodity Prices and Intermediate Inputs

Since the Bank of Korea reports nominal and real Make Tables and real Used Tables, nominal Used Tables should be generated for obtaining nominal intermediate input shares, which are used in estimating total factor productivity. Following the guidance by Timmer (2005), we have used the commodity prices to nominalize all uses of the commodities under the assumption that the same commodity has the same price whichever industry uses it.

$$P_{ij}^{X} = P_i^{C} \qquad \text{for all } j \tag{1}$$

where P_{ij}^{X} denotes a price index for intermediate input of commodity i in industry j, and P_i^C denotes a price index of commodity i.

The commodity prices (P_i^C) we have used are the weighted averages of domestic and imported commodity prices, since the Used Tables cannot be separated into domestic and imported Used Tables to apply separated prices. Producer's Price Index (PPI) has been used as a proxy for domestic commodit prices (P_i^D), and Imported Price Index (CIF) has been used as imported commodity prices(P_i^{IM}). Even though PPI is not purchaser's price for the lack of transportation and trade margins, it is a reasonable proxy for domestric commodity price index. The above procedure can be shown as follows:

We can derive real domestic commodity inputs (X_i^D) substracting real imported commodity inputs in Input-Output Tables (X_i^{IM}) from real commodity inputs in Used Tables (X_i).

$$X_i^D = X_i - \frac{P_i^{IM} X_i^{IM}}{P_i^{IM}} \tag{2}$$

From Eq(2), we can calculate the weighted average commodity price index using nominal domestic and imported intermediate commodity inputs.

$$P_i^C = \frac{P_i^D X_i^D}{P_i^D X_i^D + P_i^{IM} X_i^{IM}} \cdot P_i^D + \frac{P_i^{IM} X_i^{IM}}{P_i^D X_i^D + P_i^{IM} X_i^{IM}} \cdot P_i^{IM} \tag{3}$$

Using Eq (1) and (3) we have nominalized each intermediate input in Used Tables, and normalized its value in order to equalize it with the nominal intermediate inputs in National Accounts as following:

$$PX_{ij}^{(1)} = X_{ij} \cdot P_{ij}^{X} \tag{4}$$

$$PX_{ij} = PX_{ij}^{(1)} \cdot \frac{PX_j}{\sum_i PX_{ij}^{(1)}} \tag{5}$$

where $PX_{ij}^{(1)}$ and PX_{ij} denote a first estimate and a final estimate of intermediate input commodity i in industry j, respectively. X_{ij} denotes real intermediate input commodity i in industry j, and PX_j denotes total nominal intermediate input in industry j.

2.3 Estimation of Make and Used Tables for the missing years

We have estimated the Make and Used Tables for the missing years, 1970-1984 and 2003-2004 through a biproportional adjustment methodology, RAS. For the years 1970-1984 we have used the 1985 tables as benchmark tables, and for the years 2003-2004 we have used the 2002 tables. We have annual series of each industry's gross output, value-added, intermediate input, and so on. However, because we do not have annual series of each commodity's data in Input-Output Tables, we have applied the interpolation method beween existing tables and normalized them to the National Accounts data.

2.4 Aggregation Issues

A Make and Used Table framework gives more detailed information of transactions in an economy than aggregated National Accounts data: constant values, volume indices, and price indices of commodities. In addition to this, the ESA 95 Input-Output Manual (2002) gives more advantages: (1) the numerical consistency, reliability and plausibility, (2) differenct volume indices and deflators according to different level of aggregation, (3) relationship between trade and transport margin, taxes, subsidies, and so on.

We have applied a simple summation for the Make Table aggregation over commodities under the assumption of the same deflator over all commodities produced in the sam industry following the guidance of Timmer (2005). With regard to the aggregation in Used Tables, we have not applied any aggregation technique considering each commodity as different inputs.

In order to aggregate detailed industrial data, we have used chained Laspeyres Index following the guidance of Timmer (2005). While the major advantage of chained Laspeyres index is addditivity, it can also give us an advantage of a better match between products in consecutive time periods than between periods that are far apart (SNA -1993). Since this index uses changing weights, the problems of rapid shifts in the composition of an economy are minimized.

2.5 Make Tables at Purchase Prices and Used Tables at Basic Prices

Purchase prices and basic prices are defined as follows:

$$
\begin{aligned}
& \text{Purchase price} \\
= \; & \text{Basic price} \\
& +\text{Trade margins (TR)} \\
& +\text{Transport margins (TT)} \\
& +\text{Non-deductible VAT (TV)} \\
& +\text{Other taxes on products - Subsidies on products (T)} \qquad (6)
\end{aligned}
$$

We will explain the method of transforming Make Tables at basic prices into those at purchase prices, but the reverse procedure can be applied without significant modification.

In order to transform Make Tables at basic prices into those at purchase prices, valuation matrices of the above four components (TR_{ij}, TT_{ij}, TV_{ij}, and T_{ij}) are needed. However, the information we have regarding those components are only the commodity vectors of TR, TT, and T[3]. The data regarding non-deductible VAT does not exist. Due to data unavailability, we have not been able to transform Make Table at basic prices into those at purchase prices in matrix forms like the following:

$$PY_{ij}^{pur} = PY_{ij}^{bas} + TR_{ij} + TT_{ij} + T_{ij} \qquad (7)$$

where PY_{ij}^{pur} and PY_{ij}^{bas} denote the supply of commodity i in industry j.We have transformed Make Tables at purchase prices into vector forms of commodity adding up the rows over industry like the following

$$PY_{i}^{pur} = PY_{i}^{bas} + TR_{i} + TT_{i} + T_{i} \qquad (8)$$

Also, in order to isolate imported commodities from total commodity supply, we have used the information on imported commodity vectors from Input-Output Tables to derive the following vectors:

$$PY_{i}^{bas} = PY_{i}^{D} + PY_{i}^{IM} \qquad (9)$$

where PY_{i}^{D} and PY_{i}^{IM} denote domestic and imported (before tariffs) commodity supply, respectively. Trade margins and Transportation margins are normalized to equal the total supply of the respective commodity. Net taxed on products and imports are also normalized to respective National Accounts annual series.

The above procedures have been applied to the transformation of Used Table at purchase prices into those at basic prices. Used Tables at basic prices have also been generated incompletely by substracting the valuation commodity vectors from the commodity directions.

[3]Those vectors have been obtained from Input-Output Tables (commodity-by-commodity), so we are not able to know industry-by-commodity matrix.

The above procedures have been shown in Figure 1 and 2, and the trends of gross output and value-added have been shown in Figure 3.

Figure 1. Make Table at purchase prices

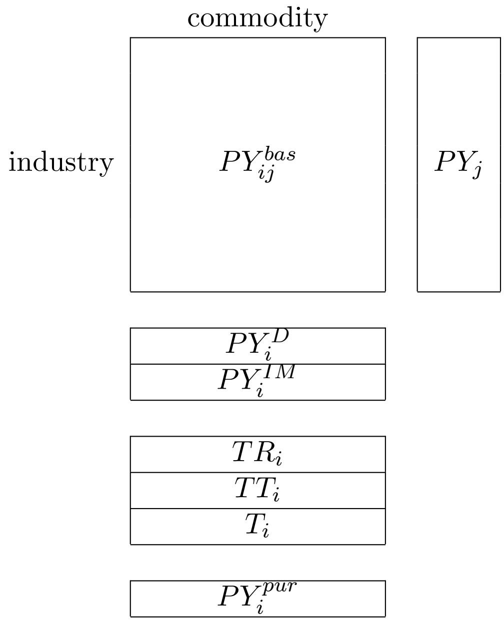
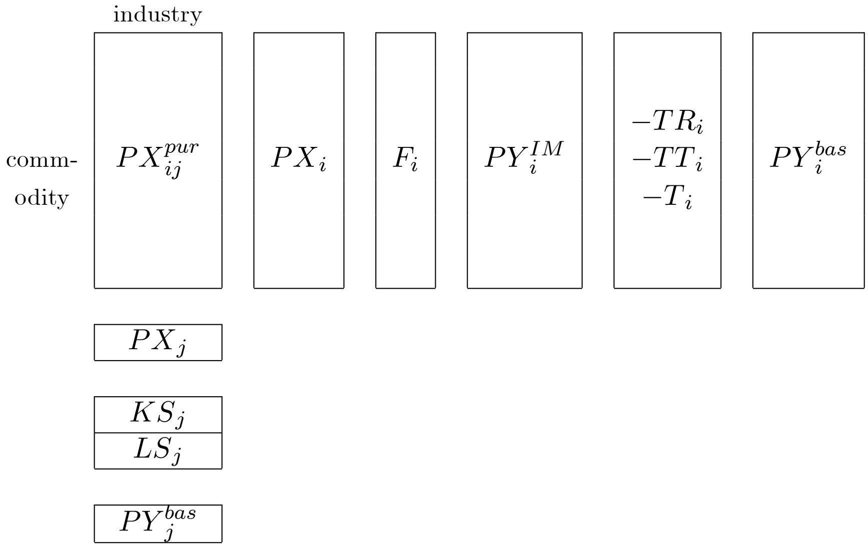
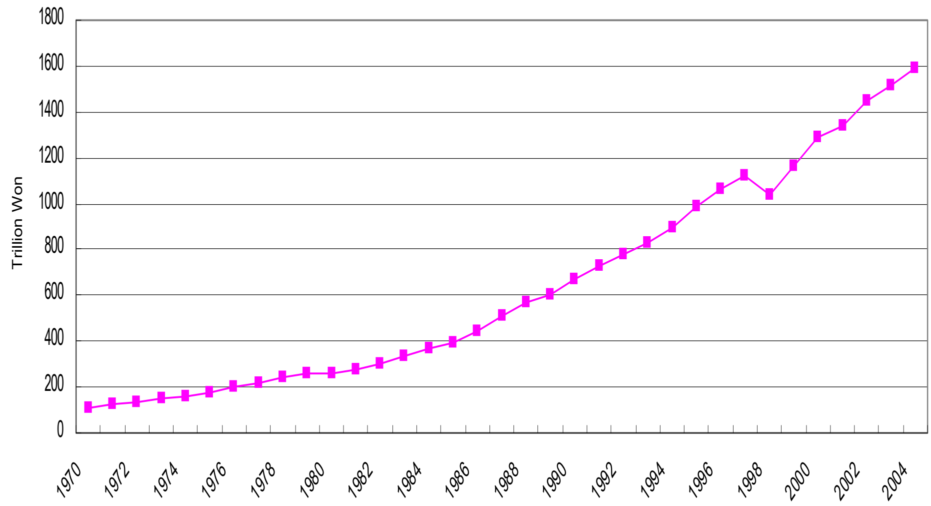


Figure 2. Used Table at basic prices



(Note) KS_j and LS_j denote shares of capital and shares of labor in industry j respectively. F_i denotes final demand of commodity i.

Figure 3. Trend of Real Gross Output (2000 prices)



3 Measurement of Capital Input

The success of late industrialization by newly industrializing economies could not have been made possible if both the rapid accumulation of capital and its changing distribution among sectors were not realized in their development process. However, it is difficult to identify these factors empirically because the time series data of capital stocks in fast-developing economies by both types of assets and by industries are not readily available. The lack of investment data for a sufficiently long period of time to apply the perpetual inventory estimation method was the main cause of the problem. However, the National Statistical Office of the Republic of Korea has conducted nation-wide national wealth survey four times since 1968. Korea is one of a few countries which have conducted economy-wide national wealth surveys at a regular interval. Since the first National Wealth Survey (NWS) was conducted in 1968, the subsequent surveys were made in every ten years in 1977, 1987, and 1997, respectively. Since such regular surveys with nation-wide coverage are very rare in both developed and developing countries, an analysis on the dynamic profile of national wealth seems warranted to examine how national wealth in a fast growing economy is accumulated and distributed among different sectors.

The estimation of national wealth by types of assets and by industries was made by Pyo(2003) by modified perpetual inventory method and polynomial benchmark year estimation method using four benchmark-year estimates. We have extended his estimates to the year 2004, and changed the base year from 1995 to 2000.

3.1 Estimation of Capital Stock[4]

3.1.1 Estimating Method for 1970-1997

In principle the existence of four benchmark year estimates of gross and net capital stocks makes it possible for us to apply the polynomial benchmark year estimation method. In Pyo's earlier studies (Pyo 1988, 1992, and 1998), he estimated proportional retirement rates and depreciation rates both by types of assets and by industries based on the polynomial equations.

When we applied the polynomial benchmark year equation to estimate the proportional retirement rates for the sub-periods of 1977-87 and 1987-97, most of estimates became negative including the average economy-wide retirement rates (-3.0% for 1977-87 and –3.1% for 1987-97) except other Construction (0.6%) and Transport Equipment (3.4%) in 1977-87 and Non-residential Building (0.9%) in 1987-97. Therefore, following Pyo (1998), we have applied the polynomial benchmark year estimation method to estimating depreciation by types of assets only. Thus we have generated net stocks by types of assets first for the period of 1968-97 and then, distributed them over different sectors of industries by using interpolated industrial weights between the respective benchmark years.

We have decided to estimate net capital stock first and then to estimate gross capital stock by using interpolated net-gross conversion ratios for the following two reasons. The basic reason is due to the fact that the margin of prediction error from the polynomial benchmark year equation turns out to be larger with gross capital stock than with net capital stock as had been observed in Pyo (1992).

3.1.2 Estimating Method after 1997

National Statistical Office of Korea has decided to terminate National Wealth Survey by 1997 and to switch from direct estimation to indirect estimation of national wealth following the method of BEA and OECD. The cost of such direct national wealth survey has increased significantly as the size of national economy has expanded considerably. In addition, some of the participating institutions such as Kookmin Bank for unincorporated business enterprises have been privatized so that National Statistical Office alone can no longer afford national wealth survey. Japan had terminated its National Wealth Census in 1970 for almost the same reasons.

Therefore, for the period after 1997 which is the last national wealth survey, we have to estimate capital stocks by a modified perpetual inventory method using 1997 NWS as benchmark estimates. First, we estimate net stocks by type of assets in constant prices by using the depreciation rates estimated from the period of 1987-1977 and distribute them across industries

[4] This section has been quoted from Pyo, Rhee, and Ha (2004)

using both industrial weights in 1997 NWS and those in subsequent Mining & Manufacturing Census and Surveys and Wholesale and Retail Surveys. In the long run, the estimated depreciation rates by type of assets may need to be updated and revised by the micro data-based studies. Second the generated net stocks by type of assets and by industries have to be converted into gross stock by using the net-gross conversion ratio of 1997 NWS for the time being. But ultimately we may need further studies on the trend of net-gross conversion ratio by type of assets and by industries and the average asset life.

3.1.3 Reconciliation with Database of Pyo(2003)

Since the database of Pyo (2003) covers 10 broad categories of industrial sector together with 28 sub-sectors of Manufacturing, it has been reclassified and reconciled with 72 industry classification using other sources such as Mining & Manufacturing Census and Surveys, Wholesale and Retail Surveys, and so on. We have classifed assets into five categories; residential building, non-residential building, other construction, transportation vehicles, and machinery, while excluding large animals & plants, household durables, and inventory stocks as shown in Table 2.

3.2 Estimation of Capital Service Inputs

The purpose of this subsection is to outline the estimation of capital service flows in Korea. We have followed the mothodology of Jorgenson, Ho, and Stiroh (2005) except the adjustment for a rapid IT asset price decline: The capital service flows for each asset have been estimated from the capital stocks, and have been aggregated over all the assets.

We have assumed that the flow of capital service is proportional to the average of current and one-year previous capital stocks, which means that currently installed capital stock is available in the midpoint of the installed period. The k-type capital service flow in industry j at time t can be defined as in Eq. (10).

$$K_{k,j,t} = q_{k,t} \cdot \left[\frac{Z_{k,j,t} + Z_{k,j,t-1}}{2} \right] \tag{10}$$

where $Z_{k,j,t}$ denotes the k-type capital service flow in industry j at time t, and $q_{k,t}$ denotes normalizing factor.

We have estimated the price of capital service through the user cost of capital formula by Jorgenson. This methodology derives the cost of capital by the equality between two alternative investments: earning a nominal rate of return (i_t) and investing in asset earning a rental fee and selling the depreciated asset:

$$P^K_{k,j,t} = (i_t - \pi_{k,j,t}) \cdot P^I_{k,j,t-1} + \delta_k \cdot P^I_{k,j,t} \quad (11)$$

where $\pi_{k,j,t}$ denotes the (expected) capital gains $((P^I_{k,j,t-1} - P^I_{k,j,t})/P^I_{k,j,t-1})$, and δ_k denotes the depreciation rate specific to k-type asset.

We have used yields of corporate bonds for nominal rates of return (i_t) and Pyo's (2003) results for depreciation rates as shown in Table 2. We did not consider tax effects in estimating cost of capital for the unavailability of data.

Table 2. Depreciation Rates of Assets (Unit: %)

	before 1978	1978-1987	after 1988
Residential Building	5.5	1.2	3.3
Non-residential Building	-6.7	-1.3	3.0
Other Construction	9.7	8.4	1.0
Transportation Vehicles	49.3	28.7	16.9
Machinery	1.1	11.4	9.2

Source : Pyo (2003)

Using the above capital service flow and capital service price of each asset, we have derived aggregated capital service input by a Tornqvist index.

$$\Delta \ln K_j = \sum_k \overline{v}_{k,j} \cdot \Delta \ln K_{k,j} \quad (12)$$

where the $\overline{v}_{k,j}$ are the two-period average shares of the k-type capital income in total capital income.

We have also estimated implicit price index of capital inputs (P^K_j) from the following equality:

$$P^K_{j,t} \cdot K_{j,t} = \sum_k P^K_{k,j,t} \cdot K_{k,j,t} \quad (13)$$

3.3 Stagnation of Investment after 1997 in Korea

After the economic crisis, the trend of investment in Korea changed drastically as shown in Figure 4. The growth of investment has slowed down and the volatility of investment has increased greatly. The growth rates of all types of assets have decreased as shown in Figure 5. According to Pyo and Ha (2005), this phenomenon is not confined to Korea, but is common in all crisis-conflicted economies: Indonesia, Malaysia, Philippines, Thailand, and so on. Although not to the extent of the above economies, this phenomenon is also observed in non-crisis-conflicted economies; Japan, Singapore, Taiwan, Hong Kong, and China. Pyo and Ha (2005) have confirmed that there were structural breaks between before- and after- crisis, and found that asymmetrical adjustment, institutional rigidities, and shortage of infrastructure for R&D and education have caused those breaks.

Figure 4. Trend of Real Capital Stock (2000 prices)

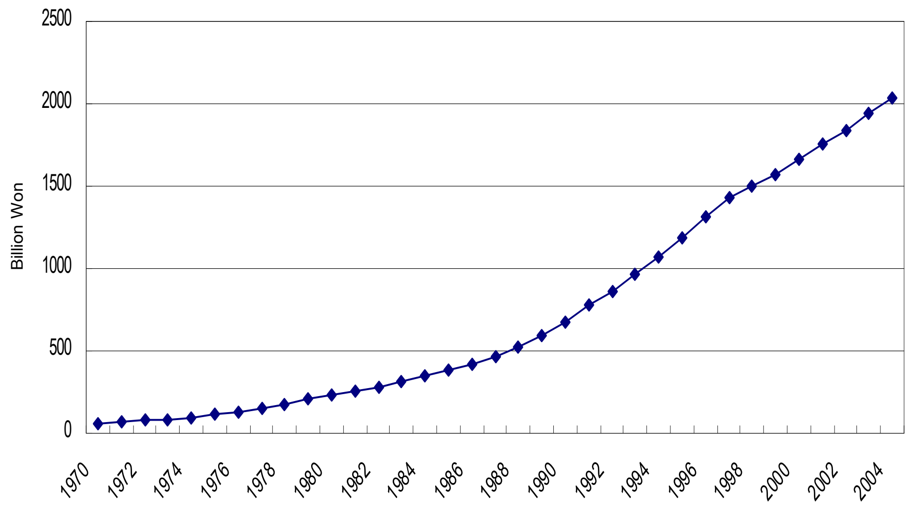
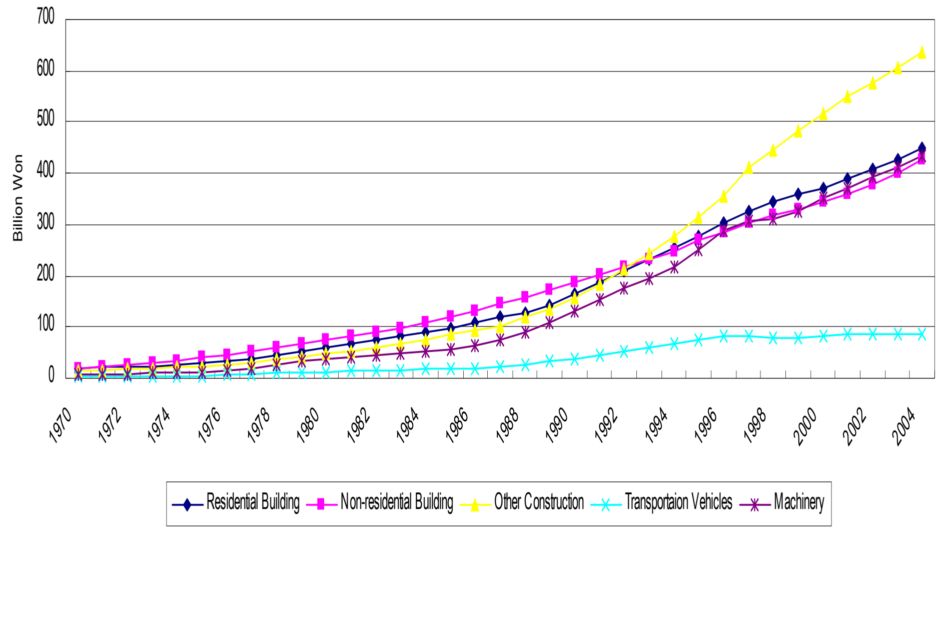


Figure 5. Composition of Real Capital Stock (2000 prices)



4 Measurement of Labor Input

4.1 Data

In order to measure labor input for KLEMS model, we have to obtain both quantity data of labor input such as employment by industries and hours worked and quality factors such as sex, education and age. Both availability and reliability of labor statistics in Korea have improved since 1980. But the measurement of labor input by industries cannot be readily made because the statistics of employment by industries are not detailed enough to cover 72 sectors. Therefore, we have used other sources for breaking down the labor data. More detailed classifications of employment will have to rely on Employment Table, which is published as a supporting table to Input-Output Table. But it is available only every five year when main Input-Output Tables are published. Mining and Manufacturing Census and Survey by National Statistical Office also report employment statistics but it is limited to mining and manufacturing only.

Economically Active Population Yearbook by National Statistical Office reports the number of employment, unemployment, not-economically-active population and economically active population. Report on Monthly Labor Survey by Ministry of Labor publishes monthly earnings and working days of regular employees. Survey Report on Wage Structure by the same ministry reports wages. Nominal wages are also available from this survey.

For the present study, we have obtained the raw data file of Survey Report on Wage Structure from the Ministry of Labor and Economically Active Population Survey from National Statistical Office for the period of 1980-2003. The data are classified by two types of gender (Male and Female), three types of age (below 30, 30-49, and 50 above), and four types of education (middle school and under, high school, college, and university above) and, therefore, there is a total of 24 categories of labor as shown Table 3.

Table 3. Classification of Labor Input

	Categories
Gender	(1) male (2) female
Age	(1) below 30 (2) 30-49 (3) above 50
Education	(1) middle school and under (2) high school
	(3) college (4) university or above

4.2 Estimating Labor Quantity and Quality Inputs

Since the raw-data file of the Survey Report on Wage Structure contains more detailed industrial classification than that of the Economically Active

Population Survey, we calculated the quantity of labor from the Economically Active Population Survey and the quality of labor from the Survey Report on Wage Structure. This enables us to include self-employed labor as well as to use more detailed data. However, since the Survey Report on Wage Structure does not include the Agriculture and Government sectors, we had to use the average value of the entire economy for the quality measure of these two sectors.

In order to make quality adjustments to the employment data, we have taken the following steps[5]:

(1) Defining P_{Ll}^{j} as wage rate for j industry and l type category of labor, the share of labor income by l type category of labor in j industry can be expressed as;

$$v_{Ll}^{j} = \frac{P_{Ll}^{j} L_{l}^{j}}{\sum\limits_{l} P_{Ll}^{j} L_{l}^{j}} \tag{14}$$

The average weight of j industry and l type labor income during the period of $(t-1)$ and t can be generated as;

$$\overline{v}_{Ll}^{j} = \frac{1}{2}\left[v_{Ll}^{j}(t) + v_{Ll}^{j}(t-1)\right] \tag{15}$$

(2) In order to make a quality adjustment to labor input data, we have further decomposed labor input of j industry and l type as follows:

$$L_{l}^{j}(t) = d_{l}^{j}(t) \cdot M^{j}(t) \cdot H^{j}(t) \tag{16}$$

where $d_{l}^{j}(t)$ denotes relative weight of working hours of l type in j industry. In other words, $L_{l}^{j}(t)$ measures labor input of l type labor in j industry. $M^{j}(t)$ and $H^{j}(t)$ denote the employment and average working hours of j industry respectively.

(3) Finally, the growth rate of j industry labor input has been computed as follows:

$$\begin{aligned} \ln L^{j}(t) - \ln L^{j}(t-1) &= \left[\ln M^{j}(t) - \ln M^{j}(t-1)\right] \\ &\quad + \left[\ln H^{j}(t) - \ln H^{j}(t-1)\right] \\ &\quad + \sum_{l} \overline{v}_{Ll}^{j}\left[\ln d_{l}^{j}(t) - \ln d_{l}^{j}(t-1)\right] \end{aligned} \tag{17}$$

where the first bracket on the right hand side measures change in employment, the second bracket measures change in average working hours, and

[5] Jorgenson, Gollop, and Fraumeni (1987)

the third bracket measures the change in quality of labor through change in weighted working hours. This method defines that total labor input growth is measured by the sum of separate growth of different categories of labor and that the quality of labor is measured by the difference between the growth of aggreagated labor and the sum of the separate growth of different categories of labor.

5 Measurement of Energy, Material, and Service Inputs

In order to decompose intermediate inputs into energy (E), material (M), and service (S) inputs, we have identified coal and lignite, crude petroleum and natural gas, uranium and thorium ores, metal ores, coke, refined petroleum products and nuclear fuel, gas, water, and electricity commodities as energy inputs, both primary commodities and remaining manufacturing commodities as material inputs, and remaining service inputs as service inputs.

6 Input Shares

Regarding shares of inputs, we have used compensation of employees as shares of labor inputs and remaining value-added as shares of capital inputs. This method may underestimate the shares of labor input by allocating the compensation of self-employed to the shares of capital input, and this gap is especially great in primary industry. There are some adjustment processes for that underestimation, for example Harberger (1978), but we have not applied it for avoiding arbitrary adjustments. This can be improved in future studies. As for energy, material, and service inputs, we have used nominal inputs for their own shares.

7 Conclusion

The purpose of this paper is to explain the methodologies how the database has been established for estimating productivities by industry in KLEMS model. For this purpose we have employed several conceptual tool and data as follows.

(1) Gross Output and Intermediate Inputs

We have used Make Tables and Used Tables as well as Input-Output Tables (commodity-by-commodity) for measuring gross output and intermediate input (energy, material, and service). In order to generate tables in missing years, we have applied RAS method. The weighted average of

Producer's Price Index and Imported Price Index has been applied for input prices in Used Tables.

(2) Capital Input

Pyo (2003)'s estimates have been reconciled for capital stock, and the user costs of capital by Jorgenson have been generated for estimating capital service inputs.

(3) Labor input

Total labor input is decomposed into labor quantity (menhour) and labor quality. The former is generated form the Economically Active Population Yearbook by NSO, and the latter from the Survey Report on Wage Structure by Ministry of Labor while following the methodology of Jorgenson, Gollop, and Traumeni (1987).

Productivities in an economy are not identical over industries, and productivity differences are also observed when compared with the same industry in other economies. For example, most industries in Japan exhibit higher productivity such as electrical machinery, motor, other transport vehicles, and instruments industries resulting in higher productivity in the entire economy. However, total factor productivities of Korea in construction, petroleum products, fabricated machinery, and finance industries are higher than those of Japan. International comparison of productivity among industries will demonstrate a relative productivity of each industry, illustrating whether the way the goods or services are produced is relatively efficient or not and referring to the appropriate policies for improvement such as competition, restriction, R&D policies, and so on. Establishement of dataset with the same standards for productivity measurement will facilitate these inter-industry and international comparison, and contribute to a better understanding of economic growth.

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Appendix

Table A-1. EU KLEMS Industrial Classification

	EU KLEMS
1	Agriculture
2	Forestry
3	Mining of coal and lignite;extraction of peat
4	Extraction of crude petroleum and natural gas and services
5	Mining of uranium and thorium ores
6	Mining of metal ores
7	Other mining and quarrying
8	Food products and beverages
9	Tobacco products
10	Textiles
11	Wearing Apparel, Dressing And Dying Of Fur
12	Leather, leather products and footwear
13	WOOD AND PRODUCTS OF WOOD AND CORK
14	Pulp, paper and paper products
15	Coke, refined petroleum products and nuclear fuel
16	Rubber and plastics products
17	OTHER NON-METALLIC MINERAL PRODUCTS
18	Basic metals
19	Fabricated metal products
20	MACHINERY, NEC
21	Office, accounting and computing machinery
22	Motor vehicles, trailers and semi-trailers
23	Manufacturing nec
24	Recycling
25	WATER SUPPLY
26	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
27	Wholesale trade and commission trade, except of motor vehicles and motorcycles
28	Retail trade, except of motor vehicles and motorcycles; repair of household goods
29	Inland transport
30	Water transport
31	Air transport
32	Supporting and auxiliary transport activities;activities of travel agencies
33	POST AND TELECOMMUNICATIONS
34	Financial intermediation, except insurance and pension funding
35	Insurance and pension funding, except compulsory social security
36	Activities related to financial intermediation
37	Renting of machinery and equipment
38	Computer and related activities
39	Research and development

Table A-1. EU KLEMS Industrial Classification (Continued)

	EU KLEMS
40	Sewage and refuse disposal, sanitation and similar activities
41	Activities of membership organizations nec
42	Other service activities
43	Publishing
44	Pharmaceuticals
45	Insulated wire
46	Electronic valves and tubes
47	Telecommunication equipment
48	Radio and television receivers
49	Building and repairing of ships and boats
50	Aircraft and spacecraft
51	Gas supply
52	Printing and reproduction
53	Chemicals excluding pharmaceuticals
54	Other electrical machinery and apparatus nec
55	Scientific instruments
56	Other instruments
57	Railroad equipment and transport equipment nec
58	Electricity supply
59	Imputation of owner occupied rents
60	Other real estate activities
61	Legal, technical and advertising
62	Other business activities, nec
63	Media activities
64	Other recreational activites
65	FISHING
66	CONSTRUCTION
67	HOTELS AND RESTAURANTS
68	PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY
69	EDUCATION
70	HEALTH AND SOCIAL WORK
71	PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS
72	EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES

Table A-2. Reclassification of National Accounts into 72 Industries

	National Accounts	EU KLEMS
1	Agriculture, Forest and Fishing	1, 2, 65
2	Mining and Quarrying	3-7
3	Food, Beverages and Tobacco	8-9
4	Textiles and Leather	10-12
5	Wood, Paper, Publishing and Printing	13, 14, 43, 52
6	Petroleum, Coal and Chemicals	15, 44, 53
7	Non-metallic Mineral Products except Petroleum and Coal	16, 17
8	Metal, Fabricated Metal Products	18, 19
9	Machinery and Equipment	20, 21, 45-48, 54-56
10	Transport Equipment	22, 49-50, 57
11	Furniture and Other Manufacturing Industries	23, 24
12	Electricity, Gas and Water	25, 51, 58
13	Construction	66
14	Wholesale and Retail Trade, Restaurants and Hotels	26-28, 67
15	Transport, Storage and Communcation	29-33
16	Financial Intermediation	34-37
17	Real Estate, Renting and Business Activities	38, 39, 59, 60-62
18	Public Administration and Defense; Compulsory Social Security	68
19	Education	69
20	Health and Social Work	70
21	Other Service Activities	40-42, 63-64, 71, 72