The 2008 World Congress on National Accounts and Economic Performance Measures for Nations
May 12-17, 2008, Washington DC
May 14 Session 1

The Estimation of Industry-level Capital Stock for Emerging-Market and Transition Economies

Hak K. Pyo
pyohk@plaza.snu.ac.kr
Seoul National University

The paper shows the inherent danger of applying perpetual inventory method to estimating net capital stock and productive capital stock for developing economies as emphasized by Ward (1976a). The limited availability of long time series of investment data makes it inevitable to rely on other alternative methods of estimating capital stock. Based on the empirical experience with constructing Korea Industrial Productivity Database, relative merits of alternative estimation methods of capital stock are discussed and implications for estimating capital stock at industry-level for emerging-market and transition economies are derived. In addition, the issue of decomposing ICT and non-ICT capital stock by OECD and EU-KLEMS is revisited. In order to capture real contribution of ICT capital on the user side, it is argued that consumer durables need to be included as capital stock following Bureau of Economic Analysis (1993).

* The research has been supported by the Second Brain Korea 21 project, Department of Economics, Seoul National University administered through Ministry of Education of Korea. I am indebted to research assistance by Sunyoung Jung.

1. Introduction

As the international comparison of productivities among nations move from aggregate level such as ICP (International Comparisons Project) to industry-level such as ICPA (International Comparison of Productivity among Asian Countries) project and EU KLEMS project, there are two key issues to be resolved. One is the method of generating purchasing power parity and the choice between expenditure purchasing power parities and unit value ratios as recently addressed by Timmer ,Ypma and van Ark (2007c). The other is to estimate capital stock at industry-level to impute capital service input by industry. The purpose of the present paper is to address the second issue particularly in the context of international comparison of productivities with emerging market economies and transition economies.

The Perpetual Inventory Method (PIM), which accumulates real investment series, has been the most commonly used method of estimating capital stocks. EU KLEMS Growth and Productivity Accounts also adopt PIM and apply geometric depreciation rates to estimate net capital stocks. However, as noted by Ward (1976a) and OECD (2000), the method may generate capital stock series far from realities that can be inconsistent with underlying magnitudes of output and other inputs. The validity of PIM crucially depends on whether the following three conditions are met: the availability of real investment series longer than expected lifetime of assets, the stability of investment deflator being used to deflate current price investment series and the reasonable estimates of depreciation rates by both types of assets and industries. These conditions are not usually met by emerging market economies and transition economies.

For example, emerging market economies such as Russia, Mexico, Brazil, Indonesia, Malaysia, Philippines, Thailand and South Korea have experienced financial crises and the sharp reduction in output and real investment. Recently these crises have come in the form of “twin crises” where foreign exchange crisis is combined with domestic credit and banking crisis resulting in sudden reduction of real investment. According to IMF (2003), during the capital account crisis in 1998, three representative emerging market economies experienced a significant reduction in growth of GDP: Indonesia (13.1 %), South Korea (- 6.7 %) and Brazil (0.1 %). In case of South Korea, the growth rate of real gross fixed capital formation fell from 13.1 percent and 8.4 percent in 1995 and 1996 respectively to -2.3 percent and – 22.9 percent in 1997 and 1998 respectively. Then the application of PIM breaks down because the reduction of real investment becomes greater than depreciation making the real level of capital stock itself is likely to be reduced.

The application of PIM to transition economies is more problematic because those economies used GMP (Gross Material Product) instead of GDP and Fixed Asset Balance Sheets (FA B/S) instead of gross fixed capital formation on national income accounts. Since their fixed assets were evaluated at "plan prices" and were deducted by only physical deterioration without accommodating the reduction of asset values due to obsolescence, they tend to be overestimated because the replacement value after the transition period becomes much higher due to the usual hyper-inflation during transition to market economies. According to Svejnar (2002), all of the transition economies experienced unexpectedly large declines in output at the start of the transition ranging from 13 to 25 percent in Central and Eastern Europe to 45 to 65 percent in Russia and Ukraine. It also points out that while the Central and Eastern European countries reversed the decline after 3-4 years, in Russia and the CIS no turnaround was visible through most of the 1990s. All of transition economies experienced hyperinflation: Poland, Slovenia, Albania, Bulgaria, and Romania (200 % in at least one year during 1990-1993), Estonia, Latvia, and Lithuania (around 1,000 %), Russia, Ukraine and Kazakhstan (at least one year above 2,000 %). Even though their inflation rates came down to the range of 9 to 35 percent by 2001, the application of PIM to those economies' dataset needs careful attention. However, the data on Fixed Asset Balance Sheets prior to the early 1990's can serve as benchmark estimates in PIM.

In particular, if we are interested in comparing level-productivity among nations including emerging market and transition economies, we need to supplement PIM. For level comparison of productivities among nations we cannot ignore initial values of capital stocks in each country and therefore, and should come up with some ways of recovering initial values and supplementing PIM. For this purpose, the paper is organized as follows. In section 2, a simultaneous estimation of production functions and capital stocks proposed by Dadkhah and Zahedi (1986) is applied to estimate the initial values from which PIM can be used. Section 3 deals with industrial decomposition of capital stocks when earlier investment data are missing and when the investment data are available by either types of assets or by industries but not by both. Section 4 revisits several issues in estimating capital stocks for emerging market and transition economies such as estimation of depreciation rates, the decomposition of ICT and non-ICT capital stocks and the imputation of capital service inputs. The last section concludes the paper.

2. The Estimation of Initial Capital Stocks

In applying PIM to estimate capital stocks at industry-level, we need reliable data or information on initial capital stocks, real investment series and depreciation rates by industries.

2.1 Model

Following Dadkhah and Zahedi (1986), consider an aggregate Cobb-Douglas production function with the assumption of constant returns to scale:

$$Q_t = AK_t^{\alpha} L_t^{1-\alpha} \tag{1}$$

where
Q_t = output produced during period t,
K_t = capital stock at the beginning of period t,
L_t = labor utilized during period t

It can be rewritten as:

$$K_t = (Q_t / AL_t^{1-\alpha})^{(1/\alpha)} \tag{2}$$

$$Q_t = [(1-\lambda)Q_{t-1}^{\frac{1}{\alpha}} L_{t-1}^{-\frac{(1-\alpha)}{\alpha}} + I_{t-1}]^{\alpha} L_t^{1-\alpha} \tag{3}$$

Write the production function in a growth rate form as

$$\dot{Q}_t = \alpha \dot{K}_t + (1-\alpha)\dot{L}_t \tag{4}$$

The capital stock identity is as follows:

$$K_t = (1-\lambda)K_{t-1} + I_{t-1} \tag{5}$$

where
I_{t-1} = gross investment during period t-1,
λ = depreciation rate.

Rewriting the above equation,

$$\dot{K}_t = I_{t-1} / K_{t-1} - \lambda \tag{6}$$

Combining production function and capital stock identity,

$$\dot{Q}_t = \alpha A^{(1/\alpha)} (I_{t-1}{}^{\alpha} L_{t-1}{}^{1-\alpha} / Q_{t-1})^{(1/\alpha)} - \alpha\lambda + (1-\alpha)\dot{L}_t \tag{7}$$

Now, let A=1, then

$$\dot{Q}_t = \alpha (I_{t-1}{}^{\alpha} L_{t-1}{}^{1-\alpha} / Q_{t-1})^{(1/\alpha)} - \alpha\lambda + (1-\alpha)\dot{L}_t \tag{8}$$

α and λ can be estimated by a search technique where the search is conducted for α over the open interval (0,1).

2.2 Data and Results

We have applied the above model of simultaneous estimation of production function and capital stock to a set of countries whose capital stock series have been released by EU KLEMS (March 2008 Release). In case of Korea, we have used KIP database used in Chun, Pyo and Rhee (2008) because EU KLEMS Korea dataset has not been released yet. We have used aggregate real value-added, real GFCF and labor input data and a search method to estimate two key parameters, share of capital compensation and depreciation rate.

In Table 1, currency unit and data period by each country are reported and in Figure 1, estimated profiles of each country's capital stocks with different estimated depreciation rates are presented together with EU KLEMS' capital stock series which must have been generated by PIM method with some benchmark year's estimates if such estimates were available. Table 2 reports estimated parameters that generates profiles which are closest to EU KLEMS' capital stock series.

Table 3 presents estimated initial capital stock recovered from the estimated production function and Figure 2 presents the difference between estimated initial stock and EU KLEMS' estimate of initial stock. Except estimates of Austria and Netherlands, the estimated initial capital stocks were larger than EU KLEMS' estimates of initial capital stocks. In particular, the margin of difference is the largest with Korea(133.0%) followed by Czech Republic (63.0 %), UK (29.4 %), Finland (23.4 %), Australia

(22.5 %) and Slovenia (20.2 %). Japan had the smallest margin of difference (2.7 %). It might have been due to the fact that Japan reported to EU KLEMS 1970 National Census estimate as benchmark year's estimate.

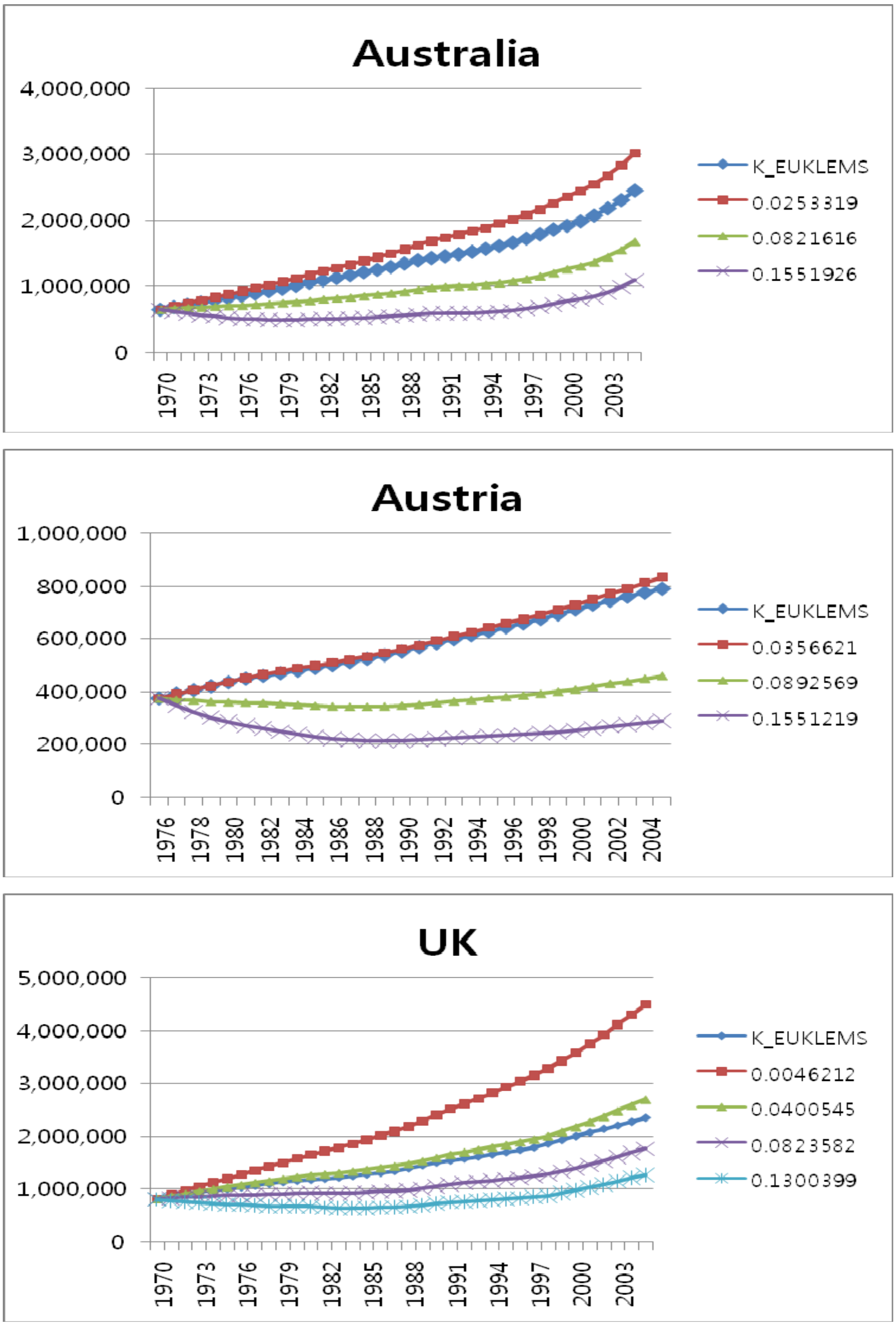
The estimated results of initial capital stocks and the seemingly large margin of difference in initial capital stocks are not surprising at all given that PIM crucially depends on the value of initial capital stock or assumed value of some benchmark year's estimates. Our estimates of initial stock have such implication that they are consistent with underlying aggregate production structure. They may be quite different from the actual value of initial capital stock if the country went through a period of long recession or war. However, they provide us rough estimates of what level of capital stock must have been maintained to support the production level and labor input at the initial year. Therefore, it can provide us a way of indirectly checking whether the estimates based on PIM are significantly diverging from those estimate that may be consistent with underlying production structure.

Table 1 Currency Unit and Data Period by Country

Country	Unit	Period
Australia	Millions of Austrian Dollars	1970-2005
Austria	Millions of Euros	1976-2005
UK	Millions of British Pounds	1970-2005
Finland	Millions of Euros	1970-2005
Germany	Millions of Euros	1991-2005
Italy	Millions of Euros	1970-2005
Netherlands	Millions of Euros	1970-2005
Japan	Millions of Japanese Yens	1973-2005
Korea	Millions of Korean Won	1977-2005
Slovenia	Millions of Slovenian Tolars	1995-2005
Czech	Millions of Czech Koruna	1995-2005

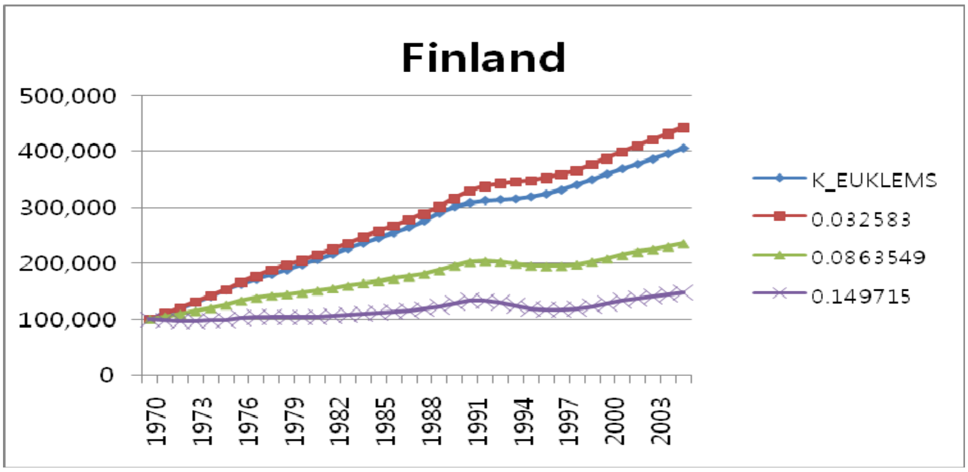
Sources: EU KLEMS (March 2008 Release)

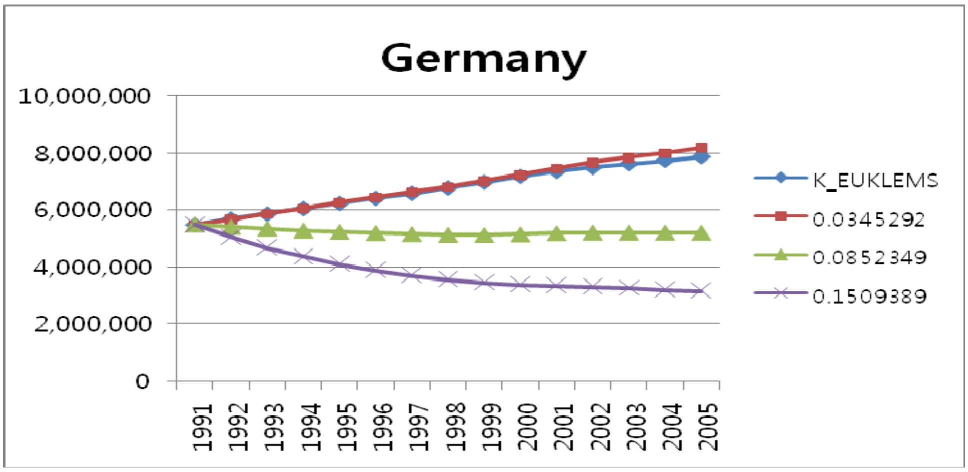
Figure 1 Estimated Depreciation Rates and Capital Stock[1]



[1] K_EUKLEMS indicates capital stock which is made public by EUKLEMS (March 2008 Release) except Korea. In case of Korea, we have used Korea Industrial Productivity (KIP) Database.

Figure 1 Estimated Depreciation Rates and Capital Stock(Continued)





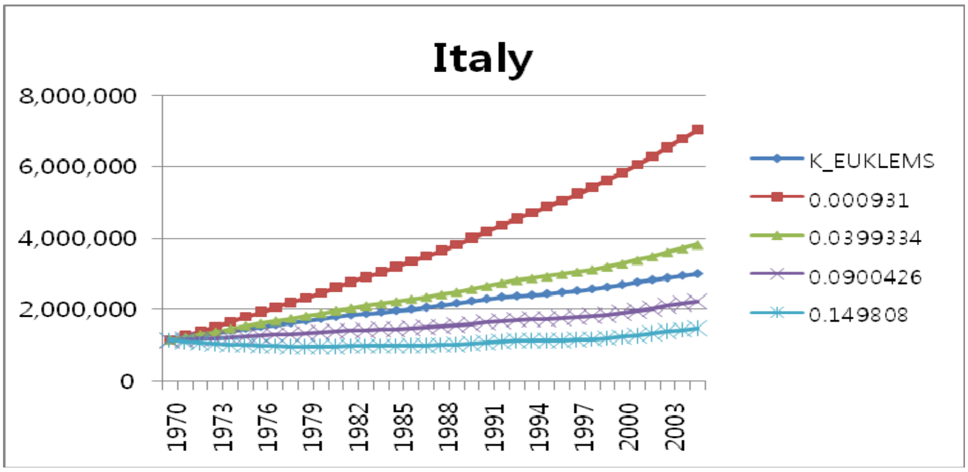
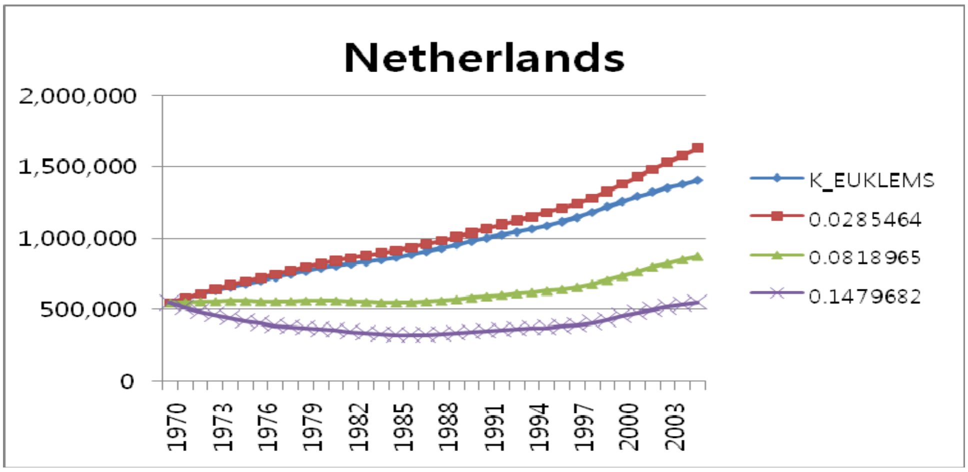
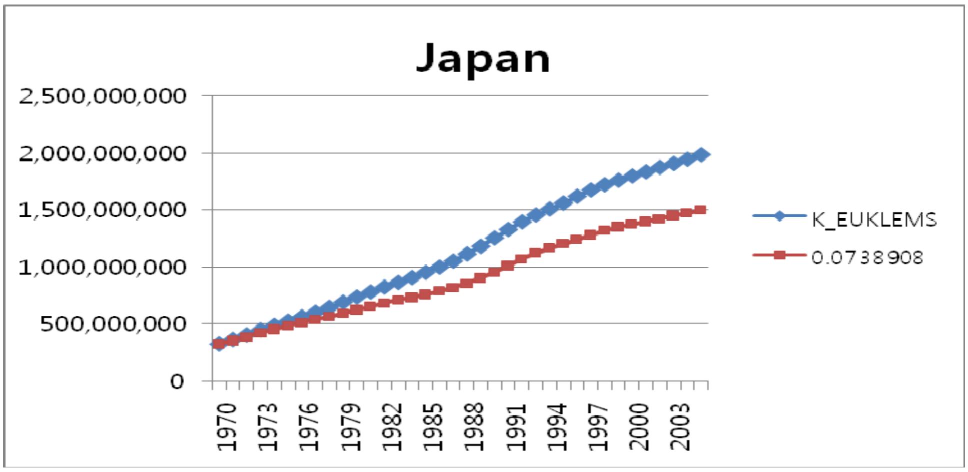


Figure 1 Estimated Depreciation Rates and Capital Stock(Continued)





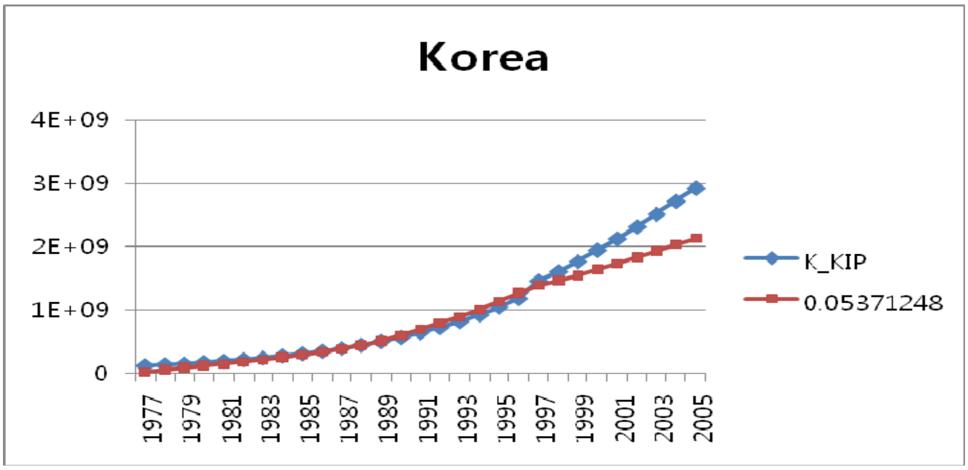
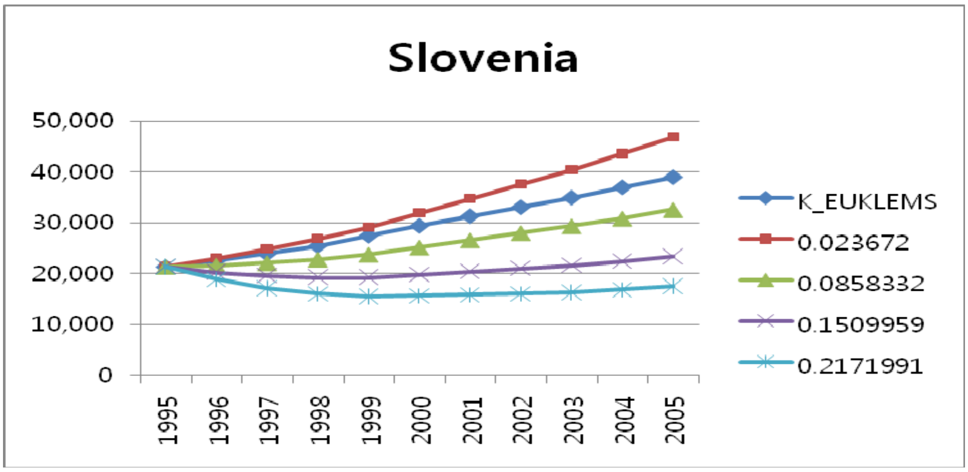


Figure 1 Estimated Depreciation Rates and Capital Stock(Continued)



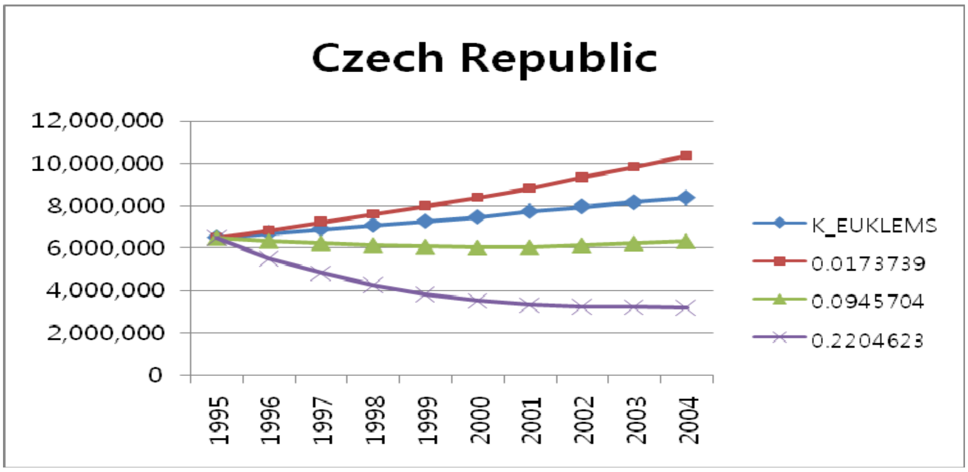


Table 2 Estimated Parameters

	α	λ
	Ratio of compensation to capital	Depreciation rate
Australia	0.7	2.53%
Austria	0.7	3.57%
UK	0.7	4.01%
Finland	0.7	3.26%
Germany	0.7	3.45%
Italy	0.7	3.99%
Netherlands	0.7	2.85%
Japan	0.9	7.39%

Korea	0.9	5.37%
Slovenia	0.6	2.37%
Czech	0.7	1.74%

Sources: EU KLEMS (March 2008 Release) and KIP Database(2007)

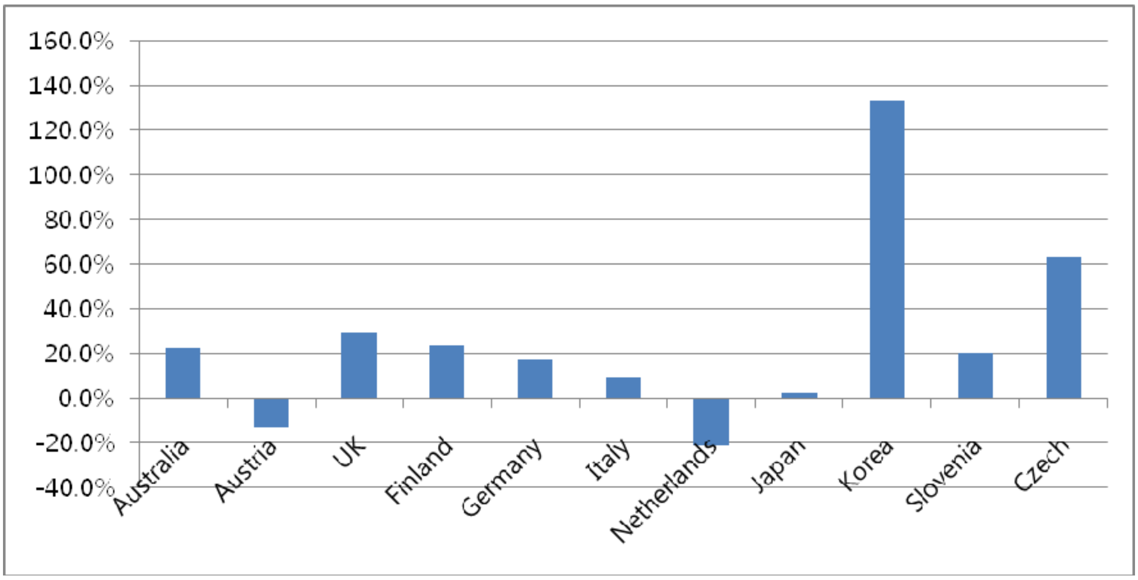
Table 3 Estimated Initial Capital Stock

	Australia	Austria	UK	Finland	Germany
initial year	1970	1976	1970	1970	1991
K_EUKLEMS	650,802	375,181	812,482	100,231	5,480,048
α	0.7	0.7	0.7	0.7	0.7
initial Q	218,458	100,733	1,326,226	45,847	1,580,444
initial L	10,662	6,488	46,800	4,528	59,788
estimated K	796,984	326,299	1,051,334	123,647	6,430,996
difference	146,182	-48,883	238,852	23,416	950,948
% difference	22.5%	-13.0%	29.4%	23.4%	17.4%

	Italy	Netherlands	Japan	Korea	Slovenia	Czech
initial year	1970	1970	1973	1977	1995	1995
K_EUKLEMS	1,143,575	548,984	452,780,704	119,339,604[2]	21,391	6,501,090
α	0.7	0.7	0.9	0.9	0.6	0.7
initial Q	434,217	139,908	203,844,739	113,487,243	8,675	1,326,226
initial L	36,639	10,024	122,063	35,650	1,699	10,385
estimated K	1,252,831	432,994	464,920,978	278,071,758	25,718	10,599,354
difference	109,256	-115,991	12,140,274	158,732,153	4,328	4,098,264
% difference	9.6%	-21.1%	2.7%	133.0%	20.2%	63.0%

[2] Since EU KLEMS' Korea Database has not been released yet, we have used KIP database for 1977 estimate.

Figure 2 Percentage Difference between K_EUKLEMS and Estimated Initial Capital Stock



3. Industry-level Decomposition of Capital Stocks

In principle, the above method of generating initial capital stock for the aggregate economy can be applied to each industry if the industrial GDP and labor input data are available. But in practice, estimating Cobb-Douglas production for each industry may not be an easy task and the assumption of constant returns to scale may not hold for each industry. In order to recover initial capital stocks by industry, we can adopt the following method.

The data on gross fixed capital formation in national accounts are available either by type of capital goods or by industries not by both. In case of South Korea, the Bank of Korea has published the asset-by-industry distribution matrix of Gross Fixed Capital Formation in recent selected years (1990, 1995, 2000 and 2003) as Supporting Table to Input-Output Tables as discussed in Pyo, Jung and Cho (2007). However, it is not by ownership but by user-industry's activity based. For example, the heavy commercial vehicle being leased and used by a construction company is not identified in GFCF but is identified in the distribution matrix. But since this is the only source of information about the distribution of GFCF by assets and by industries, we have used it as initial values in the application of RAS method to generate GFCF by both assets and industries for EU KLEMS Korea database.

For many emerging market and transition economies, such information may not be available making it difficult to apply PIM specifically to each industry. In my earlier studies (Pyo (1988) and Pyo (2003)), I have taken the following steps and it can serve as an alternative method.

Since the initial values of capital stocks by both assets and industries are not usually available, we can first distribute the estimated initial value of aggregate net capital stock into types of assets by using the cumulative weights of real GFCF. As Table 4 and Figure 3 show, the cumulative weights of GFCF by assets have changed over time but quite stably in Korea. A notable trend is that the cumulative share of Machinery and equipment has increased while the shares of Residential buildings and Non-residential buildings have declined steadily. If we were to distribute initial value of Korea's aggregate capital stock in 1970, the 1970 share of GFCF can be used. Then since depreciation rate is a more relevant concept to capital stock by types of assets rather than capital stock by industries, we can generate capital stocks through PIM by assets using estimated depreciation rates. After generating estimated net capital stocks by assets, we need to decompose each asset into industries. If other information such as industrial census or establishment or manufacturing surveys is available, we may use them for decomposition. For example, information on automobile registration and the survey on computer usage can be used. As a supplement, we can look at the cumulative weights of real GFCF by industries and apply that weight proportionally. Table 5 and Figure 4 illustrate the cumulative weights of real GFCF by industries in Korea. We note the cumulative industrial weights of real GFCF have converged to a quite stable pattern after 1997 and such weights can be safely used to distribute net capital stock by assets into different industries.

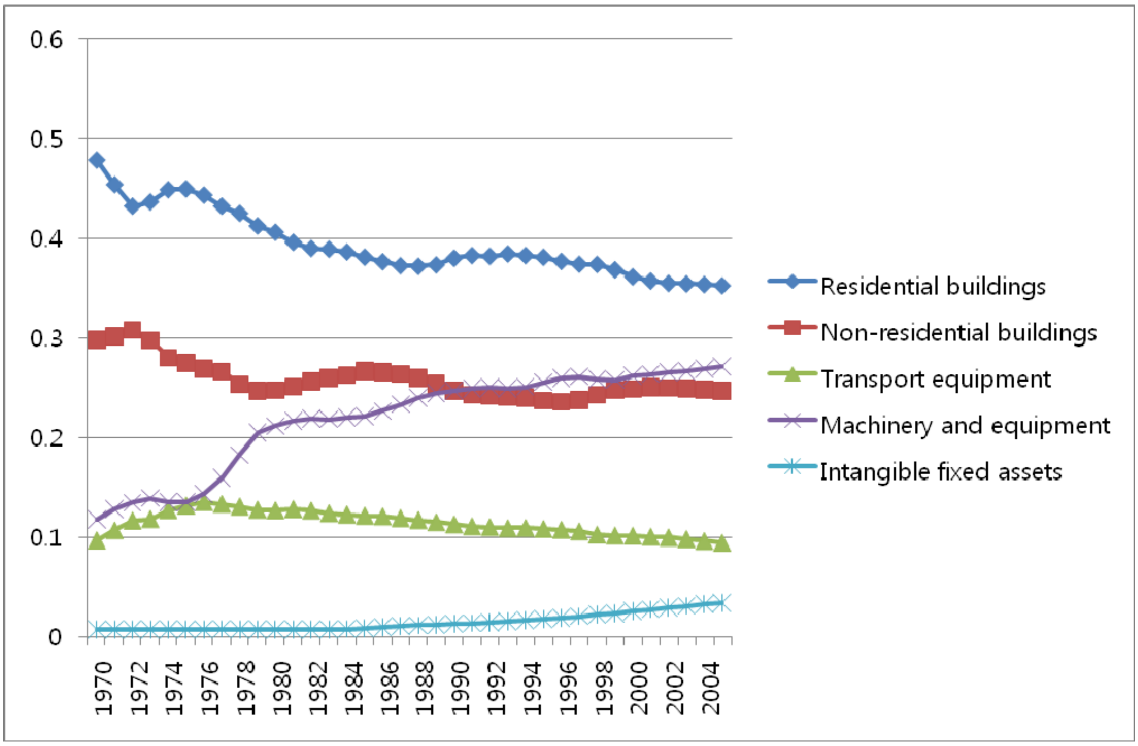
Table 4 Cumulative Weights of Real Gross Fixed Capital Formation by Assets in Korea (1970-2005)

(In 2000 prices)

Gross Fixed Capital Formation by Type of Capital Goods	1970	1975	1980	1985	1990	1995	2000	2005
Residential buildings	0.479	0.450	0.407	0.381	0.380	0.381	0.362	0.353
Non-residential buildings	0.298	0.275	0.248	0.267	0.247	0.237	0.249	0.247
Transport equipment	0.097	0.132	0.127	0.122	0.113	0.108	0.102	0.094
Machinery and equipment	0.118	0.136	0.212	0.221	0.247	0.255	0.262	0.271
Intangible fixed assets	0.008	0.007	0.007	0.009	0.013	0.018	0.026	0.034

Source: Bank of Korea, National Accounts (2007)

Figure 3 Cumulative Weights of Real Gross Fixed Capital Formation by Type of Capital Goods in Korea (1970-2005)



Source: Bank of Korea, National Accounts (2007)

Table 5 Cumulative Weights of Real Gross Fixed Capital Formation by Kind of Economic Activity in Korea (1970-2005)

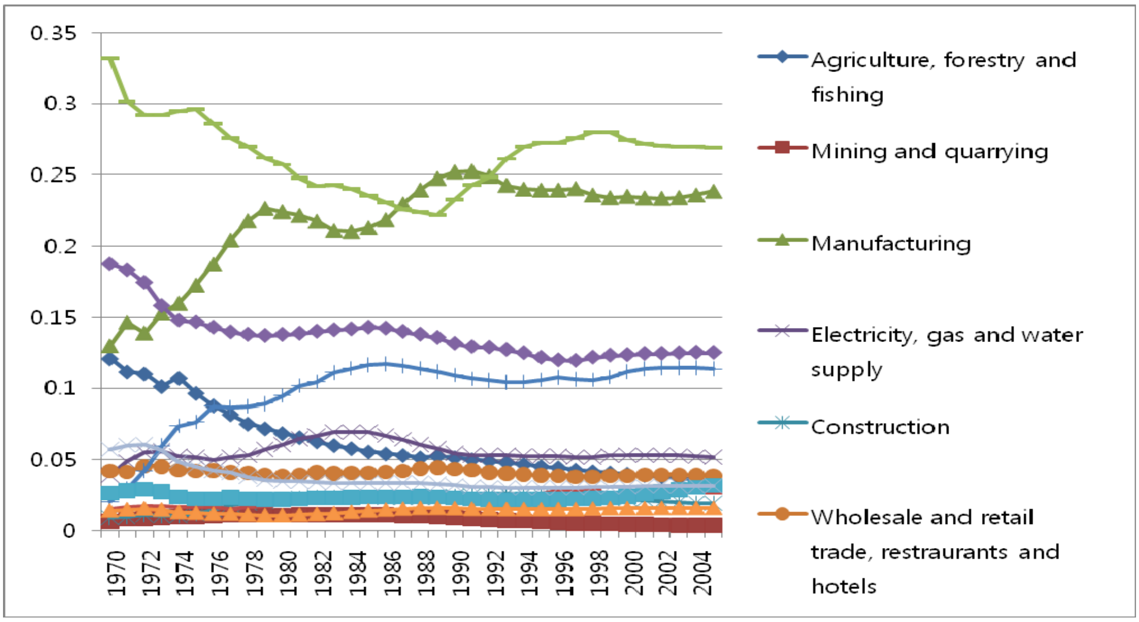
(In 2000 prices)

	1970	1975	1980	1985	1990	1995	2000	2005
Agriculture, forestry and fishing	0.121	0.096	0.068	0.055	0.051	0.045	0.040	0.035
Mining and quarrying	0.006	0.010	0.011	0.011	0.009	0.006	0.004	0.004
Manufacturing	0.130	0.173	0.225	0.213	0.252	0.240	0.235	0.239
Electricity, gas and water supply	0.039	0.052	0.061	0.069	0.055	0.053	0.053	0.052
Construction	0.009	0.012	0.021	0.024	0.024	0.025	0.022	0.019
Wholesale and retail trade, restaurants and hotels	0.042	0.042	0.039	0.041	0.044	0.039	0.039	0.039
Transport, storage and communications	0.021	0.077	0.095	0.116	0.109	0.106	0.111	0.114
Financial intermediation	0.015	0.017	0.018	0.020	0.022	0.026	0.027	0.027
Real estate, renting and business activities	0.332	0.296	0.257	0.236	0.233	0.272	0.274	0.269
Public administration and defense: Compulsory social security	0.187	0.146	0.138	0.143	0.131	0.121	0.123	0.125
Education	0.026	0.022	0.022	0.023	0.023	0.022	0.024	0.031
Health and social work	0.014	0.013	0.011	0.014	0.016	0.015	0.016	0.016
Other service activities	0.057	0.045	0.035	0.034	0.032	0.030	0.031	0.031

Source: Bank of Korea, National Accounts (2007)

Figure 4 Cumulative Weights of Real Gross Fixed Capital Formation by Kind of Economic Activity in Korea (1970-2005)

(In 2000 Constant prices)



Source: Bank of Korea, National Accounts (2007)

4. Depreciation, ICT Asset Decomposition and User Costs

4.1 Depreciation

In applying PIM to decomposed industry-level capital stock, we need to decide on which method of depreciation is to be used. As noted in OECD Manual(2002), it is practical to apply geometric depreciation rate to most of emerging market and transition economies because it can be applied to PIM to generate past series of capital stock prior to benchmark year or initial year of the estimation even though the data on past capital formation do not exist. Straight-line depreciation and sum-of-the-digits depreciation can not be applied because they require past records of asset acquisition.

The depreciation rate we estimate or assume affects the imputed service flow of capital input through two channels. One is the efficiency profile it implicitly assumes and the other is the user cost of capital. The geometric depreciation rate is more appropriate to those assets of which efficiency declines faster in earlier asset life than in later asset life. So unless we estimate productive capital using hyperbolic efficiency profiles as BLS (Harper (1999) and Australia, the assumed depreciation rate reflects such efficiency profile. As depreciation rate enters into the formula of user costs of capital, higher (lower) depreciation rate makes user cost higher (lower). Therefore, assuming higher geometric depreciation for a certain asset will lower the efficiency level of the asset in earlier asset life but will make user cost of capital higher.

Geometric depreciation rates used in EU KLEMS project and estimated in Pyo (2003) are compared in Table 6. The estimates in Pyo (2003) were derived by the polynomial benchmark estimation method using two benchmark years' National Wealth Survey's net stocks and GFCF in national income accounts. Most of my estimates fall in the range assumed by EU KLEMS except computing equipment and software.

Table 6 Geometric Depreciation Rates Used in EU KLEMS and Estimated in Pyo(2003)

(unit: %)

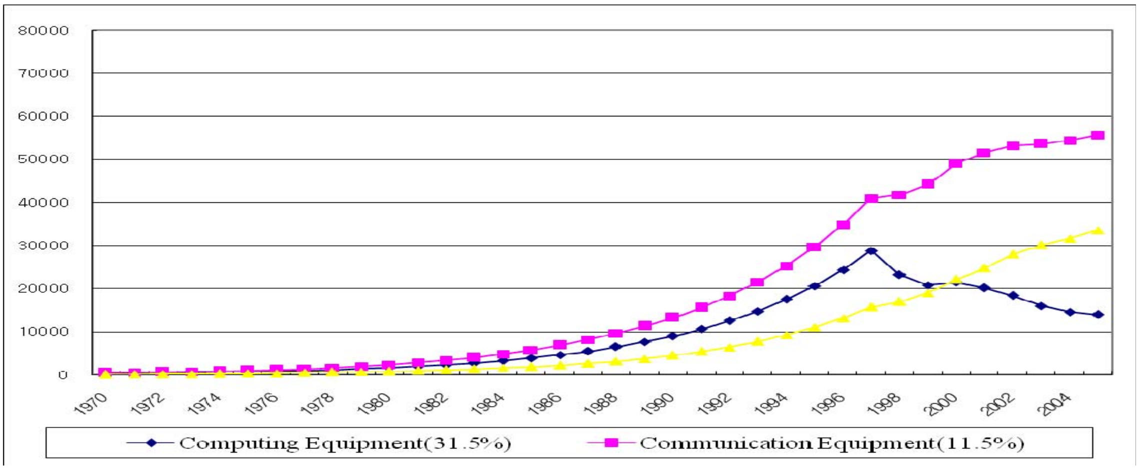
EU KLEMS Asset Type	EU KLEMS(2007)		Pyo(2003)
	Maximum	Minimum	
Residential structures	1.1	1.1	3.3
Non-residential structures	2.3	6.9	3,0
Infrastructure	2.3	6.9	1.0
Transport equipment	6.1	24.6	16,9
Computing equipment	31.5	31.5	11.5
Communications equipment	11.5	11.5	9.2
Other machinery and equipment	7.3	16.4	9.2
Software	31.5	31.5	24.7

Sources: EU KLEMS (2007) and Pyo (2002) (2003)

EU KLEMS' depreciation rate (31.5 %) of Computing equipment and Software seems too high compared with my estimates (11.5 % and 24.7 % respectively) and other existing estimates. I conjecture that EU KLEMS wants to reflect higher user cost of Computing equipment and Software and assumes intentionally higher depreciation rates of these assets because they have generated net capital stocks rather than productive capital stocks. The net capital stocks being generated by geometric depreciation rates are declining faster at earlier period of asset lifetime than the productive capital stock being generated by a hyperbolic age-efficiency profile. However, as illustrated in OECD (2002), the overestimated geometric depreciation rate makes the age-value profile diverge further away from age-efficiency profile at earlier period so that the merit of such adjustment may disappear.

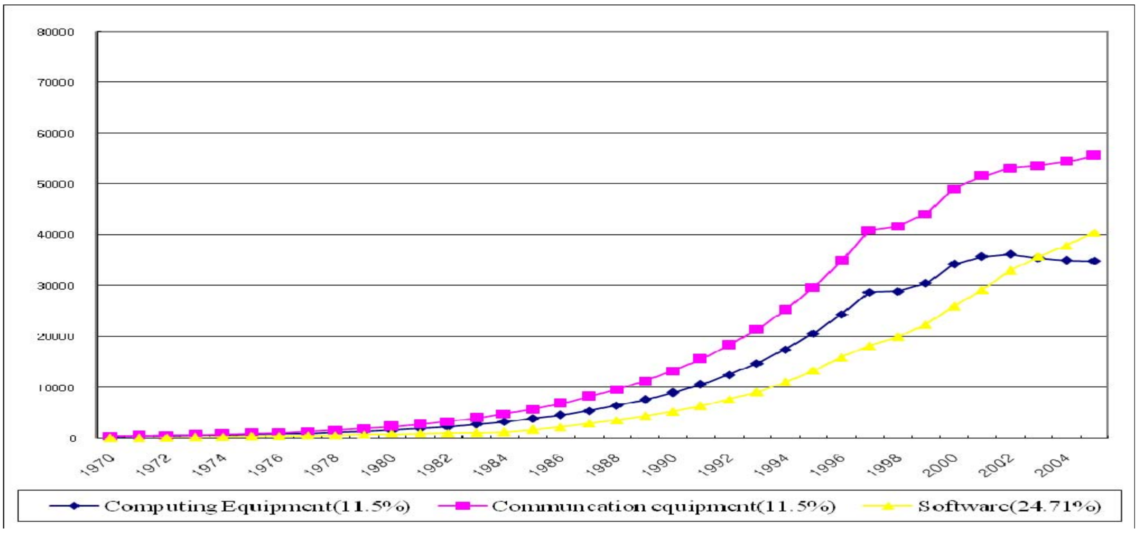
We have applied EU KLEMS' depreciation rates to the study in Fukao, Miyagawa, Pyo and Rhee (2008). The capital stock of Computing Equipment in Korea started declining after 1998 as shown in Figure 5, which implies the assumed depreciation rate (0.315) is too high. Therefore, we have adjusted the depreciation rate for Computing Equipment to 0.115, which is the same rate as Communication Equipment, and the depreciation rate for software to 0.247, which was used in Pyo (2002). With this adjusted depreciation rates, the profile of net capital stocks seem more reasonable for the years 1998-2005 as shown in Figure 6.

Figure 5 ICT Capital Stock with Depreciation Rates by EU KLEMS in Korea



Sources: Fukao, Miyagawa, Pyo and Rhee (2008)

Figure 6 ICT Capital Stock with Adjusted Depreciation Rates in Korea



Sources: Fukao, Miyagawa, Pyo and Rhee (2008)

4.2 ICT and Non-ICT Decomposition

In recent years, the measurement of ICT sector's contribution to economic growth has been subject to extensive empirical studies. One of the key issues in the literature is how to define ICT assets and ICT sectors. Table 7 summarizes the difference in ICT asset classification between EU KLEMS and OECD. OECD defines ICT assets in much wider context and classification. In my judgement, if we were to define ICT assets in the narrower context as EU KLEMS, we may have to include consumer durables as part of ICT assets because most of consumer durables such as TV, automobiles, cellular phones, game players, electronic camera and other entertainment devices are ICT products. In addition, there could have been well-known measurement error such that self-employees' and salespersons' use of automobiles and cellular phones may not have been adequately identified as capital input.

Table 7 ICT Asset Classification by EU KLEMS and OECD

EU KLEMS	OECD
Computing Equipment	Telecommunication Equipment
Communications Equipment	Computer and Related Equipment
Software	Electronic Components
	Audio and Video Equipment
	Other ICT Related Goods

Sources: EU KLEMS (2007) and OECD (2003)

Table 8 presents GFCF and consumption of consumer durable goods in Korea in selected years over the period of 1970-2005. The ratio of consumer spending on durable goods to GFCF increased steadily from 3.8 % in 1970 to 15.9 % in 2000. Therefore, the real measurement of ICT use-effect needs to include the imputed services of consumer durables following the BEA tradition of including consumer durables as part of investment.

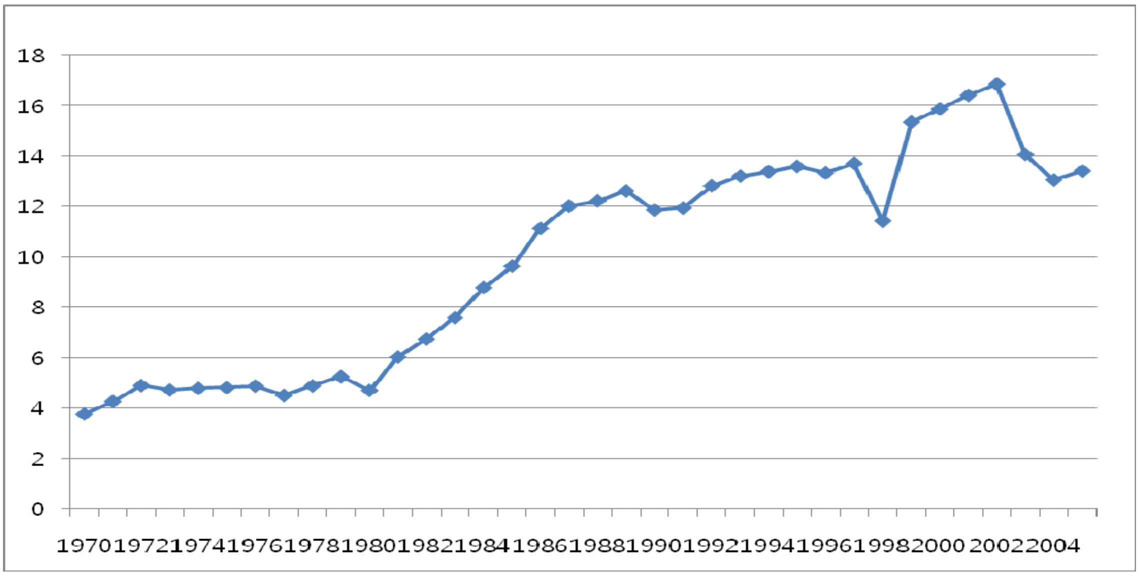
Table 8 Gross Fixed Capital Formation and Final Consumption Expenditure of Durable Goods in Korea (1970-2005)

(In 2000 Constant prices)

	1970	1980	1990	2000	2005
A. Gross Capital Formation	10,320	35,783	114,989	179,908	208,055
B. Final Consumption Expenditure of Households: Durable goods	391	1,691	13,671	28,581	27,955
100 x B/A (%)	3.8	4.7	11.9	15.9	13.4

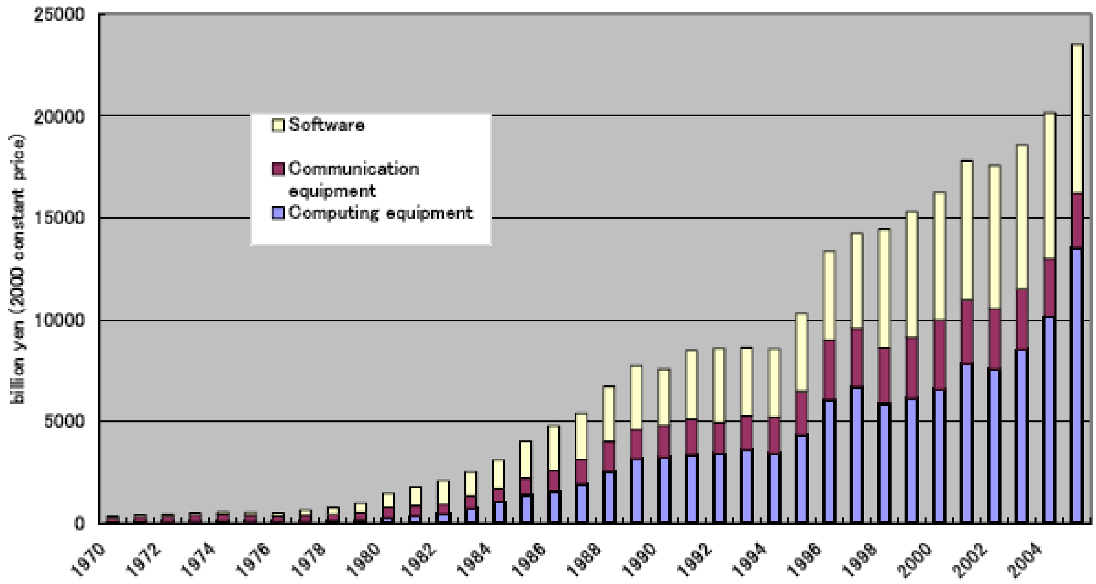
Figure 7 The Ratio of Durable Goods Consumed to Gross Fixed Capital Formation in Korea (1970-2005)

(%)



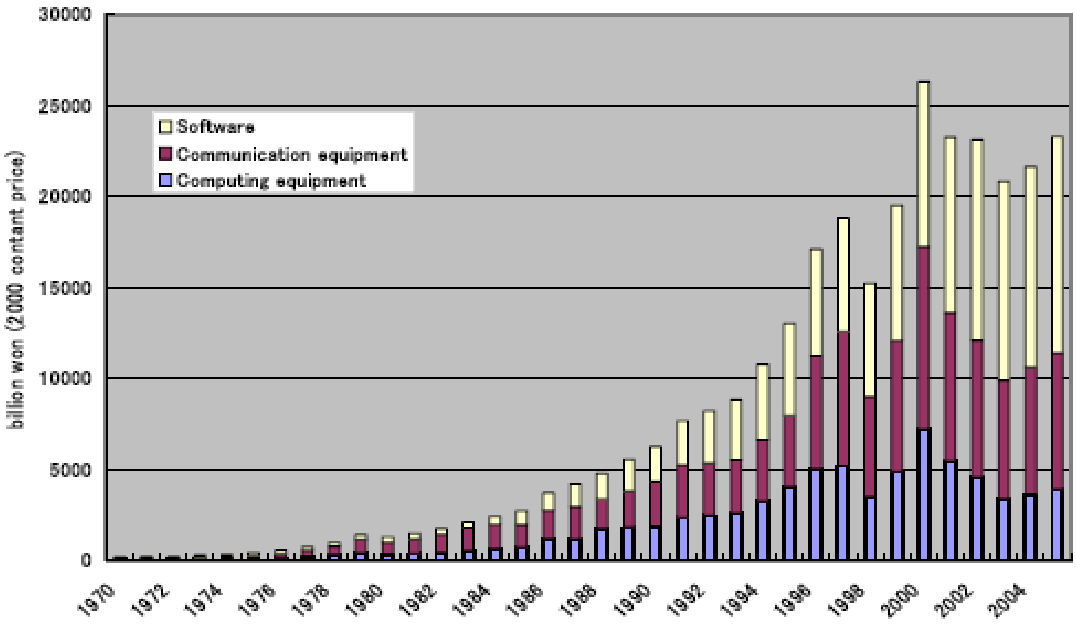
In a recent study of Fukao, Miyagawa, Pyo and Rhee(2008), we have examined the decomposition of ICT investment in Japan and Korea, which are global ICT-equipment producers. The share of computing equipment in total ICT assets in Japan has been increasing but the corresponding share in Korea has declined. We note different use patterns of ICT assets in Japan and Korea. Korea's use of ICT asssets may have been skewed to the use of consumers' durable goods such as personal computers, internets and cellular phones.

Figure 8 ICT Investment in Japan



Source: JIP 2008 Database

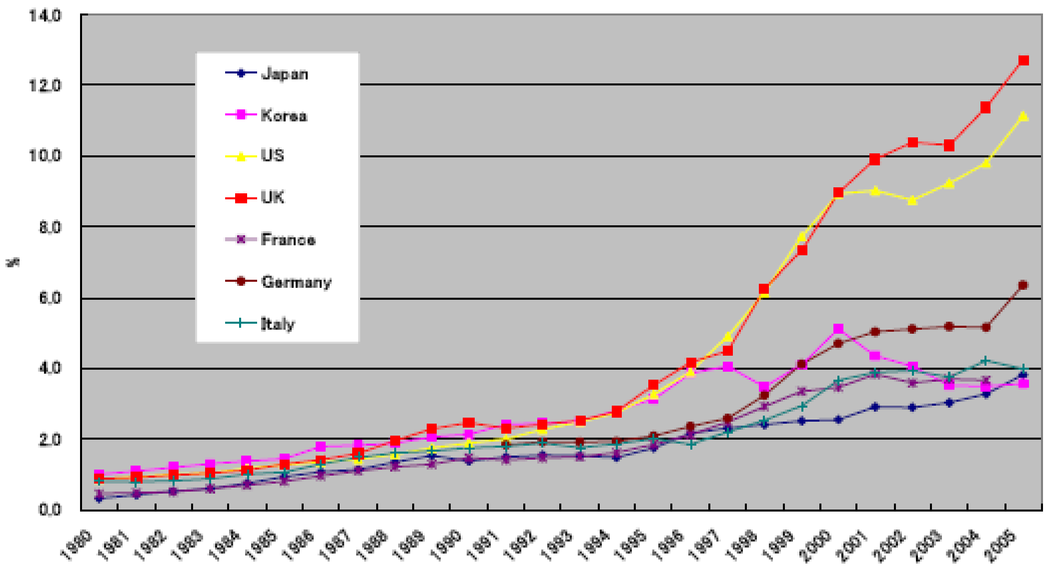
Figure 9 ICT Investment in Korea



Source: KIP Database

Finally, Figure 10 presents the ratio of ICT investment to GDP in selected major developed economies. Even though Japan and Korea are strong ICT equipment producers, they lag behind UK, US and Germany in terms of the share of ICT investment in GDP.

Figure 10 ICT Investment/GDP Ratio in the Major Developed Countries



Sources: EUKLEMS Database 2008 March Release, KIP Database, JIP 2008 Database

4.3 Estimation of User Cost

EU KLEMS is using the following formula of user cost for imputing capital service flow from net capital stock:

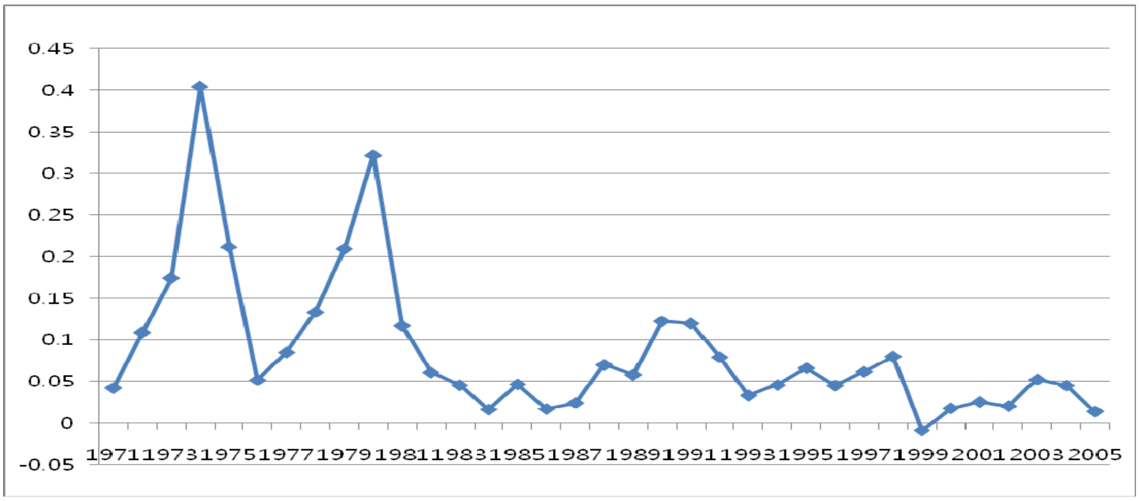
$$P_j^i(t) = \{r_j(t) + \delta_i - \Pi_i(t)\}q_i(t-1) \tag{9}$$

where $r_j(t)$ is the rate of return of industry j, δ_i is the rate of depreciation of asset i, $q_i(t)$ is the acquisition price of investment good i with $\Pi_i(t) = \frac{[q_i(t) - q_i(t-1)]}{q_i(t-1)}$ which is the rate of inflation in the price of investment good i.

In the practical implementation of such formula, we may have to confront jumps and outliers of the data particularly in emerging market and transition economies. To illustrate potential problems, the inflation rate measured by the growth rate of aggregate GFCF deflator from National Accounts by the Bank of Korea over the period of 1970-2005 is plotted in Figure 11. There were two distinct peaks in 1974 after the first oil crisis and 1980 after the second oil crisis combined with political turmoil following the assassination of President Park. Such outliers can make user cost jump too and in case of some sectors' assets, the imputed user cost of capital can become negative. Financial crises in emerging markets and hyper-inflation during the transition period in transition economies can easily make such outliers exist.

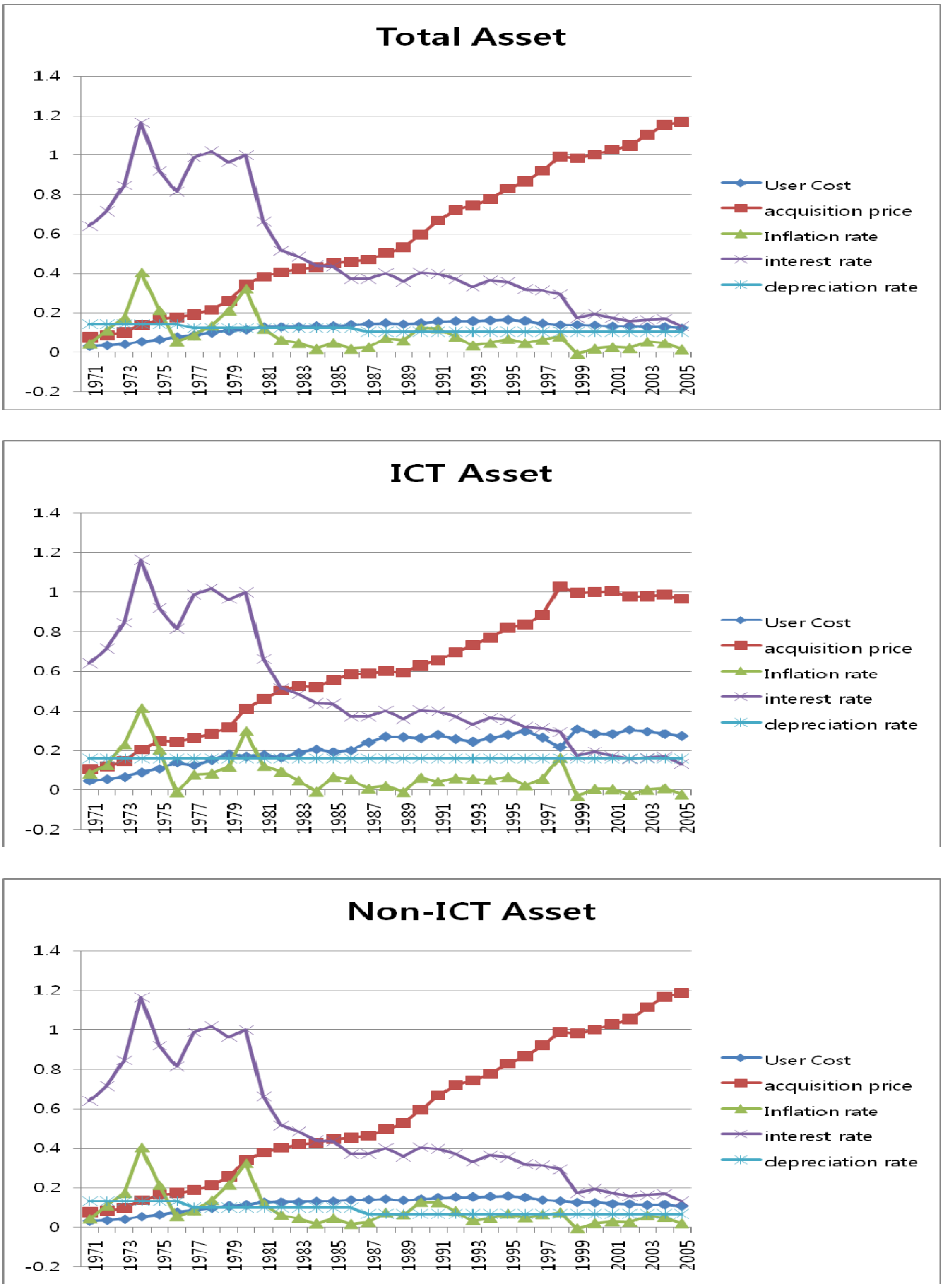
In Figure 12, the estimated user costs of capital of aggregate total capital as well as that of ICT capital and non-ICT capital and the profiles of their determinants, interest rate, depreciation rate, inflation rate and acquisition price are plotted. We note the co-movement between inflation rate and interest rate; interest rate also has two distinct peaks. We also note the difference in the profiles of acquisition prices between ICT assets and Non-ICT assets. The price of ICT assets gets stabilized and declines a little bit reflecting the quality improvement in ICT assets, the user cost while that of Non-ICT assets continue to rise.

Figure 11 Inflation Rate Measured by Aggregate Investment Deflator in Korea(1970-2005)



Sources: Bank of Korea, National Accounts(2007)

Figure 12 Estimated User Costs and Determinants of User Costs in Korea(1970-2005)



5. Concluding Remarks

In the present paper, we have discussed several issues in estimating net capital stocks of emerging market and transition economies. We have also discussed such related issues as estimating depreciation rates, industrial decomposition, ICT and Non-ICT decomposition and imputing user costs of capital. It was pointed out that the measurement of initial capital stock is important and essential for level comparison of industry-specific productivities among nations.

We have outlined an alternative method of indirectly checking the compatibility of initial values of net capital stock with underlying production structures and parameters by adopting the model of Dadkhah and Zahedi (1986) and using EU KLEMS Database. The estimated results of initial capital stocks for some countries diverge from EU KLEMS' estimates of initial values based on PIM. It suggests to use some reliable benchmark year's estimates as far as possible: some information is better than no information or assuming zero value of initial capital stocks. We also have proposed an alternative way of decomposing total net capital stock into capital stock by industries and by assets using cumulative weights of GFCF by industries and by types of assets.

We have pointed out that the depreciation rate (31.5 %) of Computing Equipment and Software assumed by EU KLEMS may turn out to be too high. Even though it may reflect higher user cost of such ICT assets, it will make the net capital stocks of these assets diverge from the realistic age-efficiency profile: for example, a typical notebook may depreciate in value by 31.5 percent in the first year of its usage but its efficiency level may decline by less than 10 percent. In case of Korea, the resulting estimates of ICT capital stock estimated by assuming 31.5 percent depreciation rate turn out to be declining rather than accumulating so that we had to use downward-adjusted rates of depreciation.

We have discussed the decomposition of ICT and Non-ICT assets and noted that EU KLEMS definition of ICT capital could be too narrow compared to that of OECD to reflect the contribution of ICT assets to economic growth. We also have noted the difference in the use pattern of ICT-assets in Japan and Korea. We have also noted that even though both Japan and Korea are strong ICT-equipment producers, they lag behind UK, US and Germany in the relative weight of ICT investment to GDP. We propose to include consumer durables in the imputation of ICT assets' capital service flow. Finally we have discussed the possibility of outliers in the data of emerging market and transition economies which will make imputation of user costs difficult. Smoothing by moving averages and aggregation over broader categories of assets and industries may help out the imputation. Since EU KLEMS may have interest in encompassing important economies like Brazil, Russia, India and China, it seems desirable to reiterate inherent problems of PIM before it diverges too far away from realities.

References

Bank of Korea, National Accounts, 2007

Bong Chan Ha and Hak K.Pyo, "The Measurement of IT Contribution by Decomposed Dynamic Input-Output Tables in Korea(1980-2002)", *Seoul Journal of Economics*, Seoul National University Press , Vol.17 No. 4, 2004

Bureau of Economic Analysis (BEA) , *Fixed Reproducible Tangible Wealth in the United States 1925-89*, Department of Commerce, Washington, DC, January 1993

Harper, Michael J., "Estimating Capital Inputs for Productivity Measurement: An Overview of U.S. Concepts and Methods," International Statistical Review, Vol.67, 1999, pp.327-337

Hyunbae Chun, Hak K. Pyo and Keun Hee Rhee, *Data Structure and Productivity Estimates of Korea Industrial Productivity Database,* Korea Productivity Center, 2007

IMF, "The Role of the IMF in Recent Capital Account Crises," the Independent Evaluation Office (IEO) , June 18, 2002

Inklaar, Robert, Marcel P. Timmer and Bart van Ark, "Mind the Gap!: International Comparisons of Productivity in Services and Goods Production," unpublished manuscript, 2006.

Jan Svejnar, "Transition Economies: Performance and Challenges," The Journal of Economic Perspectives, Vol.16, No.1, (Winter, 2002), pp.3-28

Kamran M.Dadkhah and Fatemeh Zahedi, " Simultaneous Estimation of Production Functions and Capital Stocks for Developing Countries", Review of Economics and Statistics, Vol.68, Issue 3, 1986

Kyoji Fukao, Tsutomu Miyagawa, Hak K. Pyo and Keun Hee Rhee, "Estimates of Total Factor Productivity, ICT Contributions and Resource Reallocation Effects in Japan and Korea," Prepared for the Workshop for the Vol. II in EU KLEMS project at Frankfurt, January 15, 2008

National Statistical Office, *Indirect Estimation of National Wealth Statistics*, Report submitted to National Statistics Committee, August 30, 2007-11-30 (in Korean).

OECD, *Manual on Capital Stock Statistics*, OECD, Paris, 2000

OECD, "Working Party on Indicators for the Information Society- A Proposed Classification of ICT Goods," Directorate for Science, Technology and Industry, OECD, Nov-2003

Pyo, Hak K., "Estimates of Capital Stock and Capital / Output Coefficients by Industries: Korea, 1953-1986, " *International Economic Journal*, summer 1988.

Pyo, Hak K., "A Synthetic Estimate of National Wealth of Korea," 1953-1990, KDI Working Paper No. 9212, Korea Development Institute, Seoul, 1992.

Pyo. Hak K, "Estimates of Fixed Reproducible Tangible Assets in the Republic of Korea, 1953-1996," KDI Working Paper No.9810, Korea Development Institute, Seoul, 1998.

Pyo, Hak K., *Estimation of Intangible Assets for Indirect Estimation of National Wealth in Korea,* Final Project Report submitted to Korea National Statistical Office, November 2002 (in Korean).

Pyo, Hak K., "Estimates of Capital Stocks by Industries and Types of Assets in Korea (1953-2000)," *Journal of Korean Economic Analysis*, Panel for Korean Economic Analysis and Korea Institute of Finance, Seoul 2003.

Pyo, Hak K., "Interdependecy in East Asia and the Post-Crisis Macroeconomic Adjustment in Korea," *Seoul Journal of Economics*, Vol. 17 No. 1, Spring 2004.

Pyo Hak K., Keun-Hee Rhee, and Bongchan Ha , "Productivity Analysis by Industry in Korea and International Comparison through EU KLEMS Database: Data Structure," Paper presented at EU-KLEMS Workshop, May 7-9, 2006, Valencia.

Pyo Hak K., Sunyoung Jung, Jung Sam Cho, "Estimates of Gross Fixed Capital Formation, Net Capital Stock and Capital Intensity in Korea: 11 Assets by 72 Sectors(1970-2005)," Journal of Korean Economic Analysis, Vol.13 No.1, December 2007.

Timmer, Marcel, "EU KLEMS Road map WP1," EU KLEMS webpage, October, 2005.

Timmer, Marcel, Ton van Moergastel, Edwin Stuivenwold, Gerard Ypma, Mary O'Mahony, and Mari Kangasniemi, "EU KLEMS Growth and Productivity Accounts (Version 1.0, Part I Methodology)," EUKLEMS Consortium, March

2007a.

Timmer, Marcel P., Mary O'Mahony, and Bart van Ark, "EU KLEMS Growth and Productivity Accounts: Overview, " EUKLEMS Consortium, March 2007b.

Timmer, Marcel P., Ypma, Gerard, and Bart van Ark, 2007c, "PPPs for Industry Output: A New Dataset for International Comparisons," Groningen Growth and Development Centre, Research Memorandum GD-82(Holland:University of Groningen)

Ward,M., "Problems of Measuring Capital in Less Developed Countries," *The Review of Income and Wealth*, September 1976a, 207-221