

**Conference on Growth and Stagnation in the World Economy
The Third World KLEMS Conference, Tokyo, Japan, May 19-20, 2014**

Estimation of Land and Inventory Stocks by Industries as Capital Inputs in Korea*

Hak K. Pyo and Keun-Hee Rhee**

* An earlier version of this paper was presented at Seminar on Estimation of Land and Inventory Stocks for AsiaKLEMS Database, Statistics Directorate, OECD, Paris, November 21, 2013 and at Meeting on Harmonization of Japan Industrial Database with Asia KLEMS Database on January 11, 2013, and at Meeting on Estimation of Land and Inventory Stocks for Asia KLEMS Database on April 25, 2013 at RIETI in Tokyo, Japan

** Visiting Scholar, Korea Institute for International Economic Policy and Professor of Economics Emeritus, Seoul National University and Senior Fellow, Korea Productivity Center respectively. All correspondences should be addressed to pyohk@plaza.snu.ac.kr

I. Introduction

The estimation of land and inventory stocks as sources of capital inputs is not only controversial on theoretical grounds but also difficult on measurement issues. Mamalakis (1992) has argued that broadening the coverage of capital stock may entail too many imputations and measurement error. He has defined capital as those assets which can pass three criteria: ‘means-of-production’, ‘produced means-of-production’ and ‘durability’. According to his criteria, land is certainly a means-of-production and also passes the durability standard since it is used as an input over a certain accounting period. However, it is not produced means-of-production. Goldsmith (1975) had noted that the difficulties of estimation and the errors in the resulting figures would be greatest for land among the components of national wealth. Nomura (2004) argues that inventory stocks should be defined as a part of capital because it is a produced means-of-production and is used over one-year accounting period. However, it is not a durable good and, therefore, we cannot apply the estimation method applied to durable goods to inventory stocks. For these reasons, the inclusion of land and inventory stocks as capital inputs has been divided between the two groups: (1) The group which excludes land and inventory stocks from capital input is Bureau of Economic Analysis (1993), National Wealth Survey (1968, 1977, 1987 and 1997) in Korea and EU KLEMS (2007) and (2) the group which includes land and inventory stocks as capital inputs is Goldsmith (1975), Kendrick (1976), Jorgenson, Gollop and Fraumeni (1987) and OECD (2009).

While the inclusion of land and inventory stocks as capital inputs is still a subject to debate, the estimation of land and inventory stocks seems inevitable for the following two reasons. The first reason is that land is an important part of ‘productive stock’ which generates capital services to production activities. The significant portion of national income accrued to capital is rents to land of owner-occupied residential structure and tenant-occupied residential and nonresidential structure. In addition, if the economy has a large agricultural sector, then exclusion of land and inventory stocks introduces a significant bias in the measurement of capital income and the rates of return which is used in imputing capital services by industries. The second reason is that even though at the total economy level the amount of land and inventory stocks used does not change much, at the industry level the amount of land and inventory stocks could change substantially. Moreover, exclusion of land and inventory stocks might impact the estimates of rates of return as EU KLEMS (2007, p.34) points out.

Jorgenson, Gollop and Fraumeni (1987) have defined six types of asset class as capital input: (1) Producers’ durable equipment (2) Consumers’ durable equipment (3) Tenant-occupied residential or nonresidential structure (4) Owner-occupied residential structure (5) Inventory, and (6) Land. OECD (2009) defines four types of land: (1) Natural land under buildings and structures and associated surface water (2) Natural land under cultivation and associated surface water (3) Natural recreational land and associated surface water and (4) Other natural land and associated surface water. Therefore, it is important to identify whether the value of residential and nonresidential structure includes the value of land on which these structures are built on and the estimation of land aims for all four categories of land or for only selected ones. On the other hand, 1993 SNA defines four categories of inventory stocks: (1) Materials and Supplies (2) Finished Goods (3) Goods purchased for resale and (4) Work-in-progress. It should be noted that National Wealth Survey in Korea includes all three categories except Construction-in-progress which is a part of Work-in-progress. National Wealth Survey treats

Construction-in-progress as a part of fixed tangible assets. It also includes Construction-in-progress not all of Work-in-progress in the fixed tangible assets because 93 definition of Work-in-progress is so wide that some other types of Work-in-progress may not be regarded as capital inputs.

In addition to identification of categories of land, we have to deal with valuation of land. 2008 SNA (Paragraph 13.44) states: In principle, the value of land to be shown under natural resources in the balance sheet is the value of land excluding the value of improvements, which is shown separately under fixed assets, and excluding the value of building on the land which is also to be shown separately under fixed assets. Land is valued at its current price paid by a new owner excluding the costs of ownership transfer which are treated by convention, as gross fixed capital formation and part of land improvements and are subject to consumption of fixed capital. In terms of inventory stocks, we need to decide whether we should include all of Work-in-progress in the inventory stocks.

The purpose of the present paper is to construct a synthetic estimate of land and inventory stocks in Korea using two benchmark estimates and estimates of land reported in Mining and Manufacturing Census. The paper is organized as follows. In section 2, a brief description of data situation in Korea is outlined. Section 3 provides estimates of land in Korea for the period of 1953-2010. Section 3 presents a desirable method of estimating inventory stocks. The last section concludes the paper.

2. Estimation of Land by Industries

As noted in Pyo (1992), it seems extremely difficult to derive estimates of land unless there is a comprehensive census-type estimate of land because we cannot apply perpetual inventory method which can be applied to reproducible tangible assets with depreciation rates assumed. In case of the Republic of Korea (here-in-after called Korea for simplicity), the Study Report by the Committee for the Public Concept of Land (here-in-after called the Land Report for simplicity) published in 1989 was the first economy-wide benchmark estimates of land. The report contains estimates of land by types of land as of January 1 of 1985. According to the report, the share of agricultural land (paddy field, ordinary fields and forest land) and that of non-agricultural land (land for buildings and structures, plant sites and others) in value was 32.8 percent and 67.2 percent respectively. However, there is no information on industrial composition of non-agricultural land. At Mining and Manufacturing level, there have been Mining and Manufacturing Census and Reports which includes the value of land in manufacturing establishments at the beginning of year, value increase and decrease during the year and at the end of year. At the level of Service industries, there was an Establishment Survey on Service Industries in 2005. Another potential source of estimates of land is Financial Statement Analysis published by the Bank of Korea but it only covers listed firms' data in selected industries. Economic Census in 2010 by the Statistics Korea was conducted on all establishments engaged in industrial activities to provide products or services at or within one geographic area, such as a factory, a shop, a mine, a business office, a branch office or a head office. However, the Economic Census did not have enough sample size and therefore, the total amounts surveyed were far below the levels of Manufacturing and Service Industries' census.

(1) Estimates of Land (1954 – 1990)

We have found the fact that the data on land are typically available by the zoning area not by industries. But fortunately we found that Establishment Census in 1987 reported the size (not value) of land by industries. In order to make use of Establishment Census, we have taken following steps to estimate value of land by industries:

i) We deflated the 1985 value estimate of land by the average land price index for the entire nation to convert the estimate into constant price series. Since the index is available only after 1985, we had to generate backward the index by regressing it on the Metropolitan Land Price Index which is available since 1964. Then, the generated index during 1964-1974 and the observed index during 1985-1989 are regressed on the index of GNP deflator to generate backward further for the period of 1953-1963. The combined series of the average land price index has been used to deflate the 1985 value estimate of land.

ii) Even in real terms, it is difficult to assume that the value of land remained constant over 25 years between 1953 and 1989. Therefore, for the period of 1953-1984, we subtracted the amount of land improvement and orchard development in 1985 constant prices which appear in national income accounts from the 1985 value estimate of land.

iii) Additional adjustment has been made to account for the change in agricultural land. According to the Land Report (1989), the total area of agricultural land has increased from 1,970 thousand ha in 1950 to 2,144 thousand hectare in 1985 for 2,000 farm households. Therefore, for the period of 1953-1984, we calculated the proportional area of agricultural land increase in value and subtracted it from the estimate of the agricultural land. The difference was allocated to the nonagricultural land.

iv) We allocated the value estimate of paddy fields, ordinary fields and forest land to Agriculture, Forestry & fishing. The land for buildings and structures needs to be decomposed into residential land and nonresidential land before being allocated to non-agricultural industries. We assumed that about 7.2 percent (205.7km²) of the total unincorporated private land (2,847.4km²) for buildings and structures belong to the unincorporated business. We also allocated the value estimate of the plant site to the Manufacturing and Electricity, Gas & Water industry only

v) Finally, the sum of 7.2 percent of the unincorporated private nonresidential land and other types of land is allocated to all industries using the weights of land space by industries in 1986 Establishment Census.

The resulting estimates of land are compared with estimates of other wealth components which are more readily available in current prices. The share of land in Gross National Wealth was estimated to be 32.2 % in 1954 but increased to 44.7 % level in 1968 and then declined to reach 34.3 % in 1990 as shown in Table 1. The estimates by industries are presented in Table 2 and 3. For valuation of land on which residential buildings and nonresidential buildings and structures were built, Goldsmith (1975) used the value land/structure ratio to estimate the value of non-agricultural land in his study. Starting from the estimate (0.39) for 1904 of Japan by Igarashi and Takahashi, he assumes that it had risen over time and reached in the neighborhood of unity in 1970. However, as he admitted the method of applying the land/structure ratio to estimate the value of land is quite questionable due to the divergence between the book-value ratio and the market-value ratio and the lack of

a comprehensive survey on both land and structures. According to Goldsmith (1975), the urban land price index in Japan has risen almost 4,600 times between 1936 and 1970 while the urban area has expanded by a little over one-third. According to Pyo (1992), the land price index in Korea has risen 2,310 times between 1953 and 1990.

<Table 1> Summary Estimates of National Wealth of Korea(1953-1990)

Unit : Billion Won, current prices (%)

	1954	1962	1968	1977	1987	1990
Reproducible Fixed Assets	473 (65.59)	1715.7 (61.97)	4748.6 (48.52)	45236.7 (43.25)	386894.2 (53.09)	645926.7 (48.00)
Nonresidential Fixed Assets	296 (41.04)	1074.1 (38.8)	2932.3 (29.96)	32374.5 (30.95)	305950.6 (41.98)	498670.1 (37.06)
Inventory stocks	14.9 (2.07)	94.9 (3.43)	472.6 (4.83)	6999.5 (6.69)	54928.6 (7.54)	79118.0 (5.88)
Land	232.3 (32.21)	932.4 (33.68)	4376 (44.71)	41858.7 (40.02)	210955.4 (27.71)	461370.0 (34.29)
Consumer Durables	1 (0.00139)	25.5 (0.92)	189.9 (1.94)	10507.5 (10.05)	85006.7 (11.66)	159152.7 (11.83)
Gross Domestic Wealth	721.2 (100)	2768.5 (100)	9787.1 (100)	104602.4 (100)	728784.9 (100)	1345567.4 (100)
Net Foreign Liabilities	1.4	11.6	175.2	4152.3	21236.3	9291.80
Gross National Wealth (GNW)	719.8	2756.9	9611.9	100450.1	707548.6	1336275.6
GNP	66.2	355.5	1652.9	17806.6	106024.4	166437.8
GNW/GNP Ratio	10.9	7.8	5.8	5.6	6.7	8.0

Sources :Pyo(1992), Table 1

<Table 2> Estimates of Land by Industry

Unit : Billion Won at Current Prices

	1	2	3	4	5	6	7	8	8A	8B	9	TOTAL
1953	55.2	0.8	11.5	0.8	0.1	0.6	0.4	100.3	100.1	0.2	6.4	176.2
1954	73.4	1	14.9	1.1	0.1	0.8	0.5	132.3	132	0.3	8.2	232.3
1955	119.9	1.6	23.9	1.8	0.2	1.2	0.8	214.3	213.9	0.4	12.9	376.6
1956	162.1	2	31.7	2.3	0.2	1.5	1.1	287.4	286.8	0.6	16.7	505
1957	199.7	2.4	38.3	2.8	0.3	1.8	1.3	351.2	350.5	0.7	19.7	617.4
1958	198.8	2.3	37.3	2.7	0.2	1.7	1.2	346.6	346	0.6	18.8	609.6
1959	203	2.2	37.3	2.7	0.2	1.7	1.2	351.1	350.5	0.6	18.3	617.9
1960	228.6	2.4	41.2	3	0.3	1.8	1.3	392.2	391.5	0.7	19.7	690.4
1961	262.6	2.6	46.4	3.4	0.3	2	1.4	446.8	446.1	0.7	21.6	787.2
1962	313.5	3	54.3	4	0.3	2.3	1.6	528.8	528	0.8	24.6	932.4
1963	408.9	3.8	69.4	5.1	0.4	2.8	2	683.9	682.8	1.1	30.7	1206.9
1964	442.1	3.9	73.6	5.4	0.4	2.9	2	733.3	732.2	1.1	31.6	1295.3
1965	579	4.8	94.6	6.9	0.5	3.7	2.5	952	950.6	1.4	39.5	1683.6
1966	786.6	6.3	126.2	9.2	0.7	4.8	3.3	1282.2	1280.4	1.8	51.3	2270.5
1967	1083.6	8.3	171	12.5	0.9	6.3	4.3	1749.9	1747.6	2.3	67.8	3104.6
1968	1538.8	11.4	239.5	17.5	1.2	8.7	6	2459.7	2456.5	3.2	93.2	4376
1969	2654.6	19.3	408.6	29.9	2.1	14.6	10.1	4196.7	4191.3	5.4	157.5	7493.2
1970	3369.5	23.9	513	37.5	2.6	18.2	12.5	5268.3	5261.5	6.8	195.8	9441.3
1971	4311.2	33.5	675.6	49.4	3.6	25.5	17.5	6763.3	6753.8	9.5	274.3	12153.7
1972	4722.7	40.2	762.6	55.8	4.3	30.5	21	7429.6	7418.3	11.3	328.6	13395.3
1973	5127.2	47.9	855.6	62.6	5.1	36.4	25	8078.9	8065.4	13.5	392.1	14630.8
1974	6010.9	61	1033.8	75.6	6.5	46.3	31.8	9493.8	9476.6	17.2	498.5	17258.1
1975	7858.9	86.3	1393.9	102	9.2	65.5	45.1	12437	12412.7	24.3	705.4	22703.3
1976	10267.3	119.6	1863.9	136.4	12.8	90.8	62.5	16229.1	16195.3	33.8	978.4	29760.8
1977	14393.3	178.7	2679.7	196.1	19.1	135.6	93.4	22701.8	22651.4	50.4	1461.1	41858.7
1978	23565.7	312.4	4507.1	329.8	33.4	237	163.2	37055	36966.9	88.1	2554.2	68757.8
1979	27869.8	388.9	5450.3	398.8	41.5	295.1	203.2	43764.9	43655.2	109.7	3180	81592.5
1980	31364.8	459.4	6267.9	458.6	49.1	348.6	240	49193.4	49063.8	129.6	3756.7	92138.6
1981	33858.3	523.3	6935.6	507.4	55.9	397.1	273.4	53038	52890.4	147.6	4279.3	99868.5
1982	35795.8	583.1	7516.7	550	62.3	442.6	304.7	55989.5	55825	164.5	4768.6	106013.3
1983	43166.9	741.6	9299.7	680.4	79.2	562.8	387.5	67378.9	67169.7	209.2	6064.2	128361.2
1984	49394.4	894.8	10923.5	799.2	95.6	679.1	467.5	76900.4	76647.9	252.5	7317.1	147471.5
1985	53131.7	1013.2	12059.3	882.3	108.2	769	529.4	82491.4	82205.5	285.9	8285.6	159270.1
1986	57600.5	1136.2	13282.2	971.8	121.4	862.3	593.6	88751.6	88431	320.6	9291	172610.5
1987	67428.3	1390.2	15880.6	1161.9	148.5	1055.1	726.4	102796	102404	392.2	11368.6	201955.4
1988	89577.7	1915.6	21476.7	1571.4	204.6	1453.8	1000.9	135318	134777	540.5	15665	268183.3
1989	124409	2749.6	30319.9	2218.4	293.7	2086.7	1436.6	186325	185550	775.8	22484.4	372323.6
1990	154222.8	3521	38207.5	2795.5	376.1	2672.2	1839.7	228943	227949	993.4	28792.9	461370

Notes: 1.Agriculture, Forestry & Fishing, 2. Mining & Quarrying, 3. Manufacturing, 4. Electricity, Gas & Water, 5.Construction, 6. Wholesale & Retail Trade, Restaurants & Hotels
7. Transport, Storage, & Communication, 8.Financing, Insurance, Real Estate, & Business Services, 8A. Residential Structures of Housing, 9.Community

Sources : Pyo(1992), Table A-4

<Table 3> Estimates of Land by Industry

Unit: Billion Won at 1985 Constant Prices

	1	2	3	4	5	6	7	8	8A	8B	9	Total	Land Deflator
1953	45313.8	645	9412.8	688.7	68.9	489.5	337	82387.5	82205.5	182	5274.4	144617.6	0.0012
1954	45691.1	624.5	9299.4	680.4	66.7	473.9	326.3	82381.7	82205.5	176.2	5106.4	144650.3	0.0016
1955	46074.6	604.5	9190.1	672.4	64.6	458.8	315.9	82376.1	82205.5	170.6	4943.6	144700.6	0.0026
1956	46455.8	584.4	9079	664.3	62.4	443.5	305.3	82370.4	82205.5	164.9	4778.5	144743.5	0.0035
1957	46842.6	564.7	8971.6	656.4	60.3	428.6	295	82364.8	82205.5	159.3	4617.8	144801.9	0.0043
1958	47229.5	545	8863.8	648.5	58.2	413.6	284.8	82359.3	82205.5	153.8	4456.8	144859.6	0.0042
1959	47616.1	525.2	8755.6	640.6	56.1	398.6	274.4	82353.7	82205.5	148.2	4295.1	144915.5	0.0043
1960	48001.3	505.3	8646.2	632.6	54	383.5	264	82348.1	82205.5	142.6	4132	144966.9	0.0048
1961	48398.7	486.5	8544.5	625.2	52	369.2	254.2	82342.8	82205.5	137.3	3978.3	145051.3	0.0054
1962	48803.2	468.3	8447.2	618	50	355.4	244.7	82337.6	82205.5	132.1	3829.8	145154.4	0.0064
1963	49222.9	451.5	8359.1	611.6	48.2	342.7	235.9	82332.9	82205.5	127.4	3692.5	145297.4	0.0083
1964	49640.9	434.5	8269.2	605	46.4	329.7	227	82328.1	82205.5	122.6	3552.9	145433.7	0.0089
1965	50066.6	418	8183.5	598.8	44.6	317.3	218.4	82323.4	82205.5	117.9	3418.5	145589.1	0.0116
1966	50503.3	402.5	8104	592.9	43	305.5	210.3	82319.1	82205.5	113.6	3291.4	145771.9	0.0156
1967	50974.1	389.9	8044.7	588.6	41.6	295.9	203.7	82315.5	82205.5	110	3188.7	146042.8	0.0213
1968	51493.4	381.6	8014	586.3	40.8	289.6	199.4	82313.2	82205.5	107.7	3120.5	146438.7	0.03
1969	52065.6	377.7	8013.4	586.3	40.3	286.6	197.3	82312.1	82205.5	106.6	3088.6	146967.9	0.051
1970	52645.1	374.1	8014.8	586.4	40	283.9	195.4	82311	82205.5	105.5	3058.8	147509.4	0.064
1971	52475.1	408.2	8222.8	601.6	43.6	309.8	213.3	82320.7	82205.5	115.2	3338.2	147933.2	0.0821
1972	52334.1	445.3	8450.3	618.3	47.6	337.9	232.7	82331.1	82205.5	125.6	3641.4	148438.6	0.09
1973	52258.1	488.7	8720.1	638	52.2	370.9	255.3	82343.4	82205.5	137.9	3996	149122.5	0.098
1974	52142	528.8	8967.9	656.1	56.5	401.3	276.3	82354.7	82205.5	149.2	4324.1	149707.6	0.115
1975	52047	571.3	9231.4	675.4	61	433.6	298.5	82366.7	82205.5	161.2	4671.7	150356.5	0.151
1976	52115.6	607.3	9461.1	692.2	64.9	460.9	317.3	82376.8	82205.5	171.3	4966.3	151062.4	0.197
1977	52235.3	648.4	9725.1	711.5	69.3	492.1	338.8	82388.5	82205.5	183	5302.6	151911.7	0.2755
1978	52404.4	694.6	10022.8	733.3	74.2	527.1	362.9	82401.5	82205.5	196	5680	152900.8	0.45
1979	52480.6	732.3	10263.2	750.9	78.2	555.7	382.6	82412.1	82205.5	206.6	5988.2	153643.8	0.5311
1980	52551.2	769.7	10501.8	768.4	82.2	584.1	402.2	82422.7	82205.5	217.2	6294.2	154376.4	0.5968
1981	52624.6	813.4	10779.7	788.7	86.9	617.3	425	82435	82205.5	229.5	6651.2	155221.7	0.6434
1982	52711.3	858.7	11068.8	809.9	91.7	651.7	448.7	82447.8	82205.5	242.3	7022	156110.5	0.6791
1983	52829.7	907.6	11381.5	832.7	96.9	688.8	474.2	82461.6	82205.5	256.1	7421.7	157094.6	0.8171
1984	52975.9	959.7	11715.6	857.2	102.5	728.3	501.4	82476.3	82205.5	270.8	7847.7	158164.4	0.9324
1985	53131.7	1013.2	12059.3	882.3	108.2	769	529.4	82491.4	82205.5	285.9	8285.6	159270.1	1
1986	53545.5	1056.2	12347.1	903.4	112.8	801.6	551.8	82503.5	82205.5	298	8636.9	160458.8	1.0757
1987	54128.7	1116	12748.3	932.7	119.2	847	583.1	82520.4	82205.5	314.9	9126.2	162121.6	1.2457
1988	54636.7	1168.4	13099.5	958.4	124.8	886.7	610.5	82535.2	82205.5	329.7	9554.6	163574.8	1.6395
1989	55117.9	1218.2	13432.9	982.8	130.1	924.5	636.5	82549.2	82205.5	343.7	9961.5	164953.4	2.2571
1990	55617.5	1269.8	13778.8	1008.1	135.6	963.7	663.4	82563.8	82205.5	358.3	10383.6	166384.3	2.7729

Notes: 1. Agriculture, Forestry & Fishing, 2. Mining & Quarrying, 3. Manufacturing, 4. Electricity, Gas & Water, 5. Construction, 6. Wholesale & Retail Trade, Restaurants & Hotels
7. Transport, Storage, & Communication, 8. Financing, Insurance, Real Estate, & Business Services, 8A. Residential Structures of Housing, 9. Community

Sources : Pyo(1992), Table 5

(2) Estimates of Land after 1990

1) A Synthetic Estimation using National Wealth Surveys and Census Data

A synthetic estimation of land after 1990 can be made by making use of *National Wealth Survey* published by Statistics Korea for the period of 1997-2010. Statistics Korea had conducted National Wealth Survey four times since 1968 and the last national wealth survey in 1997. But it included fixed reproducible tangible assets, inventory stocks and consumer durable and semi-durable goods not land. Therefore, there are two alternative methods to make a synthetic estimation of land after 1990. One is to extend the series of 1953-1990 by making use of some flow data (1970-1998) such as land improvement and orchard improvement in Table 4 to the stock of 1990. The imputed deflator for land improvement increased by 22.1 times between 1970 and 1998. However, the Bank of Korea no longer publishes the data after 1998. We can make use of Mining and Manufacturing Reports which includes the value of land at the beginning of establishments, increase and decrease of the value during the year and the value of land at the end of the year as summarized in Table 5. These are book values reported by establishments. The data in 2010 seems from Economic Census conducted in 2010 which reports from firm-level survey not establishment survey and therefore, cannot be compared on an equal basis to the series before 2010.

<Table 4> Land Improvement and Orchard Improvement

	1	2	3. Deflator
1970	64.4	1253.8	0.0514
1971	55.5	999.3	0.0555
1972	74.0	1205.1	0.0614
1973	113.1	1622.3	0.0697
1974	133.2	1397.3	0.0953
1975	188.6	1545.1	0.1221
1976	232.0	1734.6	0.1337
1977	320.5	2082.1	0.1539
1978	434.5	2230.1	0.1948
1979	470.9	1867.7	0.2521
1980	619.8	1837.8	0.3373
1981	799.0	2088.9	0.3825
1982	875.1	2290.9	0.3820
1983	983.4	2620.8	0.3752
1984	1110.2	2789.9	0.3979
1985	1163.4	2796.4	0.4160
1986	1324.4	2936.7	0.4510
1987	1868.7	4019.7	0.4649
1988	1781.4	3449.8	0.5164
1989	1870.7	3112.5	0.6010
1990	2377.0	3210.6	0.7404
1991	3120.0	3591.3	0.8688
1992	3299.8	3555.8	0.9280
1993	3603.0	3865.1	0.9322
1994	4376.2	4551.0	0.9616
1995	5470.6	5470.6	1.0000
1996	6895.1	6515.9	1.0582
1997	8282.7	7386.6	1.1213
1998	7217.4	6341.9	1.1381

Notes : 1. Land Improvement and Orchard Improvement at Current Prices

2. Land Improvement and Orchard Improvement at Constant 1995 Prices

3. Implicit Deflator for Land Improvement

Sources : National Accounts, pp330-339, Bank of Korea, 1999

<Table 5> Value of Land in Manufacturing

Unit : Million Won, current prices

Year	Obs.	Value (beginning of year)	Increase	Decrease	Value (end of year)
1991	46,670	14,253,553	3,319,044	261,876	17,320,809
1992	46,624	17,739,515	2,396,465	369,447	19,766,481
1993	51,801	20,096,970	4,815,876	330,445	24,582,401
1994	52,692	25,541,512	3,092,888	396,898	28,237,502
1995	52,673	29,234,884	3,881,333	592,717	32,523,500
1996	52,128	33,080,102	4,149,581	502,784	36,726,717
1997	46,704	35,232,122	4,036,178	591,655	38,676,645
1998	41,926	38,602,904	7,196,730	1,070,577	44,729,057
1999	47,529	51,546,981	5,456,639	2,055,789	54,947,831
2000	51,176	55,389,833	4,690,459	1,030,932	59,049,360
2001	52,127	58,862,511	2,679,961	1,156,097	60,386,375
2002	54,091	59,691,525	3,262,905	2,654,878	60,299,552
2003	54,618	58,147,667	2,685,660	1,509,866	59,323,461
2004	54,037	57,639,283	4,783,804	1,563,519	60,859,568
2005	56,483	58,624,666	6,128,196	2,136,820	62,616,042
2006	58,199	63,097,415	6,947,332	1,951,158	68,093,589
2007	61,237	67,475,620	7,785,009	2,009,910	73,250,719
2008	58,328	73,785,106	27,331,188	2,832,948	98,283,346
2009	57,907	100,308,975	15,964,946	2,247,995	114,025,926
2010	62,250	27,109,626	4,471,484	646,383	30,934,727

Sources : Statistics Korea, Mining and Manufacturing Survey

For the period of 1980-2011, the estimates of fixed reproducible tangible assets are available from Pyo (2012) as shown in Appendix (Table A1-A4). The estimates of residential buildings and nonresidential buildings and structure can be used to impute the value of land on which they were built. A preliminary report by the Bank of Korea (2012) suggests to apply 40 % to impute land value of all nonresidential buildings and structures, 65 % to impute land value of all residential buildings and about 50 % to impute land value of all Agricultural land, Forest land and public and other land from National Wealth estimates of Statistics Korea. The report estimates the economy-wide value of land as of the end of 2010 as 5,300 trillion Won at market prices which is greater than the sum of land value (3,536 trillion Won) evaluated at the public-notice prices announced by the Ministry of Land, Transport and Maritime Affairs and estimate of land (3,568 trillion Won) in National Wealth compiled by Statistics Korea (2011) which occupies 45.9 % of all national wealth total (7,778.6 trillion Won) as shown in Table 6. Therefore, the valuation of land makes a great difference among estimates depending on what price index of land are used.

<Table 6> National Wealth by Types of Assets

Unit: Trillion Won, (%)

As of end of 2010 (preliminaries)	Total Assets Amount	Tangible Fixed Assets	Intangible Fixed Assets	Inventory	Land	Standing Timber	Underground Resources	Durable Consumer Goods
Public asset	7,778.6 (100)	3,380.3 (43.5)	43.3 (0.6)	489.7 (6.3)	3568.4 (45.9)	34.2 (0.4)	57.8 (0.7)	204.9 (2.6)
Variation	344.1	168.1	0.8	35.5	110.3	7.4	9.9	12.1

Sources : Statistics Korea (2011)

On the other hand, Statistics Korea's Economic Census (2010) reports Land (274 trillion Won), Building (185 trillion Won) and Structure (60 trillion Won) as of the end of 2010 from the 254,373 total number of enterprises being surveyed as shown in Table 7 and 8. Therefore, even after applying 50 % valuation of land for Building and Structure, we still end up with an estimate of total land of 396.5 trillion Won which is only 11.1 % of their own estimate of land (3,568 trillion Won) on National Wealth. This illustrates how little can be covered from establishment surveys as far as estimation of land is concerned because residential land, agricultural land and other public-use land are not included in the establishment surveys.

<Table 7> Number of Enterprises and Tangible and Intangible Assets in 2010 (All industries)

Unit : Million Won, current prices

Number of Enterprises	254,373				
Tangible Assets					
	At beginning of year	Annual increase	Annual decrease	Annual depreciation	At end of year
Total(A)	820,984,404	202,946,854	62,108,179	55,070,888	906,752,191
Land	247,179,783	36,446,673	8,994,461	0	274,631,995
Building	169,893,789	35,460,059	5,326,876	14,212,452	185,814,520
Structure	55,736,209	8,977,035	681,620	4,064,089	59,967,535
Machinery and equipment	164,864,197	60,120,124	5,381,873	25,196,040	194,406,408
Vehicle & equipment	40,663,096	11,288,346	6,176,538	4,151,039	41,623,865
Others	63,960,654	19,290,293	8,621,650	7,447,268	67,182,029
Construction in progress	78,686,676	31,364,324	26,925,161	0	83,125,839
Intangible Assets					
	At beginning of year	Annual increase	Annual decrease	Annual depreciation	At end of year
Total(B)	42,480,052	63,354,891	7,635,873	47,616,161	50,582,909
Industrial right	2,055,057	155,979	1,915,497	103,031	192,508
Copyright	8,389	30	1	43	8,375
Software	59,596	137,832	20,009	32,032	145,387
R&D	13,653,542	14,709,519	881,963	11,505,854	15,975,244
Others	26,703,468	48,351,531	4,818,403	35,975,201	34,261,395
Total Assets					
	At beginning of year	Annual increase	Annual decrease	Annual depreciation	At end of year
Total(A+B)	863,464,456	266,301,745	69,744,052	102,687,049	957,335,100

Sources : Statistic Korea, Report on the Economic Census(2010), 2012

<Table 8> Number of Enterprises and Tangible and Intangible Assets in 2010 (Manufacturing)

Unit : Million Won, current prices

Number of Enterprises	60,545				
Tangible Assets					
	At beginning of year	Annual increase	Annual decrease	Annual depreciation	At end of year
Total(A)	223,621,740	59,785,163	14,245,943	15,738,298	253,422,662
Land	76,026,177	11,450,758	1,617,313	0	85,859,622
Building	51,192,192	12,470,513	921,482	4,811,823	57,929,400
Structure	8,153,176	2,036,254	147,072	712,486	9,329,872
Machinery and equipment	56,649,539	19,685,227	2,207,340	8,451,934	65,675,492
Vehicle & equipment	2,576,015	1,195,001	450,721	349,701	2,970,594
others	11,642,960	4,029,788	1,847,540	1,412,354	12,412,854
Construction in progress	17,381,681	8,917,622	7,054,475	0	19,244,828
Intangible Assets					
	At beginning of year	Annual increase	Annual decrease	Annual depreciation	At end of year
Total(B)	7,144,757	17,833,296	2,290,843	13,409,731	9,277,479
Industrial right	630,291	29,061	608,229	3,538	47,585
Copyright	0	0	0	0	0
Software	4,905	37,834	0	7,173	35,566
R&D	4,808,240	5,964,525	316,138	4,833,981	5,622,646
Others	1,701,321	11,801,876	1,366,476	8,565,039	3,571,682
Total Assets					
	At beginning of year	Annual increase	Annual decrease	Annual depreciation	At end of year
Total(A+B)	230,766,497	77,618,459	16,536,786	29,148,029	262,700,141

Sources : Statistic Korea, Report on the Economic Census(2010), 2012

2) Estimation of Land using Financial Statement Analysis

Another alternative source of estimates of land is Balance Sheet data in Financial Statement Analysis compiled by the Bank of Korea as summarized in Table 9. The data covers only listed firms in selected industries and therefore cannot be regarded as economy-wide estimates of land by business establishments. For the period of 2008-2011, the value of land occupied about 18 % of total value of non-current assets.

<Table 9> Value of Land on Balance Sheets

Unit : Billion Won, current prices (%)

	2007	2008	2009	2010	2011
Non-current Asset	1,003,355 (100)	1,310,372 (100)	1,669,578 (100)	1,828,236 (100)	2,005,625 (100)
(1) Investments	316,383	345,044	415,195	477,412	586,560
(2) Tangible assets	607,578	800,470	1,060,386	1,142,032	1,174,468
(2a) land	146,873 (14.64)	228,783 (17.46)	301,772 (18.07)	325,989 (17.83)	342,475 (17.08)
(2b) Building and structures	187,784	221,458	267,636	281,862	303,964
(2c) Machinery and equipment	156,972	178,796	189,730	204,546	250,414
(2d) Ship, vehicles and transportation equipment	30,193	47,214	40,786	50,090	41,731
(2e) Other plant assets	33,805	47,613	115,681	125,750	123,140
(2f) Construction in progress	45,534	72,713	144,783	153,795	112,745
(2g) Other tangible assets	6,418	3,922	0	0	0

(3) Intangible assets	32,537	74,586	97,301	111,147	137,163
(4) Other non-current asset	46,858	90,273	96,695	97,646	107,433

Sources : The Bank of Korea, Financial Statement Analysis, 2011

3) Estimation of Land using Land Property Tax Reports

Our last source of alternative estimates of land is the tax records on land by the Ministry of Public Administration and Security. The Annual Report of Local Tax Administration reports property tax base and tax amount by Land and Buildings and Structures. The Annual Report (2012) reports a total of 48, 541,389 cases with a total tax base of 3,589.7 trillion Won and a total tax amount of 12.2 trillion Won in 2011. Therefore, an implicit property tax rate is estimated to be 0.34 %. The total property tax records are decomposed into two parts; taxable part by kinds of property and non-taxable part by kinds of property. The taxable part reports a total of 30,745,834 cases with total tax base of 2,721.7 trillion Won and total tax amount of 7.9 trillion Won in 2011. The portion on land is 10,595,847 cases with total tax base of 1,151.3 trillion Won and total tax amount of 3.9 trillion Won. The portion on Buildings and Structures is 3,573,268 cases with total tax base of 335.9 trillion Won and total tax amount of 1.1 trillion Won. The portion on Houses has a total of 16,563,384 cases with the tax base of 1,228.4 trillion Won and tax amount of 2.9 trillion Won. Therefore, the implicit effective property tax rate on taxable part of Land, Buildings and Structures and Houses are 0.34 %, 0.33 % and 0.23 % respectively. The Annual Report also reports the non-taxable or tax reduction and exemption part of Land and Buildings and Structures with a total of 17,795,555 cases with total tax base of 867.9 trillion Won with the tax amount of 4.3 trillion Won and therefore with an implicit tax rate of 0.5 %. The non-taxable and tax reduction and exemption part is decomposed into taxation on land (15,207,415 cases with tax base of 706.0 trillion Won and tax amount of 3.8 trillion Won and therefore with an implicit land tax rate of 0.54 %), taxation on Buildings and Structures (1,149,268 cases with tax base of 104.5 trillion Won and tax amount of 0.4 trillion Won and therefore with an implicit tax rate of 0.35 %) and taxation on Houses (1,390,096 cases with a total tax base of 50,165.1 trillion Won and tax amount of 84,737.1 and therefore, with an implicit tax rate of 0.38 %).

In summary, as shown in Table10 (Pyo and Rhee(2013)), total tax base of land in Korea which was subject to the land property tax in Korea in 2011 is estimated to be a total of 1,857.3 trillion Won with 1,151.3 trillion Won of taxable land and 706.0 trillion Won of land subject to non-taxation, reduction and exemption. On the other hand, total tax base of Buildings and Structures and Houses in Korea in 2011 is estimated to be a total of 1,718.8 trillion Won (440.3 trillion Won of Buildings and Structures and 1,278.5 trillion Won of Houses) with a total of 1,564.3 trillion Won of Taxable Buildings and Structures and Houses (335.9 trillion Won of Buildings and Structures and 1,228.4 trillion Won of Houses) and a total of 154.5 trillion Won of Buildings and Structures and Houses subject to non-taxation, reduction and exemption (104.4 trillion Won of Buildings and Structures and 50.1 trillion Won of Houses). Therefore, the overall Land/Structure ratio in valuation in Korea in 2011 is estimated to be around 1.86/1.72 (1,857.3/1,718.8) which is slightly bigger than 1.0 quoted in Goldsmith (1975) from Igarashi and Takahshi's study on Japan's estimate of Land/ Structures.

3. Estimation of Inventory Stocks

There are several alternative methods to estimate inventory stocks. In the present paper, we will review three methods as follows.

(1) Harberger's Method

Harberger (1978) was mainly concerned with estimating capital stocks for developing countries where typically there are no economy-wide census-type benchmark estimates of capital stocks and long-term investment series to apply perpetual inventory method (PIM). He defined three types of capital stocks: Buildings, Machinery and Equipment and Inventory Stocks. Then he applied unilateral depreciation rates: 2.5 % for Buildings and 8 % for Machinery and Equipment. For inventory stocks, he did not apply any depreciation because the inventory investment statistic on national accounts reflects net change of inventory stocks.

<Table10> Comparative Estimates of Land (2010)

Unit : Trillion Won, (%)

1. Bank of Korea(2012)			
(Residential building, 65%), (Nonresidential building and structure, 40%)			5,300
2. Ministry of Land, Transport and Maritime Affairs(2011)			
			3,536
3. Statistics Korea, National Wealth (2011)			
	Tangible Fixed Assets	3,380	(1,690)
	<u>Land</u>		<u>3,568</u>
	Imputed Total Land		5,258
4. Statistics Korea , Economic Census(2012)			
	(All industries)		
	Building	185	(93)
	Structure	60	(30) 123
	<u>Land</u>		<u>274</u>
			397(100%)
	(Manufacturing)		
	Building	58	(29)
	Structure	9	(4) 33
	<u>Land</u>		<u>86</u>
			119(30.0%)
5. Pyo and Rhee(2012)			
	Residential Building	878	
	Non residential building	957	
	<u>Structure</u>	<u>1,254</u>	
		3,089	(1,545)
			3,536
			5,181
6. Pyo and Rhee (2013) based on land tax records			
	Taxable Land		1, 151.3
	Land subject to non-taxation, reduction and exemption		<u>706.0</u>
			1.857.3 (a)
	Taxable Structures and Houses		1,564.3
	Structures and Houses subject to non-taxation, reduction and exemption		<u>154.5</u>
			1,718.8 (b)
	Land/Structure Ratio: (a)/(b) = 1.85/1.72		

Sources: Bank of Korea(2012), Ministry of Land, Transportation and Maritime Affairs(2011), Statistic Korea, National Wealth(2011), Statistic Korea, Economic Census(2012), Pyo and Rhee(2012) and Pyo and Rhee (2013)

Harberger defined a normal economic condition as a kind of steady state in which we observe almost identical growth rates between GNP and three types of capital stocks. From the past series of macroeconomic data, he picked up three normal years. Then he used a three-year moving average for inventory stocks because inventory is very sensitive to business cycle. He used the following equation to derive investments of three assets from their capital stock (K):

$$I_t = (\delta + \gamma)K_{t-1} \quad (1)$$

where I is the three-year moving average of investment during three normal years, δ is depreciation rates (2.5 % for Buildings, 8 % for Machinery and Equipment and 0 % for inventory stocks) and γ is the average growth rate of GNP during the three normal years.

Harberger noted that the above formula is more appropriate to be applied to estimating Buildings and Machinery and Equipment than to estimating inventory stocks. But he argued that the accumulation of inventory investments is the result of economic growth rather than its cause. Therefore, he assumed that there will not be a great deal of errors in estimating inventory stocks by using the ratio of inventory investment to GNP. He estimated the initial capital stock for the period of 1956 and 1975, for example, by deriving the ratio of accumulated inventory investments to accumulated incremental GNP. The ratio is multiplied by 1955 GNP to estimate 1955 inventory stocks.

(2) The Acceleration Model

This method of estimating inventory stocks is based on the theory of inventory investment in standard macroeconomics. According to Mankiw (1994), inventory investment is the smallest expenditure item in GDP accounting which occupies about 1 % of total GDP in the United States. But it is very sensitive to business cycle and fluctuates a lot so that it is an important expenditure item in forecasting aggregate demand. The theory of investment states that the firms reduce inventory investment when business conditions go down because they do not replenish the inventory while their products are sold. In the United States, at least half of the aggregate demand reduction can be accounted for by the reduction of inventory investment.

There are four motives for firms to hold inventory stocks:

(1) Production smoothing

When the firms face unexpected sales increase, they can use inventory stocks rather than increasing production capacity and when the demand gets reduced, then they can increase inventory stocks rather than production-cut.

(2) Management efficiency

For the retail business, the inventory stocks improve sales efficiency because it can be shown to the potential customers without delay. For manufacturing, the firms can prepare for the risk of break-down in their machineries and equipments by storing inventory parts and components and raw materials and other intermediate goods.

(3) Stock-out avoidance

Since firms cannot forecast their actual sales, they need to make inventory

investments to be prepared for unanticipated sales increase.

(4) Work-in-progress

For production of certain products, firms go through multiple stages of production and take longer time than other products. When firms complete producing only a part of the entire products, the remaining products are defined as Work-in-progress.

A theoretical model which encompasses all of the above four motives for inventory stocks is the acceleration model of inventory investment. The model assumes real inventory capital stock (N) is a proportion of real GDP (Y) to reflect firms' motives for holding a portion of their output as inventory stocks.

$$N = \beta Y \quad (2)$$

Since inventory investment (I) has no depreciation, it can be defined as the change of inventory stocks as follows:

$$I = \Delta N = \beta \Delta Y \quad (3)$$

The change in GDP (ΔY) is defined as acceleration referring GDP as speed of production. In other words, inventory investment is viewed as a variable which adjusts as the economy is either accelerating or slowing down. The following equations can be derived to estimate inventory stocks following the acceleration principle.

$$\begin{aligned} I &= \Delta N = \beta \Delta Y \quad (4) \\ \Delta N &= N_t - N_{t-1} = \beta(Y_t - Y_{t-1}) \\ N_t &= N_{t-1} + \beta(Y_t - Y_{t-1}) \\ &= N_{t-1} + \beta \Delta Y_t \end{aligned}$$

Suppose that there is a benchmark estimate of inventory stocks, for example, the 1997 National Wealth Survey in Korea. Then the following acceleration model can be specified to estimate inventory stocks after 1997, for example, inventory stock in 2012 (N_{2012}) as follows;

$$\begin{aligned} N_{2011} &= N_{2010} + \beta \Delta Y_{2011} \quad (5) \\ N_{2012} &= N_{2011} + \beta \Delta Y_{2012} \\ &= N_{2010} + \beta \Delta Y_{2011} + \beta \Delta Y_{2012} \end{aligned}$$

According to Mankiw (1994), the following equation was estimated for the US data:

$$I = 0.2 \Delta Y \quad (6)$$

which states that if the real GDP increases by one billion dollars, then the real inventory investment increases by 0.2 billion dollars.

In case of Korea, the following relationship was estimated in Pyo (2005) using national accounts data during the period of 1986-2004:

$$I = -8.2415 + 0.302\Delta Y \quad R^2 = 0.63 \quad (7)$$

$$(-4.516) \quad (5.188) \quad DW = 1.10$$

where the values in parenthesis are t- values.

According to Pyo (2005), the estimated acceleration coefficient (b=0.302) was used to generate real inventory stocks after 1987 using the deflated 1987 NWS estimate of inventory stocks as the initial level of inventory stocks. The generated real inventory stock in 1997 was compared with the deflated 1997 NWS estimate of inventory stocks to find the former reached about 71 percent level of the latter.

The above acceleration model has been re-estimated using annual data of Korea without intercept term following Mankiw (1994) for two different periods, 1971-1997 and 1971-2012 as follows:

$$I = 0.199\Delta Y \quad R^2 = 0.21 \quad (8)$$

$$(9.077) \quad DW = 1.26$$

Sample: 1971-1997

$$I = 0.199\Delta Y \quad R^2 = 0.30 \quad (9)$$

$$(5.853) \quad DW = 1.94$$

Sample: 1971-2012

In both periods, the acceleration coefficient is estimated to be equal to 0.2 which is Mankiw's estimate from the US data. So the estimated coefficient can be used to generate inventory stocks after 1997 which is the last benchmark-year on Korea's NWS.

(3) A Modified Benchmark-Year Estimation Method

As noted by Harberger (1978), there is an intrinsic difficulty in estimating inventory stocks in the sense that it is not reproducible tangible asset and therefore, it has no depreciation. The zero depreciation property and the negative values of inventory investment in certain years make it difficult to apply perpetual inventory method (PIM) to generate inventory stocks. For example, according to Pyo (2005), when the 1987 NWS estimate of inventory stocks was used as the initial value and the inventory investment data on national accounts were kept being added to it cumulatively without applying any depreciation, the generated 1997 estimate of inventory stocks (70,087 billion Won) was only 27.2 percent of the actual survey estimate (257,534 billion Won) by 1997 NWS. Therefore, a pure PIM or a modified PIM which makes use of at least one benchmark estimate seems to break down.

As an alternative model of modified PIM, Pyo (1992) applied the following method. First, the ratio of inventory stock was defined as follows:

$$\text{Inventory-output ratio} = \frac{\text{Inventory Stocks in current prices in a benchmark-year}}{\text{Gross output in current prices in preceding year of benchmark-year}}$$

The method assumes the current year level of inventory stocks is mostly affected by the gross

output in the preceding year since firms adjust their level of inventory stocks to the level of output in the preceding year not the level of value added because investment includes intermediate inputs and work-in-progress. In addition the inventory stocks are concentrated in a few industries. For example, the 1997 NWS has the distribution of inventory stocks by industries: Manufacturing (48 %), Retail and Wholesale Trade (25 %), Construction (14 %) and Agriculture Fishery and Forestry (7 %) and all other industries (6 %). Therefore, the inventory-output ratio can be computed for selected industries using inventory stock data from benchmark-year estimates and gross output data from national accounts or Input-Output Tables.

The inventory-output ratio can be computed only when the benchmark-year estimates of inventory stocks are available. Therefore, in case of Korea, the ratio can be computed for the four selected years when NWS was conducted: 1968, 1977, 1987, and 1997. As shown in <Table 11>, inventory-output ratio was 0.20, 0.19, 0.23, and 0.27 respectively. On the other hand, the inventory-GDP ratio was 0.28, 0.42, 0.53 and 0.57 respectively when the GDP in the preceding year of each benchmark-year was used instead of gross output. The former ratio is more stable than the latter ratio indicating that the inventory-output ratio can serve better for the purpose of estimating inventory stocks in non-benchmark years.

To estimate inventory stocks using inventory-output ratio for the non-benchmark years, there are two alternative approaches. The first alternative method was used in Pyo (1992). The inventory-output ratios by selected industries were interpolated between two benchmark years. For the years after the final benchmark year, we had used the final benchmark year's ratio to generate inventory stocks. The second alternative is to apply RAS for those years when the Input-Output Tables are unavailable. The inventory investments by industries when Input-Output Tables are not available are estimated by the RAS method as demonstrated in Pyo (2005) for the year 1999 using 1998 I-O Table and 2000 I-O Table.

<Table 11> Inventory Stock-Gross Output Ratio and Inventory Stock-GDP Ratio in Korea

Unit: Billion Won, Current price, (%)

	Gross Output	GDP	Total Inventory Stock	Inventory Stock-Gross Output Ratio	Inventory Stock-GDP Ratio
1967	1,799 ¹⁾	1,259			
1968		1,630	357	0.198166	0.283
1976	32,015	14,305			
1977	40,020	18,356	5,985	0.186954	0.418
1986	222,569	98,110			
1987	264,094	115,164	52,135	0.234240	0.531
1996	940,117	448,596			
1997	1,030,304	491,135	257,534	0.273938	0.574

Note : 1) The data of nominal gross output in 1967 is estimated from National Accounts in 1984

2) The rate of Inventory= $INV_t / \text{Gross output}_{t-1}$ (or GDP_{t-1}), where t is a benchmark year

Sources: Pyo(2005) Table 11 and Table 13

<Table 12> Estimation of Industrial Inventory Stock Using Four Alternative Estimations (1977-2012)

Unit: Billion Won, 2005 Constant Price

	Series A	Series B	Series C	Series D
1977	40170.47	40170.47	40170.47	40170.47
1978	48685.75	45383.99	46605.47	42719.58
1979	57201.04	51714.29	53266.28	45010.29
1980	65716.32	59204.34	59752.95	44450.72
1981	74231.61	64577.13	60602.75	46600.46
1982	82746.89	71177.13	67215.96	49186.07
1983	91262.18	78334.93	75091.52	53299.95
1984	99777.46	89276.84	86822.15	57034.98
1985	108292.7	100814.4	98219.67	60144.32
1986	116808	109868.5	108607.2	65618.95
1987	125323.3	125323.3	125323.3	71776.8
1988	143894.1	144528.2	141861.5	78348.78
1989	162464.8	160723.3	159705.3	82598.01
1990	181035.6	171429.8	171878.6	88844.18
1991	199606.4	186118.9	189378	95976.16
1992	218177.1	205473.6	209438.8	100620.6
1993	236747.9	218500.3	223276.2	106013.6
1994	255318.6	233728.6	239282.6	113960.6
1995	273889.4	255449.1	262311	122761.4
1996	292460.2	285313.8	287958.1	130475.1
1997	311030.9	311030.9	311030.9	137110.2
1998	297593.6	329104	328967.3	130156.8
1999	295577.3	325290.4	310170.4	142469.1
2000	299615.2	355005.1	343453.6	153647
2001	302308.3	389423.9	373669.8	159139.5
2002	306175.2	398725.4	388517.5	169415.8
2003	310399.4	422331.7	416296.5	173732.1
2004	316276.6	436923.3	427964.4	181044.7
2005	323452.8	473831.7	447732.2	187598.9
2006	333470	503224.1	465449.7	196515.7
2007	340671.7	536635.3	489553.8	205762.4
2008	353830.3	573765	514549.6	210137.2
2009	336728.5	639919.2	526375.9	210759.4
2010	333804.4	626226.6	528057.7	223105.6
2011	337122.9	682245.8	561432.2	230753
2012	340082.3			235154.7

Note : Series A - Summation of real inventory investments

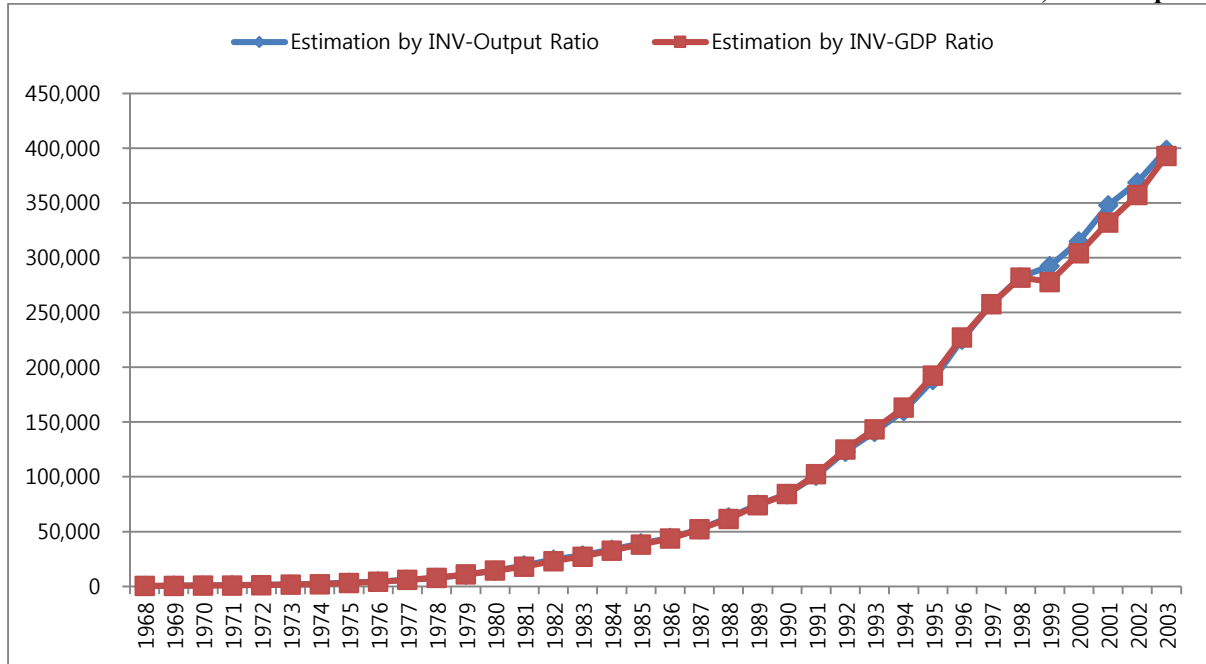
Series B - The Acceleration Model

Series C - A Modified Benchmark-Year Estimation Method (Inventory - Output ratio)

Series D - A Modified Benchmark-Year Estimation Method (Inventory - GDP ratio)

<Figure 1> Estimation of Total Inventory Stock

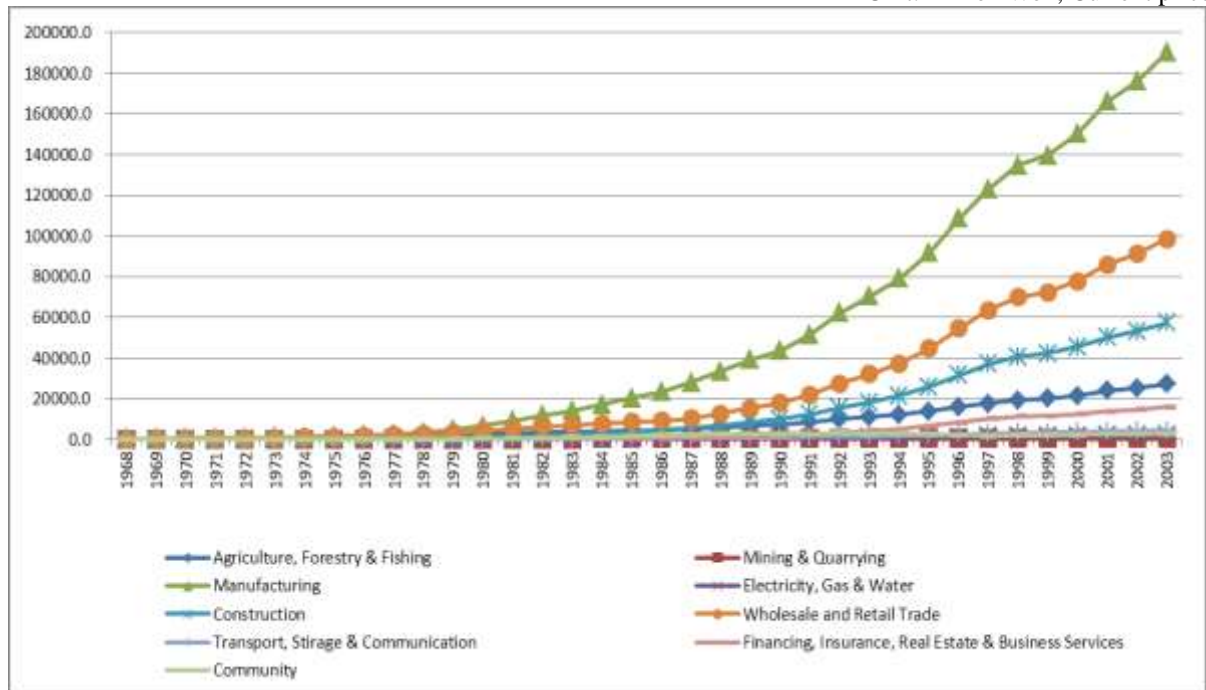
Unit: Billion Won, Current price



Sources: Pyo(2005) Table 12 and Table 14

<Figure 2> Estimation of Industrial Inventory Stock using Inventory Stock-Gross Output Ratio (1968-2003)

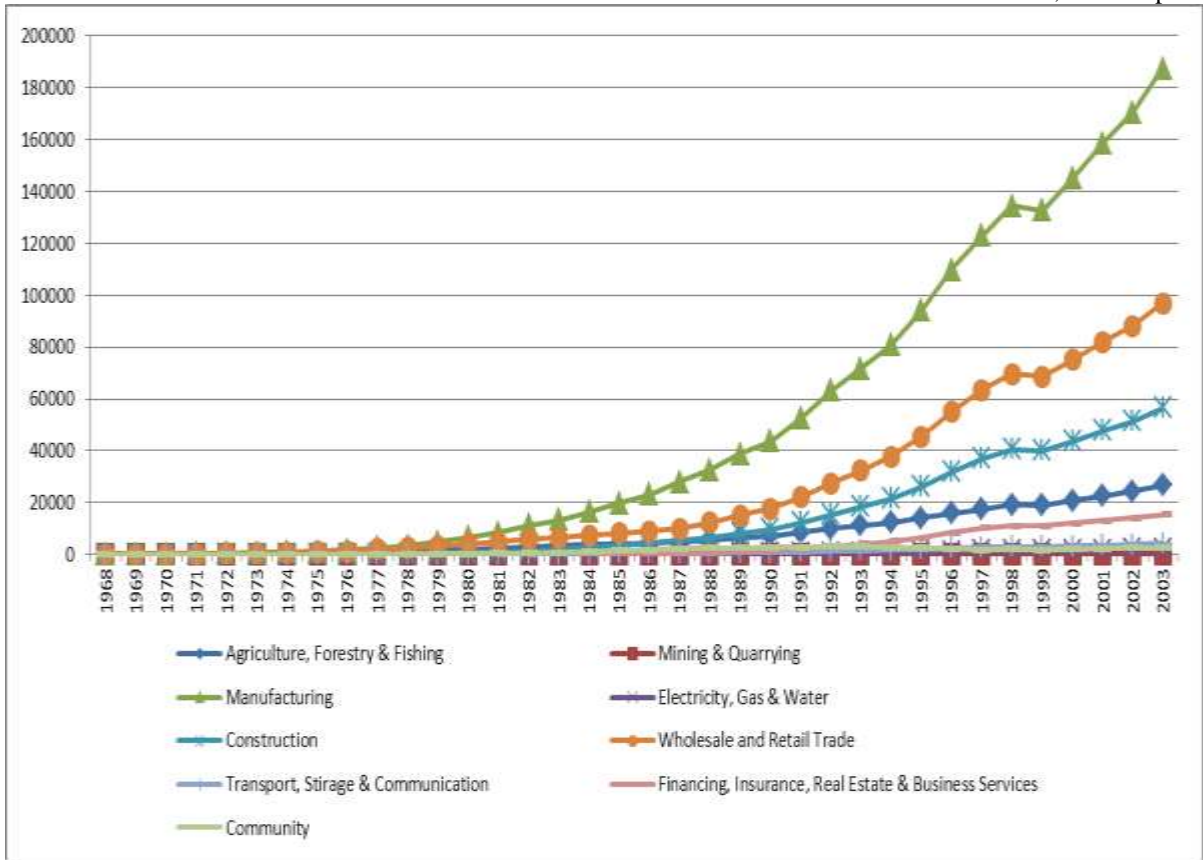
Unit: Billion Won, Current price



Sources: Pyo(2005) Table 12

<Figure 3> Estimation of Industrial Inventory Stock using Inventory Stock-GDP Ratio(1968-2003)

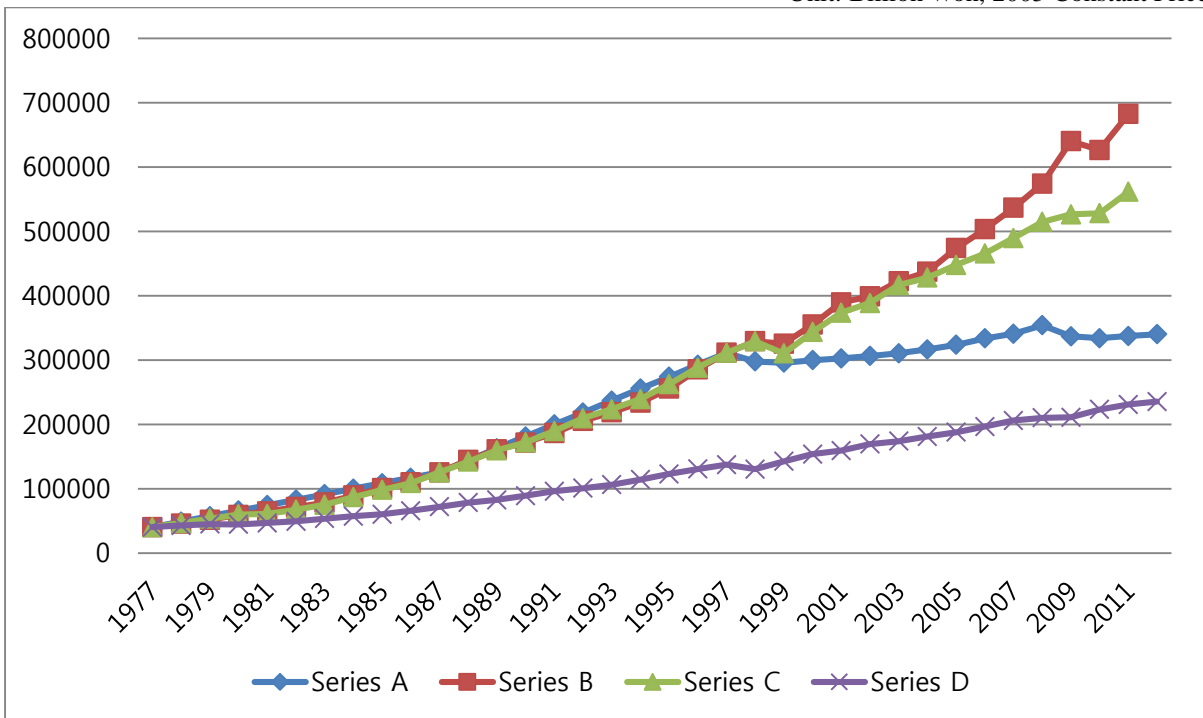
Unit: Billion Won, Current price



Sources: Pyo(2005) Table 14

<Figure 4> Estimation of Industrial Inventory Stock Using Four Alternative Estimations (1977-2012)

Unit: Billion Won, 2005 Constant Price



4. Conclusion

In the present paper, we have demonstrated how difficult it is to impute the value of land based on the existing estimates and data in Korea. There are very difficult data requirements to be met to impute the value of land. We need reasonably reliable estimates of land by regional zoning codes if not by industries. We also need data on land improvements to reflect the increase in value of land by land improvements because land itself is not reproducible and therefore, depreciation cannot be applied. We also need at least reasonable data for the price index of land by the location and the zoning of land.

We also have revisited the alternative methods of estimating inventory stocks. Because of the zero depreciation in inventory stocks, the application of a pure perpetual inventory method is likely to break down. The economy-wide level of inventory stocks can be estimated by an acceleration model. But if we need to decompose inventory stocks by both industries and types of inventories, we may have to apply the inventory-output ratio using both Input-Output data and census data.

For these reasons, EU KLEMS (2007) and Asia KLEMS Draft Manual by Pyo, Chun and Rhee (2012) have not attempted to include land and inventory stocks as capital inputs in addition to fixed tangible assets such as Buildings and Machinery and Equipment. However, because of the very agrarian nature of Asian economies and their rapid transition toward industrialization, we may have to start thinking about including imputed land and inventory stocks. Otherwise, we may be missing fundamental capital inputs and therefore may end up introducing too much bias in estimating rates of return and total factor productivity.

References

- The Bank of Korea, ‘The Estimates of Land and Residential Building in Market Prices, National Account Division, National B/S Team, December 2012 (in Korean)
- Goldsmith, R.W., ‘A Synthetic Estimate of the National Wealth of Japan, 1985-1973’, *The Review of Income and Wealth*, Series 21, Number2, June 1975.
- Harberger, A. C. “Perspectives on Capital and Technology in Less-Developed Countries” in Michael J. Artis, and A. Robert Nobay(eds.), *contemporary Economic Analysis*, London, Longman, 1978.
- Harrison, Anne, and Charles Aspden, “Inventories, Income, and Capital Services”, Canberra II Meeting, Geneva, September, 2005.
- Jorgenson Dale W., Frank M. Gollop, Barbara M. Fraumeni, “Productivity and U.S. Economic Growth” ,toExcel, New York ,1999
- Kendrick, John W., “The Formation and Stocks of Total Capital”, New York, NY; Columbia University Press for National Bureau of Economic Research, 1976
- Mamalakis, M., ‘Misuse and Use of National Accounts as a Welfare Indicator: Selected

- Analytical and Measurement Issues’, Paper presented at IARIW conference, Films, Switzerland, 1992
- Mankiw, N. Gregory, *Macroeconomics*, 2nd Edition, New York, Worth Publishers Inc, 1994
- Ministry of Public Administration and Security, *Annual Report of Local tax Administration*, 2012
- Nomura, Koji, *The Measurement of Capital- Capital Deepening and Productivity in the Japanese Economy*” (in Japanese), 2004
- OECD, “*Measuring Capital - OECD Manual: Second Edition*”, 2009
- Pyo Hak K., ‘*A Synthetic Estimate of the National wealth of Korea*’, 1953-1990, KDI Working Paper No.9212, Korea Development Institute, May 1992
- Pyo Hak K., “*The Estimation of Inventory Stocks using National Wealth Survey in Korea*”, *Economic Analysis*, Institute of Economic Research, Seoul National University, December 2005 (in Korean)
- Pyo, Hak K., KeunHee Rhee, and Bong Chan Ha, “*Growth Accounting and Productivity Analysis by 33 Industrial Sectors in Korea (1984-2002)*”, ICPA Report submitted to RIETI(Research Institute of Ministry of Economy, Trade and Industry of Japan, 2005
- PyoHak K, Rhee KeunHee, Chun Hyunbae, “*Asia KLEMS Growth and Productivity Accounts*”, A draft proposal presented at Asia KLEMS Data Management Workshop at Seoul National University July 5-6, 2012
- Pyo Hak K., ‘*Estimates of Quarterly Capital Stock and Trend in Total Factor Productivity*’, National Assembly Budget Office, December 2012 (in Korean)
- Pyo Hak K. and KeunHee Rhee, *The Estimation of Land and Inventory Stocks as a Capital Input in Korea*, Mimeograph, Institute of Economic Research, Seoul National University, 2012
- Pyo Hak K. and KeunHee Rhee, *The Estimation of Land and Inventory Stocks as Capital Inputs in Korea*, Mimeograph, Institute of Economic Research, Seoul National University, 2013
- Statistics, Korea, “*Estimates of National Wealth in 2010 (preliminary)*”, December 2011
- Timmer Marcel, Ton van Moergastel, Edwin Stuivenwold, Gerard Ypma, Mary O’Mahony and Mari Kangasniemi, “*Growth and Productivity Accounts*” , EU KLEMS, March 2007

<Appendix>

<Table A1> Real Capital Stock by Types of Assets (1980-2011)

Unit : Trillion Won (in 2005 prices)

	1	2	3	4	5	6	7	8	Total
1980	52.9	62.9	37.7	10.3	5.3	1.9	17.0	1.1	189.1
1981	57.8	68.4	43.3	10.9	6.2	2.2	18.5	1.2	208.6
1982	67.6	77.6	53.8	12.8	7.1	2.5	20.2	1.3	242.8
1983	80.9	89.6	66.8	14.0	8.3	2.9	23.1	1.4	287.0
1984	94.7	106.6	79.5	16.6	10.3	3.6	27.6	1.6	340.4
1985	107.5	122.4	93.5	18.8	11.4	4.0	29.9	2.1	389.6
1986	126.3	142.9	107.9	23.3	13.1	4.6	33.9	2.8	454.8
1987	142.9	164.5	123.1	25.8	16.1	5.6	40.8	3.7	522.5
1988	153.3	174.9	133.9	29.0	20.4	7.8	48.4	4.5	572.1
1989	168.6	191.9	144.0	32.8	26.8	10.8	60.8	5.5	641.3
1990	190.8	201.8	150.7	38.2	31.6	13.4	69.1	6.6	702.3
1991	209.8	212.0	167.0	45.6	37.5	16.4	79.4	8.0	775.7
1992	237.4	228.8	193.6	54.1	42.6	19.1	88.1	9.6	873.3
1993	283.6	263.7	231.2	61.2	47.6	21.6	96.7	11.3	1016.9
1994	321.2	294.7	268.2	74.5	54.2	25.0	108.5	13.7	1160.1
1995	357.0	323.5	296.5	84.8	63.9	29.9	126.0	16.6	1298.2
1996	398.9	357.9	336.0	92.7	74.9	35.4	145.8	19.8	1461.5
1997	432.0	389.7	376.6	98.9	83.6	39.8	161.5	22.7	1604.7
1998	455.2	414.1	424.4	92.5	85.0	41.4	162.9	24.8	1700.2
1999	475.5	430.3	475.5	94.0	89.3	44.6	168.7	27.9	1805.9
2000	491.8	450.6	523.6	99.3	98.0	50.2	181.0	32.3	1926.8
2001	511.6	473.8	571.1	101.5	103.9	53.4	191.8	36.2	2043.3
2002	534.7	503.9	614.2	105.4	109.6	55.8	205.0	40.9	2169.4
2003	560.6	540.2	657.7	105.9	114.5	56.9	219.5	44.3	2299.7
2004	587.1	576.1	700.1	104.6	119.1	57.3	237.5	47.0	2429.0
2005	613.8	608.5	742.2	103.6	123.3	56.8	258.8	50.2	2557.1
2006	638.6	641.7	783.3	103.4	128.4	56.7	282.1	53.7	2688.0
2007	661.2	675.3	825.6	105.0	134.5	57.1	307.5	57.3	2823.6
2008	679.6	706.9	866.8	106.7	139.8	57.4	329.7	60.3	2947.2
2009	696.7	736.2	914.1	108.6	142.2	56.9	343.0	62.8	3060.5
2010	707.8	768.5	955.9	111.8	149.2	58.0	368.7	65.1	3184.9
2011	713.2	801.6	992.7	114.9	156.3	59.2	394.4	68.2	3300.5

Notes : 1. Residential structures, 2. Non-residential structures, 3. Infrastructure, 4. Transport equipment, 5. Computing equipment, 6. Communications equipment, 7. Other machinery and equipment, 8. Software
Sources : Pyo(2012)

<Table A2> Real Capital Stock by Industry (1980-2011)

Unit : Trillion Won(in 2005 prices)

	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1980	16.0	1.3	49.6	8.2	6.7	14.7	16.0	3.2	47.5	19.2	3.0	0.8	3.0	189.1
1981	16.6	1.4	54.4	9.7	7.9	16.0	16.9	3.7	51.1	22.5	3.8	1.0	3.5	208.6
1982	18.2	1.7	60.2	11.5	9.5	19.2	19.2	5.0	59.3	28.6	4.7	1.3	4.4	242.8
1983	20.4	1.9	68.3	13.8	11.1	21.8	22.6	5.6	72.1	36.3	5.8	1.7	5.5	287.0
1984	23.3	2.2	81.1	16.1	13.3	27.0	26.2	6.5	84.8	43.6	7.3	2.3	6.8	340.4
1985	25.3	2.5	94.6	17.9	15.4	28.3	29.3	7.2	96.6	52.7	8.7	2.9	8.1	389.6
1986	28.2	2.8	112.1	19.2	17.5	32.9	33.7	9.5	111.8	63.2	10.3	3.6	9.9	454.8
1987	31.8	3.0	138.5	20.9	20.2	38.8	37.2	11.0	123.4	70.1	11.9	4.3	11.3	522.5
1988	32.0	2.8	154.0	22.1	23.5	47.7	38.8	11.0	124.1	83.0	14.5	5.2	13.2	572.1
1989	35.3	2.2	171.8	24.1	25.9	52.7	42.0	12.5	141.7	95.8	16.7	6.0	14.8	641.3
1990	37.1	2.1	189.6	26.2	29.4	59.4	46.3	12.0	156.7	103.5	18.7	6.2	14.9	702.3
1991	39.4	1.9	205.5	29.3	36.7	65.2	50.5	12.7	171.4	119.3	20.5	6.8	16.5	775.7
1992	42.2	1.8	222.1	35.1	45.1	70.5	55.3	15.5	193.0	141.9	23.8	7.8	19.2	873.3
1993	46.3	1.8	242.9	42.5	53.5	81.7	63.6	18.1	241.3	165.4	28.3	9.0	22.3	1016.9
1994	50.6	1.6	268.4	51.4	60.0	89.8	72.5	19.3	282.0	192.8	33.8	10.7	27.1	1160.1
1995	54.4	1.6	286.5	53.5	63.9	105.0	77.5	26.0	335.8	211.7	39.6	12.0	30.8	1298.2
1996	58.5	1.6	332.6	64.1	71.1	114.1	101.0	31.7	345.2	245.4	45.3	14.2	36.8	1461.5
1997	61.2	1.5	366.8	68.9	78.5	130.2	100.7	34.7	377.7	272.8	55.1	15.9	40.9	1604.7
1998	62.7	1.6	373.7	74.8	77.8	127.8	112.2	34.5	421.1	293.4	56.2	18.7	45.5	1700.2
1999	65.4	1.7	388.9	83.4	77.1	127.8	131.5	32.4	454.7	313.6	57.6	21.6	50.2	1805.9
2000	68.7	1.8	413.6	91.6	76.8	129.3	156.7	35.7	479.1	333.1	61.7	23.8	55.0	1926.8
2001	71.8	1.9	430.5	100.0	76.3	131.3	179.4	38.0	507.2	354.5	66.7	25.9	59.8	2043.3
2002	74.5	2.0	451.4	107.9	75.8	134.3	201.0	40.9	539.1	375.4	72.5	28.5	66.1	2169.4
2003	76.8	2.1	474.8	115.1	75.2	137.2	222.0	43.5	574.2	398.9	77.6	30.7	71.6	2299.7
2004	78.1	2.2	501.6	121.0	74.8	138.6	243.6	45.4	608.0	423.1	82.6	33.0	77.1	2429.0
2005	79.7	2.3	531.8	127.3	74.7	141.1	262.7	46.8	639.6	445.7	87.4	35.1	83.0	2557.1
2006	81.4	2.3	564.3	133.8	74.6	143.8	285.9	48.2	670.0	465.3	92.0	37.5	88.9	2688.0
2007	82.8	2.4	599.6	141.1	75.0	147.2	310.4	51.6	698.5	484.7	95.5	40.2	94.6	2823.6
2008	83.8	2.4	632.4	147.3	74.9	151.0	334.2	54.4	723.5	502.6	98.8	42.4	99.3	2947.2
2009	84.9	2.4	653.5	154.7	74.6	153.8	356.3	56.3	744.6	527.9	104.1	44.6	102.9	3060.5
2010	85.9	2.4	695.3	160.4	74.2	157.5	380.2	59.2	761.7	546.7	107.9	47.4	106.0	3184.9
2011	86.8	2.4	733.0	166.0	73.7	161.1	403.1	61.6	777.9	564.5	111.4	49.9	108.9	3300.5

Notes : 1. Agriculture, forestry and fishing, 2. Mining and quarrying, 3. Manufacturing, 4. Electricity, gas and water supply ,
5. construction, 6. Wholesale and retail trade, restaurants and hotels, 7. Transport, storage and communication,
8. financial intermediation, 9. Real estate and business activities, 10. Public administration and defense, 11. Education,
12. Health and social work, 13. Other service activities.

Sources : Pyo(2012)

<Table A3> Nominal Capital Stock by Types of Assets (1980-2011)

Unit : Trillion Won, current prices

	1	2	3	4	5	6	7	8	Total
1980	13.2	13.2	9.9	3.1	2.6	0.9	8.4	0.3	51.6
1981	16.0	15.9	12.8	3.9	3.4	1.2	10.1	0.4	63.7
1982	19.6	19.2	16.4	4.8	4.2	1.5	12.1	0.4	78.0
1983	24.6	23.6	20.4	5.9	5.2	1.8	14.3	0.5	96.0
1984	29.2	29.2	24.8	7.1	6.3	2.2	16.8	0.6	116.2
1985	34.1	34.8	30.0	8.5	7.5	2.6	19.8	0.7	138.0
1986	39.7	40.7	35.1	10.0	9.2	3.2	23.8	1.0	162.7
1987	46.1	48.5	41.0	11.8	11.4	4.0	28.9	1.3	192.9
1988	53.8	56.9	48.9	14.4	14.6	5.6	34.8	1.7	230.8
1989	63.9	68.0	58.6	17.5	18.3	7.4	41.5	2.2	277.5
1990	82.4	83.5	71.8	21.7	22.7	9.6	49.6	2.9	344.4
1991	107.0	102.2	90.6	26.5	28.1	12.3	59.4	3.8	429.9
1992	132.3	121.6	113.1	31.8	33.7	15.1	69.6	4.8	521.9
1993	161.4	145.7	137.2	37.3	39.5	18.0	80.4	5.8	625.3
1994	192.0	173.2	164.5	44.3	47.1	21.8	94.3	7.8	744.9
1995	227.9	207.6	195.4	51.4	56.9	26.6	112.2	11.4	889.4
1996	266.5	243.9	234.0	59.7	67.8	32.1	132.1	14.3	1050.4
1997	305.4	283.9	278.1	67.3	78.3	37.3	151.3	18.0	1219.6
1998	337.7	318.4	328.1	69.4	91.1	44.4	174.6	21.4	1385.1
1999	349.0	332.8	361.5	73.9	91.4	45.7	172.7	23.7	1450.7
2000	366.8	357.4	407.5	83.2	101.6	52.0	187.8	27.8	1584.2
2001	408.5	378.2	468.5	89.5	108.7	55.9	200.6	31.9	1741.7
2002	449.4	420.6	528.1	97.6	111.4	56.7	208.3	37.2	1909.4
2003	501.4	483.8	606.2	100.0	116.7	58.0	223.8	41.6	2131.6
2004	559.8	554.6	691.1	101.0	123.3	59.3	245.8	45.5	2380.5
2005	613.8	608.5	742.2	103.6	123.3	56.8	258.8	50.2	2557.1
2006	655.7	653.9	815.6	105.9	123.5	54.5	271.3	53.9	2734.1
2007	709.6	716.2	907.1	109.1	125.9	53.5	287.8	58.7	2967.9
2008	802.7	835.2	1068.9	120.6	143.3	58.9	338.0	64.5	3432.1
2009	838.6	881.8	1148.6	125.1	163.7	65.5	394.7	67.8	3685.6
2010	878.2	957.4	1254.4	127.0	165.9	64.5	410.1	70.7	3928.2
2011	935.6	1059.0	1380.3	133.1	173.6	65.7	438.0	74.4	4259.8

Notes : 1. Residential structures, 2. Non-residential structures, 3. Infrastructure, 4. Transport equipment, 5. Computing equipment, 6. Communications equipment, 7. Other machinery and equipment, 8. Software

Sources : Pyo(2012)

<Table A4> Nominal Capital Stock by Industry (1980-2011)

Unit : Trillion Won, current prices

	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1980	3.8	0.4	15.1	2.6	1.7	4.0	4.6	0.9	11.9	5.0	0.7	0.2	0.7	51.6
1981	4.5	0.5	18.5	3.4	2.3	4.9	5.6	1.1	14.1	6.6	1.0	0.3	0.9	63.7
1982	5.2	0.6	21.8	4.2	2.9	6.2	6.7	1.7	17.2	8.6	1.4	0.4	1.3	78.0
1983	6.1	0.7	25.7	5.1	3.6	7.5	8.4	2.0	22.0	11.1	1.8	0.5	1.6	96.0
1984	7.2	0.8	31.0	6.0	4.4	9.5	9.9	2.3	26.3	13.7	2.3	0.7	2.1	116.2
1985	8.1	0.9	37.8	6.9	5.3	10.4	11.6	2.7	30.8	17.0	2.9	0.9	2.6	138.0
1986	9.1	1.1	46.0	7.6	5.9	12.2	13.3	3.7	35.4	20.6	3.4	1.2	3.2	162.7
1987	10.6	1.2	58.2	8.4	7.0	15.0	15.3	4.3	40.0	23.5	4.1	1.5	3.8	192.9
1988	11.8	1.2	70.3	9.8	8.8	20.1	17.4	4.8	43.8	30.5	5.5	1.9	4.9	230.8
1989	14.1	1.0	82.7	11.5	10.5	23.7	20.3	5.7	54.0	38.9	6.8	2.4	5.9	277.5
1990	17.0	1.1	102.3	14.2	13.5	30.1	24.8	6.2	68.0	49.0	8.7	2.8	6.9	344.4
1991	20.6	1.1	123.0	17.6	19.4	36.7	29.1	7.2	87.7	64.3	10.9	3.6	8.7	429.9
1992	24.1	1.1	143.2	22.6	25.9	42.6	33.4	9.6	107.8	82.5	13.7	4.5	11.0	521.9
1993	27.4	1.1	162.6	28.1	31.7	51.3	39.8	11.7	137.9	98.2	16.9	5.3	13.3	625.3
1994	31.5	1.1	188.6	35.3	37.3	58.7	45.9	13.1	169.4	118.8	21.5	6.7	17.0	744.9
1995	36.5	1.1	214.2	38.9	42.5	73.1	51.5	19.1	216.0	140.3	27.3	8.1	20.9	889.4
1996	41.4	1.2	258.7	48.8	49.1	83.5	70.9	24.2	231.8	171.7	32.7	10.1	26.3	1050.4
1997	46.0	1.1	300.0	55.1	57.5	100.7	74.7	28.1	268.6	202.4	42.4	12.0	31.0	1219.6
1998	50.3	1.3	334.3	63.7	61.1	107.3	90.2	30.6	317.4	229.4	46.6	15.3	37.5	1385.1
1999	51.9	1.4	339.7	68.2	60.2	106.4	104.7	28.2	340.5	242.6	47.5	17.8	41.6	1450.7
2000	55.6	1.5	369.9	75.6	61.4	110.1	127.6	31.8	366.0	264.6	52.5	20.3	47.2	1584.2
2001	59.5	1.6	393.0	85.4	63.9	113.1	151.6	34.4	412.7	293.2	58.0	22.7	52.5	1741.7
2002	64.1	1.8	417.1	94.9	66.0	118.5	176.2	37.5	459.8	323.4	64.9	25.6	59.6	1909.4
2003	70.3	2.0	454.6	107.2	68.9	126.9	206.0	41.4	518.5	366.7	72.7	28.9	67.4	2131.6
2004	76.5	2.2	501.1	119.9	72.4	135.3	240.4	45.0	582.9	415.0	81.3	32.5	76.1	2380.5
2005	79.7	2.3	531.8	127.3	74.7	141.1	262.7	46.8	639.6	445.7	87.4	35.1	83.0	2557.1
2006	83.7	2.4	562.8	138.4	75.9	145.4	295.9	48.0	685.1	477.7	92.2	37.6	89.1	2734.1
2007	89.2	2.5	604.4	153.1	78.9	153.4	337.1	52.0	743.4	518.9	97.7	41.2	96.3	2967.9
2008	100.9	2.8	702.8	179.2	86.8	174.7	406.5	59.8	847.4	600.3	111.5	47.8	111.6	3432.1
2009	104.5	2.9	771.3	192.9	89.1	182.8	443.4	64.9	892.3	645.4	122.3	52.5	121.2	3685.6
2010	110.0	3.0	822.4	208.2	90.7	192.5	491.8	68.5	938.1	692.0	128.6	56.4	126.1	3928.2
2011	117.7	3.1	890.0	227.6	94.6	207.0	550.9	72.9	1009.5	752.9	137.9	61.6	134.1	4259.8

Notes : 1. Agriculture, forestry and fishing, 2. Mining and quarrying, 3. Manufacturing, 4. Electricity, gas and water supply ,
5. construction, 6. Wholesale and retail trade, restaurants and hotels, 7. Transport, storage and communication,
8. financial intermediation, 9. Real estate and business activities, 10. Public administration and defense, 11. Education,
12. Health and social work, 13. Other service activities.

Sources : Pyo(2012)