3.2.1 Price and Quantity of Capital Service

Based on the geometric approach, where $\delta^k_\tau = \delta^{P,k}_{t,\tau} = \delta^k$, we start with the perpetual inventory method in Equation (11). Since quantity of investment $A^{k,j}_t$ is defined in terms of progress in construction, the productive capital stock $S^{P,k,j}_t$ defined in Equation (11) includes capital goods that are not yet installed. For each asset we assume that new investment becomes available for production at the mid-point of the year so the installed capital stock for each industry and each asset is assumed to the arithmetic average of the current and lagged capital stock. An exception to this, considering the time lag between progress in construction and installation, is that we assume the installed stock of buildings and structures is the lagged capital stock:

$$Z^{k,j}_t = \begin{cases} S^{P,k,j}_{t-1} & k \in \text{buildings and structures} \\ \left(S^{P,k,j}_{t-1} + S^{P,k,j}_t\right)/2 & \text{otherwise} \end{cases} \tag{26}$$

The installed productive capital stock $Z^{k,j}_t$ represents the accumulation of past investments, but we are primarily interested in $K^{k,j}_t$, the flow of capital services from that stock over a given period. This distinction is not critical for individual assets, but becomes essential when we aggregate heterogeneous assets to form an industry or economy-wide aggregate. We assume the flow of capital services for each industry and each asset is proportional to the installed stock of capital:

$$K^{k,j}_t = \phi^{k,j} Z^{k,j}_t, \tag{27}$$

where $\phi^{k,j}$ denotes the proportionality constant. The constant coefficient: $\phi^{k,j}$, is an "annualization factor", which transform capital stock into capital service.[*30]

We estimate a price of capital services that corresponds to the quantity of capital input via the cost-of-capital formula. In equilibrium, with no uncertainty about capital income, investors are indifferent between earning a nominal rate of return on a different investment or buying a unit of capital, collecting a rental fee, and then selling the depreciated asset in the next period, as described in Equation (16). For investors purchasing the asset the cost of capital equals the marginal product of the asset. This implies the familiar cost of capital, or user cost, for each asset in each industry:

$$P^{K,k,j}_t = (r^j_t - \pi^k_t) P^{A,k}_{t-1} + \delta^k P^{A,k}_t, \tag{28}$$

[*30] We assume the proportional relationship between productive capital stock and capital service. Hulten (1990) inquires, "Is a chair in "service" only when it is occupied? Or, does the availability of the chair for potential occupancy count for something too? If so, are potential services equivalent to actual services? *cdots* Is an office building utilized only during business hours, or is it utilized all the time to keep out thieves and inclement weather?"(Hulten, 1990, p.135).

where the asset-specific capital gains term is π_t^k defined in Equation (25) and r_t^j is the nominal rate of return in industry j.[*31]

The cost of capital accounts for the nominal rate of return, asset-specific depreciation, and an asset-specific revaluation term. An asset with a higher depreciation rate has a higher marginal product and must receive a higher capital service price as compensation. Similarly, if an investor expects a capital loss ($\pi_t^k < 0$), then a higher service price is required. Jorgenson and Stiroh (2000) and Oliner and Sichel (2000) discuss the importance of incorporating asset-specific revaluation terms for information technology assets experiencing rapid downward revaluations.

Tax considerations are also a key component of capital service prices, as discussed by Hall and Jorgenson (1967) and developed in detail by Jorgenson and Yun (2001) for the U.S. economy and Nomura (1998, 2004a) for the Japanese economy. Following Nomura (2004a, Ch.3) in accounting for capital consumption allowances: $z_t^{k,j}$, income allowances and reserves: ζ_t^j, special depreciation: $\mu_t^{k,j}$, corporate income tax:u_t^j, business income tax: v_t^j, property taxes: κ_t^j, acquisition taxes: ω_t^j, debt/equity financing: β_t, capital gain taxes: γ_t, and dividend tax: θ_t. We estimate an asset-specific, after-tax real rate of return for each asset in each industry, $r_t^{k,j}$, that enters the cost-of-capital formula:

$$p_t^{K,k,j} = \frac{1 + \omega_t^k - (u_t^j + v_t^j)\left(z_t^{k,j} + \omega_t^k - \mu_t^{k,j}\tilde{z}_t^{k,j} + \dfrac{\mu_t^{k,j}}{1 + r_t^{k,j}}\right)}{1 - \psi_t^j}\left\{(r_t^{kj} - \pi_t^k) + (1 + \pi_t^k)\delta_t^k\right\}p_{t-1}^{A,k} + \kappa_t^k P_t^{A,k}, \tag{29}$$

where

$$z_t^{k,j} = \sum_{\tau=1}^{\infty} \frac{\widehat{m}_\tau^k}{(1 + r_t^{k,j})^{\tau-1}}, \quad \tilde{z}_t^{k,j} = \sum_{\tau=1}^{\infty} \frac{\widehat{m}_{\tau+1}^k}{(1 + r_t^{k,j})^{\tau+1}}, \tag{30}$$

$$r_t^{k,j} - \pi_t^k = \beta_t\left\{(1 - \psi_t^j)i_t - \pi_t^k\right\} + (1 - \beta_t)\frac{\rho_t^j - \pi_t^k(1 - \gamma_t)}{(1 - \theta_t)\alpha_t^j + (1 - \gamma_t)(1 - \alpha_t^j)}, \tag{31}$$

$$\begin{aligned}\psi_t^j = \Big(&1 + \{1 + (u_t^j + v_t^j)(1 - \zeta_t^j)\}i_t \\ &- \sqrt{1 + 2\{1 - (u_t^j + v_t^j)(1 + \zeta_t^j)\}i_t + \{1 - (u_t^j + v_t^j)(1 - \zeta_t^j)\}^2 {i_t}^2}\Big)\Big/2i_t,\end{aligned} \tag{32}$$

where $z_t^{k,j}$ is the present value of capital consumption allowance for tax purpose.[*32] The rate of return $r_t^{k,j}$

[*31] Using the time-series depreciation rates in Equation (22), equation (28) is also written as $P_t^{K,k,j} = (r_t^j + \epsilon_t^k)P_{t-1}^{A,k}$. The total capital service cost is the sum of the opportunity cost of finantial capital of $P_{t-1}^{A,k}$, and the cost for time-series depreciation, which consists of cross-section depreciation: δ^k, and revaluation: π_t^k.

[*32] In the Japanese tax system, a business income tax is levied on revenue for some industries like electricity. A property tax for depreciable assets except motor vehicles and residence is levied on the book value, rather than the current value. Nomura (2004a, Ch.3) apply different cost-of-capital formulas, which are different from (28), for some assets and industries.

is formulated as a weighted average of real, after-tax returns to debt and equity, where the rate of interest is i_t and rate of return on equity is ρ_t^j. The use of income allowance and reserves could reduce the effective tax rate for corporate income: ψ_t^j, so that Equation (32) represents effective tax rate for corporate income after the consideration. Inventories and land have a depreciation rate of zero and do not qualify for a capital consumption allowance for tax purposes, so the cost-of-capital formula is a simplified in Equation (29).

We then assume the after-tax rate of return: ρ_t^j, to all assets in the corporate sector of each industry is the same and exhausts the value of payments to capital across all assets in the corporate sector of each industry,

$$V_t^{K,j} = \sum_k P_t^{K,k,j} K_t^{k,j}. \tag{33}$$

The capital service: $K_t^{k,j}$, is defined by the observable variable: $Z_t^{k,j}$, in Equation (27). From the cost-of-capital formula in Equation (28) for each asset and Equation (33), the capital service prices: $(\phi^{k,j} P_t^{K,k,j})$, and the after-tax rate of return on equity: ρ_t^j, are endogenously imputed.[*33] Since $P_t^{K,k,j}$ represents index of capital service price, constant annualization factors: $\phi^{k,j}$, are computed in each asset and each industry, taking $(\phi^{k,j} P_t^{K,k,j})$ as normalized at one in the benchmark year.

3.2.2 Aggregating Heterogeneous Capital

We define the aggregate measure of capital service for the economy as a whole, by means of a Divisia index as:

$$\frac{\dot{K}_t}{K_t} = \sum_{k,j} v_t^{K,k,j} \left(\frac{\dot{K}_t^{k,j}}{K_t^{k,j}} \right), \tag{34}$$

where the weights: $v_t^{K,k,j}$, are nominal shares of each type of capital income in total capital income: $P_t^{K,k,j} K_t^{k,j} / \sum_{k,j} P_t^{K,k,j} K_t^{k,j}$.[*34] Similarly, we define the aggregate measure of capital stock by means of a Divisia index as:

$$\frac{\dot{Z}_t}{Z_t} = \sum_{k,j} v_t^{Z,k,j} \left(\frac{\dot{Z}_t^{k,j}}{Z_t^{k,j}} \right), \tag{35}$$

[*33] In our framework, $z_t^{k,j}$ is an endogenous variable, depending on the rate of return $r_t^{k,j}$, which is determined by the imputed rate of return on equity: ρ_t^j, although Jorgenson and Yun (2001) treat $z_t^{k,j}$ as exogenous. $z_t^{k,j}$ has significant role to determine the impacts of corporate income tax to the capital service price. In case of endogenous $z_t^{k,j}$, the elasticity of corporate income tax u_t^j to $P_t^{K,k,j}$ becomes small, in comparison with the case of exogenous $z_t^{k,j}$. See Nomura (2004a, Ch.3) for the details.

[*34] Hulten (1990) shows "the existence of a linerly homogeneous aggregator function K(·) allows this expression [Divisia index] to be integrated to obtain the "level" of the aggregate capital in each year (with one time period arbitrarily normalized at one)".

where the weights: $v_t^{Z,k,j}$, are nominal shares of each type of capital stock in total capital stock: $P_t^{A,k}Z_t^{k,j} / \sum_{k,j} P_t^{A,k}Z_t^{k,j}$.[*35] The corresponding price index of capital inputs P_t^K for K_t and of capital stock P_t^Z for Z_t are defined implicitly to make the value identities hold:

$$V_t^K = P_t^K K_t = \sum_{k,j} P_t^{K,k,j} K_t^{k,j}, \tag{36}$$

and

$$V_t^Z = P_t^Z Z_t = \sum_{k,j} P_t^{A,k,j} Z_t^{k,j}, \tag{37}$$

respectively. For the comparison of aggregate measures, we also define the simple sum of capital services and capital stocks,

$$K_t^* = \sum_{k,j} K_t^{k,j}, \tag{38}$$

$$Z_t^* = \sum_{k,j} Z_t^{k,j}. \tag{39}$$

Among four definitions of aggregate measure of capital in Equations (34)-(35) and (38)-(39), the adequate measure for capital inputs is only K_t in Equation (34).[*36] Note that we need the capital service prices that are not directly observed, to compute an adequate measure for capital inputs.

Table 3 represents the growth rates of capital stock: Z_t and Z_t^*, and capital service: K_t and K_t^*, at the aggregate level in Japan. Here, we compute two cases with the different coverage of capital: fixed assets and total assets that include land and inventories.[*37] In case of fixed assets only, the average annual growth rate of capital service: K_t, is 7.6 percent during 1960-2000, which is 1.4 percent point higher than the growth of the simple sum of productive capital stock: Z_t^*. In case of total assets, which includes land and inventories, the growth rates of K_t and Z_t^* are 5.9 percent and 3.3 percent per year, respectively. The difference of two measures is significant. By the quantity index to be normalized as one in 1960, K_t is 10.6 (20.8 in case of fixed assets) and Z_t^* is 3.8 (11.8) in 2000. If we use capital stock measures: Z_t^* or Z_t, as a

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[*35] On the assumption of geometric approach, productive capital stock by asset and industry: $Z_t^{k,j}$, is identical with net (wealth) capital stock. Z_t^j in Equation (35) may provide the appropriate aggregate measure of real net capital stock. Note that capital service prices that are not directly observed need not be used, to compute it.

[*36] Using the other three inadequate measures, Nomura (2004, Ch.4) defines the three measures of capital quality as K_t/Z_t, K_t/K_t^*, and K_t/Z_t^*. Jorgenson and Stiroh (2000) uses capital quality as K_t/Z_t, although they take a simple sum among industries in each asset. Nomura (2004, Ch.4) uses K_t/Z_t^*, analogously with the definition of labor quality.

[*37] To keep consistency with the present Japanese national accounts, we do not include custom and prepackaged software in Table 3. The capital service prices: $P_t^{K,k,j}$, used in the two cases with the different coverage of capital are different even for same asset in same industry, because we impute the ex-post rate of returns in each case.

capital input, it underestimates the growth of capital inputs and, therefore, it overestimates the growth of total factor productivity (TFP).*[38]

Table. 3 Growth Rates of Capital Stock and Services in Japan

	Fixed Assets				Total Assets				
	Stock		Service		Stock		Service		(ref)
	Z_t	Z_t^*	K_t	K_t^*	Z_t	Z_t^*	K_t	K_t^*	GCSPE
1960–65	9.11	7.80	13.88	8.25	4.97	3.64	9.85	5.67	11.55
1965–70	10.44	9.53	12.27	10.24	5.94	4.93	9.76	6.86	12.45
1970–75	9.56	9.25	9.96	9.19	5.43	5.05	8.17	5.92	10.10
1975–80	6.15	6.18	5.81	5.95	3.79	3.57	4.67	3.91	6.38
1980–85	4.80	4.69	5.24	4.63	2.73	2.57	3.87	2.92	6.72
1985–90	5.04	4.87	6.02	5.38	2.69	2.68	4.94	3.46	6.79
1990–95	4.42	4.40	5.08	4.75	2.42	2.52	3.82	3.20	5.15
95–2000	2.56	2.60	2.49	2.50	1.74	1.73	2.05	2.06	3.48
60–2000	6.51	6.16	7.59	6.36	3.72	3.34	5.89	4.25	7.83

Unit: average annual percentage (%). "Total Assets" includes fixed assets, land, and inventories.

Assets only for industry use and owner-occupied housing (excluding custom and prepackaged software).

GCSPE is defined by tangible fixed assets, owned by private sectors only, excluding the residence.

Schreyer (2003) estimates capital service inputs for the G7 countries, using a hyperbolic age-efficiency profile. The estimate of the growth rate in the Japanese aggregate capital service, which is defined by the Törnqvist index of capital services for all fixed assets, is 4.9 percent per year during 1980-2000. This growth rate is close to our estimates (4.7 percent) for the same periods.*[39] On the other hand, the GCSPE, which

*[38] If we define aggregate measures as a simple-sum for labor and value added, like capital inputs: Z_t^*, that overestimates by 41 percent (18 percent in case of fixed assets) of average annual growth rate of TFP, at the aggregate level during 1960-2000 in Japan (Nomura, 2004a, Ch.4).

*[39] Schreyer (2004) estimates the multifactor productivity and capital service, for fixed assets only, based on the two assumptions: exogenous rate of return (RoR) and endogenous RoR. In Japan, the growth rate of capital service inputs is reported as annually 4.6 percent by exogenous-RoR approach and 4.5 percent by endogenous-RoR approach during 1985-2000. Although the Schreyer's measure includes reallocation bias of capital service, the aggregate growth rate is also 4.5 percent for the same periods in our estimates, which is based on endogenous-RoR by industry on the Japanese tax structure described in Equation (29).

Although we don't introduce the details of our estimates of TFP in this paper, however, our TFP (or MFP) measures in Nomura (2004a, Ch.4) considerably different from Schreyer (2004) at the aggregate level. The main source of the gap is the definition of labor input. Schreyer defines the labor inputs as hours worked, in which the increase in labor quality is neglected. Our estimates based on the KEO (Keio Economic Observatory, Keio University) Database, which has chosen to classify the workers by sex, age (eleven classes), educational attainment (four classes for male, three classes for female), employment class (three types: employees, self-employed, and unpaid family workers), and industry.

is based on the traditional gross concept of capital stock, provides higher growth. During 1980-2000, the growth rate of the GCSPE is 5.5 percent per year. If the GCSPE is used as a capital input in production function, it overestimates the growth of capital inputs and, therefore, it underestimates the growth of TFP.

3.2.3 Land as a Capital

The stocks of land and inventories by industry are estimated in Nomura (2004a, Ch.C-D). In the Japanese economy, the value of land is particularly notable. In comparison with the 23.6 percent share of land to total nominal capital stock in the U.S. in 2000 (Jorgenson and Landefeld, 2005), the Japanese land share is 43.5 percent in 2000 (Nomura, 2004a, Ch.2), even though the Japanese economy has experienced a record decline of land prices in the 1990s.

Diewert and Lawrence (2000) indicate that neglecting land and inventories leads to a decline in average TFP growth rates of 0.1 percent per year in Canada. This is large in relative terms, since the average growth rate for the Canadian TFP averaged only 0.5-0.6 percent per year during 1963-1996. For the Japanese economy, Nomura (2004a, Ch.4) shows that neglecting land and inventories leads to a decline of 0.7 percent per year in the average TFP growth rate during 1960-2000, compared to 1.5 percent annual average growth rate for Japanese TFP. TFP growth is underestimated by a factor of almost fifty percent if land and inventories are ignored. Land has a significant role in the measurement of capital and productivity in Japan.

Table. 4 Relative Prices of Capital Stock and Services by Industry between the U.S. and Japan

	Fixed Assets			Total Assets		
	$RP_t^{Z,j}$	$RP_t^{K,j}$	$R\phi^j$	$RP_t^{Z,j}$	$RP_t^{K,j}$	$R\phi^j$
1.Agriculture	1.261	1.829	1.450	5.466	2.620	0.479
18.Machinery	1.120	0.886	0.791	2.009	1.415	0.704
19.Motor Vehicles	1.063	1.300	1.223	1.939	1.411	0.728
23.Transportation	1.267	1.602	1.265	2.252	1.671	0.742
24.Communication	1.262	1.014	0.803	1.694	1.131	0.668
25.Electiric Utilities	1.312	1.569	1.195	1.666	1.655	0.993
27.Trade	1.319	1.410	1.069	2.515	1.646	0.655
29.Other Service	1.282	0.945	0.737	2.738	1.088	0.397
Aggregate	1.314	1.360	1.035	3.050	1.701	0.558

Unit: Ratios of Japanese prices to the U.S. prices, evaluated in 1990 (exchange rate:144.8)

$RP_{Z,T}^j$ and $RP_{K,T}^j$ represent relative prices for capital stock and service, respectively.

$R\phi^j$ is relative measure of annualization factors.

All indexes are aggregated as Törnqvist index, for all assets within an industry.

In particular, for international level comparison of productivity or capital deepening, the land price has a significant role. Nomura (2004a, Ch.3) estimates relative prices of capital stock and service by asset and industry between the U.S. and Japan.*40 Table 4 represents the relative prices for capital stock: $RP_t^{Z,j}$, relative prices for service: $RP_t^{K,j}$, and relative annualization factors: $R\phi^j$ between the U.S. and Japan in 1990, for some selected industries.

In the aggregate measures of the relative prices, defined by Törnqvist index using the average weights between the U.S. and Japan, if we neglect the land and inventories as capital, the Japanese prices in capital stock and service are 31.1 percent and 36.0 percent higher than that in the U.S., respectively. However, if we include land and inventories, the price-gaps increased to about 3 times for capital stock and 1.7 times for capital service. The land price-gap explains 56.1 percent of $RP_t^{K,j}$. Especially, for the industries like Agriculture, the consideration of land price has a big impact to the relative prices. In the aggregate measure of TFP-gap, Japan is 26.1 percent below to the U.S. in the case of neglecting land and inventories. The neglect leads to an underestimate of the Japanese TFP level, which is 17.9 percent less than the U.S. in 1990 (Nomura 2004a, Ch.4).

The clarification of the role of land as a capital input in production account is one of the most significant aspects of Jorgenson system of national accounts. Probably due to the incomplete definition of land as a capital input in the 1993 SNA, the cost of land has been neglected in many production studies. The capital service cost of land, however, should be interpreted as implicitly included in value added in the production account.

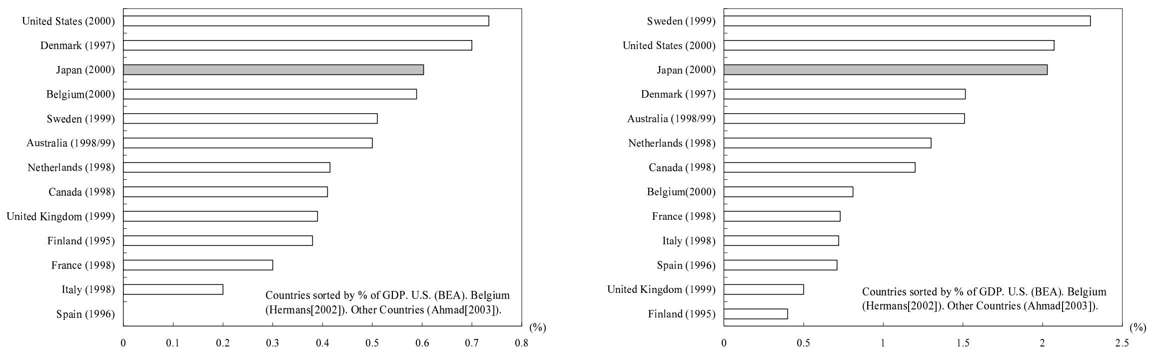
3.2.4 Capitalization of Software

The expenditure for own-account and prepackaged software are not capitalized in the official Japanese national accounts. Nomura (2004b) estimates own-account software investment by industry during 1955-2000 in Japan, based on the two kinds of methodology in the OECD Task Force on software measurement in the national accounts (Lequiller, Ahmad, Varjonen, Cave, and Ahn, 2003; Ahmad, 2003) and the U.S. BEA's methodology for estimating own-account software by industry (Grimm, Moulton, and Wasshausen, 2003).

International comparison of shares of own-account software investment to official GDP is in Figure 3(a) and for total software investment to GDP is in Figure 3(b).*41 In Japan, the share of own-account software

*40 Relative price represents the price-gap index in both countries and is not unity even in the base year. To estimate relative prices for capital stock, we need relative prices for investment by commodity. See Nomura (2004a, Ch.3) for the details of framework and data. The U.S. annualization factors by asset and industry are based on the estimates by Jorgenson. Industry is classified, based on our common industry classification between the U.S. Jorgenson Data and the KEO Database in Japan.

*41 In Figure 3, each share in each country is computed, based on the official national accounts. The share in Japan is estimates in Nomura (2004b). The share in the U.S. is based on the NIPA. The others are based on Hermans (2002) for Belgium and Ahmad to the GDP, which is adjusted to include all software investment, is 0.60 percent in 2000. It is higher than that in the EU countries but Denmark. The U.S. has the highest share of own-account software (0.73 percent) among the countries. As for total software investment in Figure 3(b), Japan has 2.03 percent GDP attributed to software investment. It is slightly lower than that in the U.S. (2.07 percent). Although Sweden has the highest share in total software, we may take the difference in economic scales and industry structures into consideration. The relative scale of software investment between the U.S. and Japan may be appropriate.



(a) Own-Account Software Investment

(b) Total Software Investment

Fig. 3 Share of Software Investment in GDP: An International Comparison

Although the GDP-share of software investment is very close between the U.S. and Japan, the composition by type of software is significantly different. Figure 4 shows the changes of composition of software investment every five years from 1970 to 2000 in the U.S. and Japan. In 1970, own-account software has the largest share in software investment and prepackaged software is minor in both countries. The share of own-account software decreases in both countries through the 1970s and the 1980s. In the U.S., the diminution of the share of own-account software is reflected by the rapid expansion of prepackaged software. On the other hand, in Japan, the diminution is mainly reflected by the expansion of custom software. In 2000, custom software occupies the largest portion, the share of which is almost two thirds of the total software investment in Japan.

One of the reasons why own-account and prepackaged software are avoided to be capitalized in the present Japanese national accounts may be that benchmark 1995 input-output (IO) table, which is one of basic statistics for estimating the national accounts, did treat only custom software as a software

(2003) for the other countries.

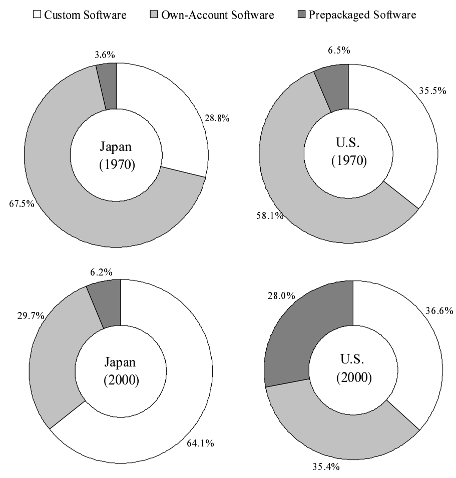


Fig. 4 Composition of Software Investment: Comparison between the U.S. and Japan

investment. In the summer of 2004, the benchmark 2000 IO table was published and began to treat prepackaged software as GFCF, in addition to custom software. However, capitalization of own-account software was postponed even in the benchmark 2000 IO table. ESRI (2000) pointed out that, in the Japanese statistics, it is difficult to identify own-account software and that R&D activity that is not recommended to be capitalized by the 1993 SNA. As the OECD Task Force on software measurement in the national accounts (Lequiller, Ahmad, Varjonen, Cave, and Ahn, 2003; Ahmad, 2003) also discusses, the difficulty is not peculiar to Japan. It is possible to estimate own-account software investment by industry in Japan, applying similar methodology as that the recommendation of the OECD Task Force on software and the BEA.

3.2.5 Impacts of IT Capital

To capture the impacts of capital related to information technology (IT), our latest estimates of capital stock and service have detailed asset classification. The capital stock and service matrixes are based on 102 assets shown in Table 5: 95 fixed assets, 3 types of inventory, and 4 types of land, and 70 capital holding sectors: 45 industries, government, household, and 23 infrastructures.[*42]

[*42] Although Nomura (2004a) estimated time-series capital formation matrixes during 1955-2000 with detailed asset classification, the assets were aggregated for the measurement of capital stock mainly because of the lack of the long-term investment prices. Author newly developed the prices and revised capital formation matrixes using 2000 benchmark capital formation matrix. Also, to compute the long-term CFC for infrastructure, the classification for assets and capital holding sectors was reformed. The productivity analysis in the Japanese industries, separately treating the IT-producing industries, is described in Jorgenson and Nomura (forthcoming).

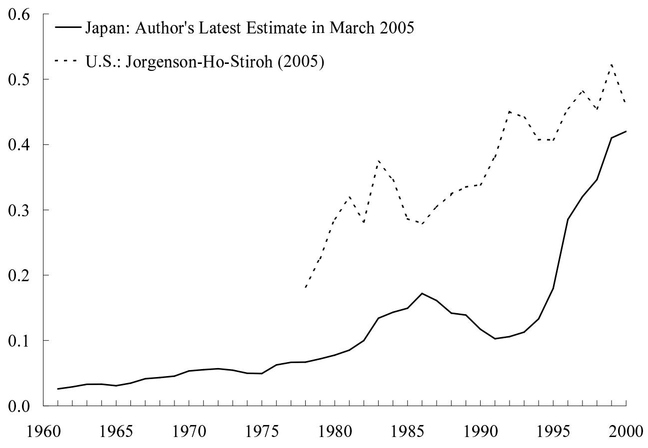


Fig. 5 IT Capital Contribution Share to Total Capital Service

Figure 5 shows the contribution share of IT capital to the growth of total capital service in the U.S. and Japan at the aggregate level. The U.S. measurement is from Jorgenson, Ho, and Stiroh (2005). Here, the IT capital is defined by computer hardware, computer software (custom, prepackaged, own-account), and communications equipment (37-40 and 93-95 in Table 5). The total capital consists of fixed assets, consumer durables, land, and inventories of all capital holders in both country. The growth rates are aggregated for the economies as a whole, based on the Törnqvist index, in both countries. In Japan, although the contribution share of IT capital gradually increases during 1960-1986, however, it still about 10 percent lower than that in the U.S. The share decreases in the bubble economy periods. As mentioned in section 2.2.3, the DOS/V as a operating system in PC was newly developed in 1991. The year of the introduction of the DOS/V is a turning point. Especially, after 1995, the IT contribution rapidly expands. In 2000, the contribution of the IT capital is 42.0 percent, approaching to the 46.0 percent in the U.S.

In nominal value of total capital stock, the share of IT capital is only 1.7 percent (3.2 percent of fixed capital) in Japan in 2000. However, the capital service cost of IT capital gradually increased to 9.8 percent in 2000 and the IT capital contributes more than 40 percent of the growth in total capital service inputs. Note that the deep impacts of IT capital can be found only in the measurement of capital service with detailed classification of assets, because the capital service prices, reflecting their marginal products, in IT capital is higher than that of other Non-IT capital due to the large depreciation rate and the rapid downward revaluation of the IT capital, as described in Equation (28).

3.2.6 Capital for Non-Market Production

As the final topics related to capital measurement, we introduce our evaluation of capital service cost for non-market production. In the 1993 SNA and also in NIPA by the U.S. BEA, for non-market production, only consumption of fixed capital (CFC) is described in their production accounts. The CFC is only a part of the capital cost. Here, our accounting is based on the Jorgenson system of national accounts.[*43] The extension to the Jorgenson system of national accounts means the replacement of the CFC to the appropriate measure of capital service cost in non-market production, which will be considered in the next revision of SNA in 2008 (1993 SNA Revision 1) as also proposed by the Canberra II Group (Ahmad, 2004).

First, let us adjust the GDP in the present Japanese national accounts to the 1993 concepts of GDP. Figure 6(a) gives the capital service cost to be added, associated with the revision from the 1968 SNA to the 1993 SNA concepts of GDP. The custom software investment and the CFC for infrastructure is already considered in the present Japanese national accounts, and valued at 14.7 trillion yen in 2000.[*44] Capitalizing own-account and prepackaged software leads to an increase of 3.8 trillion yen in 2000 in the Japanese GDP. [*45]

Our measurement of capital service cost for non-market production includes capital services of public capital, land for owner-occupied housing by households, and consumer durables. Based on author's estimates, Figure 6(b) shows the cost of the three capital services, which is added to the 1993 SNA concepts of GDP. In the figure, the capital service cost of public capital that excludes the CFC for public capital, because it is already included in the estimates of the GDP. Introducing the three capital service costs leads to an increase 41.8 trillion yen in 2000 in the Japanese GDP.[*46] The largest part is the capital service cost of consumer durables, which is 25.5 trillion yen and accounts for 4.6 percent in the Jorgenson concepts

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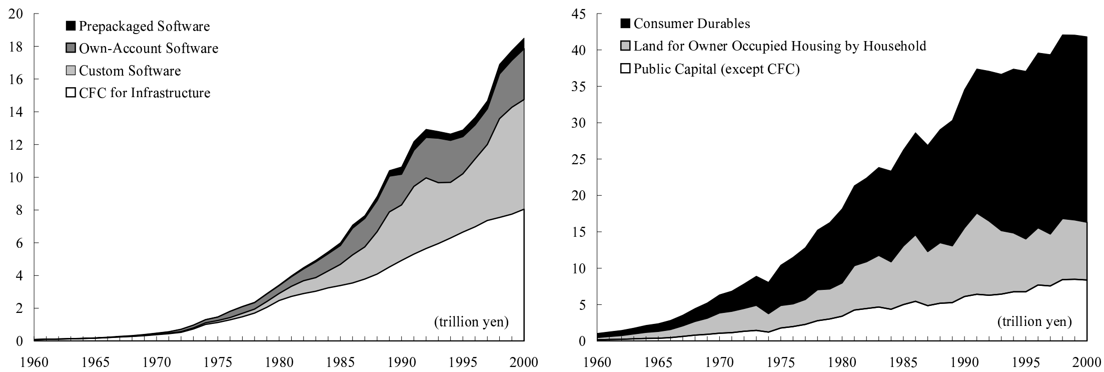
[*43] See Christensen and Jorgenson (1996), Fraumeni (2000), and Jorgenson and Landefeld (2005).

[*44] The Japanese national accounts does not still estimated before 1980, so far. Here, the CFC for infrastructure in Figure 6(a) is author's estimates, based on our capital stock estimates in 23 kinds of infrastructure during 1955-2000 (Nomura, 2004a).

[*45] Including this leads to a rebalancing of the IO tables with some difficulties to keep consistency with other data. See Nomura (2004b) for the detail. Since output of government sector is defined by the total costs, capitalization of software leads to the change of the government output. In the total economy, increase of the GDP is the sum of the increase of investment for own-account software and prepackaged software, the increase of consumption for both capitals in the government, and the decrease of own-account software produced and prepackaged software purchased by the government. The consumption for software capital is computed to be consistent with our estimates of software stock government sector holds.

[*46] We impute the capital service cost for non-market production using the average rate of return of all industries, weighted by the nominal share of capital stock in the industries. The rate of return in each industry is defined by the weighted average of rate of interest and the rate of return on equity. See Jorgenson and Nomura (forthcoming).



(a) for 93 SNA Concepts

(b) for Non-Market Production

Fig. 6 Additional Capital Service Cost for Non-Market Production

of GDP in 2000. In comparison with the U.S., the scale is about twofold, as Jorgenson and Landefeld (2005) estimates the consumer durables account for 9.6 percent in 2002, reflecting the difference the rates of return in both countries.

4 Concluding Remarks: Proposals for the Japanese National Accounts

As a concluding remarks of this paper, we summarize our proposals for sweeping improvement for measuring capital in the Japanese national accounts. Our proposals are assorted into two groups. The first group: (i)-(v), is the proposals to catch up the international standard. The second: (vi)-(viii), is the proposals to be prepared for the next revision of SNA in 2008 (1993 SNA Revision 1) or for measurement of productivity. For the second group, we attach the mark of $*$. Each proposal may be ordered by urgency, rather than importance or ease of implementation.

- **(i)** **Capitalization of Software** (related to section 3.2.4)
- **(ii)** **Reframing Net Capital Stock and CFC** (related to section 2.3 & 3.1)
- **(iii)** **Gross Capital Stock to Productive Capital Stock** (related to section 2.1 & 3.1.3)
- **(iv)** **Constant-Quality Prices in Japan** (related to section 2.2)
- **(v)** **Empirical Studies for AEP and APP in Japan** (related to section 2.3.3)
- **(vi)*** **Measurement of Price and Quantity of Capital Service** (related to section 3.2)
- **(vii)*** **Land as a Capital** (related to section 3.2.3)
- **(viii)*** **Capital Service Cost for Non-Market Production** (related to section 3.2.6)

First, (i) capitalization of own-account and prepackaged software is the most urgent requirement. As Nomura (2004b) pointed out, it is possible to estimate own-account software investment by industry in Japan, applying similar methodology as that recommended by the OECD Task Force on software and the industry approach used by the BEA.

Our proposals: (ii) and (iii), are highly desired to improve the measurement of capital in the Japanese national accounts. The traditional system of gross and net capital stock is incapable of portraying the two different aspects of capital: the productive capacity and the value of capital, except under unrealistic assumptions. A quarter century after the controversy between Jorgenson-Griliches (1972) and Denison, measuring internally consistent estimates of capital stock, capital input, and depreciation became a common objective in the national accounts, as in the international methodological standards recommended by OECD (2001a, 2001b). Fortunately, ESRI can learn a lot from the BEA's revision in 1997.

The ESRI has a plan to spend the following three years reframing measurement of capital in the Japanese national accounts. Over this time, it is important to estimate the long-term constant-quality prices, as in our proposal (iv). The main purpose of price statistics is to measure of current movement of prices, which can only be captured with constant-quality prices. However, the national accounts, in particular measurement of capital, requires the constant-quality prices be extrapolate backward, sustaining the consistency with newly developed methodology, if possible. Although this function is carried out by BEA in the U.S., we may not find any similar function in the Japanese statistical system.

Empirical studies for estimating depreciation or deterioration in the Japanese economy is also required. In the framework for measuring capital stock, the key idea is the age-efficiency profile. The AEP can be determined empirically by modeling a time series of prices of an asset by age. An alternative and more direct approach is modeling a time series of rental prices of an asset by age. Although Nomura (2004a, Ch.2) accepted the geometric distribution as approximation based on Japanese data, passenger vehicles and housing are less durable and trucks are more durable in Japan, in comparison with the BEA depreciation rates. Further empirical studies for the Japanese economy are required.

The theory for measuring capital, proposed by Jorgenson and his associates, can provide a consistent framework for measures of both capital stock and capital services. As Jorgenson (1989) clearly pointed out, measures of net capital stock and asset prices can be employed in the national wealth accounts, while measures of capital service input and capital service prices can be utilized in national production accounts. At present, although there is still no place for capital service cost in the SNA and the U.S. NIPA, only three countries - Australia, the United States, and Canada - produce time series of capital services as a part of their official statistics. Recently, work has also been taken up in the United Kingdom (Schreyer, 2003).

We recommend that ESRI should introduce capital services at the same time as reframing the measurement of capital stock. In addition, the capital service cost of land should be evaluated. Land as a capital has a significant role in the measurement of capital and productivity in Japan, although almost empirical studies for the Japanese economy do not fully recognize the importance. Measuring capital service leads the additional imputation of capital service cost for non-market production. ESRI can accomplish sweeping improvement by overcoming all our proposals, thereby anticipating the SNA 2008 (1993 SNA Revision 1). The Canberra II Group supports for introducing measures of the cost of capital services into the national accounts, as 'of-which' items in the production account (Ahmad 2004; Diewert, Harrison, and Schreyer, 2004). The time has come to turn the tables!

Table. 5 Asset Classification and Depreciation Rates

Assets	δ	Assets	δ
1.Trees	0.200	52.Steel ships	0.108
2.Livestock	0.309	53.Other ships	0.166
3.Textile products	0.347	54.Railway vehicles	0.068
4.Wooded products	0.236	55.Aircraft	0.135
5.Wooden furniture and fixtures	0.171	56.Bicycles	0.498
6.Metallic furniture and fixtures	0.098	57.Transport equipment for industrial use	0.217
7.Nuclear fuel rods	0.413	58.Other transport equipment	0.332
8.Metallic products	0.086	59.Camera	0.210
9.Boilers and turbines	0.102	60.Other photographic and optical instruments	0.218
10.Engines	0.112	61.Watches and clocks	0.118
11.Conveyors	0.098	62.Physics and chemistry instruments	0.236
12.Refrigerators and air conditioning apparatus	0.116	63.Analytical, measuring instruments & testing machines	0.236
13.Pumps and compressors	0.118	64.Medical instruments	0.199
14.Sewing machines	0.112	65.Miscellaneous manufacturing products	0.274
15.Other general industrial machinery and equipment	0.142	66.Residential construction (wooden)	0.048
16.Mining, civil engineering and construction machinery	0.171	67.Residential construction (non-wooden)	0.031
17.Chemical machinery	0.143	68.Non-residential construction (wooden)	0.057
18.Industrial robots	0.150	69.Non-residential construction (non-wooden)	0.039
19.Metal machine tools	0.127	70.Road construction	0.020
20.Metal processing machinery	0.111	71.Street construction	0.020
21.Agricultural machinery	0.098	72.Bridge construction	0.020
22.Textile machinery	0.117	73.Toll road construction	0.020
23.Food processing machinery	0.113	74.River improvement	0.019
24.Sawmill, wood working, veneer & plywood machinery	0.137	75.Erosion control	0.019
25.Pulp equipment and paper machinery	0.104	76.Seashore improvement	0.018
26.Printing, bookbinding and paper processing machinery	0.127	77.Park construction	0.048
27.Casting equipment	0.107	78.Sewer construction	0.027
28.Plastic processing machinery	0.122	79.Sewage disposal facilities	0.027
29.Other special industrial machinery & nec	0.130	80.Waste disposal facilities	0.061
30.Other general machines and parts	0.208	81.Harbor construction	0.018
31.Office machines	0.347	82.Fishing port construction	0.018
32.Vending, amusement and other service machinery	0.210	83.Airport construction	0.054
33.Electric audio equipment	0.236	84.Agricultural construction	0.028
34.Radio and television sets	0.236	85.Forest road construction	0.034
35.Video recording and playback equipment	0.236	86.Forestry protection	0.019
36.Household electric appliance	0.196	87.Railway construction	0.030
37.Electronic computer and peripheral equipment	0.347	88.Electric power facilities	0.025
38.Wired communication equipment	0.206	89.Telecommunication facilities	0.035
39.Radio communication equipment	0.275	90.Other civil engineering and construction	0.025
40.Other communication equipment	0.118	91.Plant engineering	0.025
41.Applied electronic equipment	0.196	92.Mineral exploration	0.550
42.Electric measuring instruments	0.196	93.Custom software	0.330
43.Generators	0.079	94.Pre-packaged software	0.330
44.Electric motors	0.079	95.Own-account software	0.330
45.Relay switches and switchboards	0.079	96.Finished-goods inventory	0.000
46.Other industrial heavy electrical equipment	0.109	97.Work-in-process inventory	0.000
47.Electric lighting fixtures and apparatus	0.079	98.Material inventory	0.000
48.Passenger motor vehicles	0.163	99.Land for agricultural use	0.000
49.Trucks, buses and other vehicles	0.228	100.Land for industrial use	0.000
50.Two-wheel motor vehicles	0.218	101.Land for commercial use	0.000
51.Motor vehicle parts	0.208	102.Land for residential use	0.000

Represents geometric depreciation rates used in our latest estimates of capital stock and service.

Assets 48-49 and 66-67: estimates in Nomura(2004, Ch-2).

For other assets: author's estimates based the Japanese tax-lives, converting rates to effective service life, and the BEA's declining balance rates.

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