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MEASURING CAPITAL IN JAPAN
Challenges and futures directions

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Measuring Capital in Japan

- Challenges and Future Directions *

Koji Nomura† and Tadao Futakami‡

October, 2005

Abstract

Japan's national accounts are moving toward reframing the capital measurement, which is one of the most problematic areas today concerning the national accounts. The objective of this paper is to report current problems on the official measurement of capital and our challenges and future directions for the "sweeping" revision. We propose our plans for the revision on measuring for not only more appropriate capital stock statistics, but more complete production accounts.

* This paper was prepared for the 2005 OECD Working Party on National Accounts, October 11-14, 2005, Paris, France. At the ESRI Conference on Next Steps for the Japanese SNA:"Towards More Accurate Measurement and More Comprehensive Accounts," in Tokyo, March 25, 2005, Nomura (2005a) presented his proposals for the sweeping revision on measuring capital. At the conference, we received valuable comments from Erwin Diewert (UBC, Canada), Steven Landefeld (BEA, the U.S.), and Paul Schreyer (OECD). This paper resulted from his proposal, their comments, and the later discussion at the ESRI with Masahiro Kuroda (president), Takashi Omori (vice president), and Masaaki Maruyama (director). The plans we report are preliminary. Please contact the authors if you quote. Comments are welcome.

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1 Introduction

The Japanese economy expended many years eliminating worthless assets and reforming the economic system after the collapse of the bubble economy in the beginning of the 1990s. In the so-called "lost decade," the economic system could not properly have changed against the rapid acceleration in technological change and globalization. It might not be an exception for the Japanese national accounts. In particular, there is a widespread view that the official Japanese stock statistics may be subject to substantial error, due to inappropriate concepts and parameters. Our objective in this paper is to recognize the current problems and propose Japan's plan for "sweeping" improvement on measuring capital. This move is not only to make up for lost time, but to go forward. The next revision of the SNA in 2008 (1993 SNA Revision 1), and further revisions, are being considered.

In the National Wealth Survey (NWS), the Japanese government directly investigated detailed capital stocks owned by corporations, gvernemnt, and households. The NWSs in 1955 and 1970 are the largest-scale surveys for direct observation of capital stock (DOC). [*1] The main role of NWS is to directly attain actual "gross" capital stock that are surviving in the production process at the period of the investigation. From the point of view of the theory of capital mesurement, however, the NWS's net capital stock that can be observed in business accounts no longer provides appropriate measures for the wealth or productive capacity of capital stock, since it is based on tax-lives that can considerably differ from the actual service life of the asset. The problems in the current stock measurement in the Japanese national accounts may stem from the fact that its methodology and parameters still depend on the 1970 NWS.

The intensive discussions by the Canberra Group and the revision by the BEA in the late 1990s provide valuable insights for improving the measurement of capital to reframe capital measurement in the Japanese national accounts, it is appropriate to start with an accurate understanding of current problems in stock

[*1] The NWS was implemented 12 times from 1905 to 1970, by the diffrent ministries, government offices, and Bank of Japan. The table below reports the history of the Japanese NWSs.

Servey Year	Published Year	Organization	ref
1905	N.A.	Bank of Japan	
1910	1912	Bank of Japan	
1913	Oct. 1921	Kokusuuin	
1917	N.A.	Bank of Japan	
1919	Oct. 1921	Kokusuuin	
1924	Feb. 1928	Naikaku Tokeikyoku	estimates existent statistics
1930	Nov. 1933	Naikaku Tokeikyoku	representative NWS before WWII
1935	Oct. 1948	Naikaku Tokeikyoku	based on similar method of the 1930 survey
1955	Mar. 1958	EPA	model for the NWS after WWII
1960	Dec. 1964	EPA	survey at small scale
1965	Aug. 1967	EPA	survey at small scale
1970	Feb. 1975	EPA	survey at large scale

Source: Economic Planning Agency (1976).
Kokusuuin → Naikaku Tokeikyoku → Statistics Bureau, MIC (present).
EPA → Economic and Social Research Institure, Cabinet Office (present).

statistics in Japan, based on the theory of capital measurement. In section 2, we begin with the clarification of capital stock concepts and the methodology to estimate. In section 3, we briefly introduce the current measurement of capital and examine some serious problems to be overcome.

In section 4, we report our plans to figure out our challenges for the sweeping improvement on measuring capital in the Japanese national accounts, with the brief introduction of the investigation into actual discards and the tentative estimates of average service lives for 66 assets. On reframing the capital measurement, we pursue three key concepts: internal-consistency, empirical verification, and reproducibility. The revised Japanese statistics will be able to propose accurate and internally consistent stock measures and consumption of fixed capital. We hope that Japan's examination can contribute to international discussion for the further improvement on measuring capital and production account, like capital services, land as a capital, capital service cost for non-market production, and so forth. Section 5 briefly concludes.

2 Capital Stock: Concepts and Our Goal

2.1 Concepts

2.1.1 Gross, Net, and Productive

What is the role of measurement of capital? Like other factors of production, which are used in production processes, capital has a productive capacity. Unlike other factors of production, however, capital is not consumed, but used beyond a single accounting period. This durability lets the capital retain its value so that capital can be used in future production processes. Capturing the two aspects of capital: the productive capacity and the value of capital, is the main purpose for measuring capital.

Traditionally, two distinctive concepts for capital stock, gross capital stock and net capital stock, were used. The distinction of the two concepts is based on depreciation. Gross capital stock is defined before the deduction of depreciation, and net capital stock is reduced by the depreciation. As the traditional gross concept still remains in the Japanese statistics of capital stock for production analysis, gross capital stock may have been sometimes thought suitable to measure the productive capacity of capital.

However, the traditional system of gross and net capital stock is incapable of portraying the two different aspects of capital, except under unrealistic assumptions. This was finally abandoned by BEA in 1997, a quarter century after the controversy between Jorgenson-Griliches (1972) and Denison, as Jorgenson (1989) had clearly pointed this out.

The intensive works of Dale W. Jorgenson, Robert E. Hall, Zvi Griliches, Charles R. Hulten, Walter E. Diewert, Jack E. Triplett, and many other researchers and statisticians, have developed the theory for measurement of capital and accumulated empirical results. The theory of capital measurement clarifies the distinction of these two aspects of capital: the productive capacity and the value of capital, based on the concepts of age-efficiency profile and age-price profile. We use three distinctive stock concepts in this paper: gross, productive, and net capital stocks.[*2]

2.1.2 Discard and Decay

There may be a consensus about the use of "retirement" and "discard." In the OECD manual on measuring capital, Blades (2001) uses "retirement" and "discard" interchangeably to mean the removal of an asset from the capital stock, with the asset being exported, sold for scrap, dismantled, pulled down, or simply abandoned. Also, retirements and discards are distinguished from "disposals" which include sales of assets as second-hand goods for continued use in production.[*3]

Next, we describe the distinction between retirement and decay. Jack E. Triplett (1997) also gives the definitions. He defines the term "deterioration" to represent the relative efficiency in the (AEP). Deterioration arises from two sources: "retirement" and "decay," which is defined by the loss of efficiency of a surviving asset. Retirement designates assets withdrawn from service and he uses "discard" and "scrap" synonymously. Following their definition, we use in this paper "discard of assets," "decay of surviving assets," and "deterioration" as combined concepts.

[*2] We use the name of productive capital stock after Triplett (1996, 1997) and Hill (1998, 1999). Biørn (1989) and Biørn, Holmoy, and Olsen (1989) call a productive capital stock in this paper a "gross" capital stock, since they do not need a traditional gross concept of capital stock. Blades (2001) does not give a particular name for the productive capital stock in the OECD Manual on Capital Stock Statistics.

Net capital stock in this paper is also called "wealth" capital stock, like Triplett (1997). The net capital stock is "generally, a synonym for the wealth capital stock. The "net" language thus distinguishes the depreciated capital stock (the wealth capital stock) from the undepreciated, or gross capital stock. However, the traditional "gross-net" capital dichotomy does not encompass the productive capital stock, which could cause confusion (because the productive capital stock is "net" of depreciation, compared to the undeteriorated gross stock). Once the distinction between productive and wealth capital stocks fully enters the lexicon, it will probably be preferable to avoid the net capital stock terminology." (Triplett, 1997) However, we use net capital stock in this paper, partly because we cannot find an adequate term in Japanese corresponding to "wealth capital stock," and partly because net capital stock is identical with the traditional net capital stock, although the concept is clarified.

[*3] Disposal in Blades (2001) is identical with its definition in the 1993 SNA. In the 1993 SNA (United Nations, 1993), "Disposals of assets (inventories, fixed assets or land or other non-produced assets) by institutional units occur when one of those units sells or transfers any of the assets to another institutional unit; when the ownership of an existing fixed asset is transferred from one resident producer to another, the value of the asset sold, bartered, or transferred is recorded as negative gross fixed capital formation by the former and as positive gross fixed capital formation by the latter." (paragraph 10.40).

2.2 Two Routes for One Goal

2.2.1 No Middle Reliever

Our goal is to measure the productive capital stock (PCS) that designates the productive capacity of capital, and the net capital stock (NCS) that designates the value of capital. In the framework of measuring capital stock, the key idea is the age-efficiency profile (AEP) and the age-price profile (APP). The AEP gives a schedule for the productive capacity associated with the pure aging of capital at the same point of time, taking an efficiency of a new asset as one to normalize. The APP gives a schedule of the capital value associated with its pure aging at the same point of time, normalizing the capital value of a new asset at one.

Based on the comprehensive empirical studies of Hulten and Wykoff (1981a, 1981b, 1981c), the geometric distribution in the AEP or APP is approximately accepted for many assets in the U.S. Also, Nomura (2004, ch-2) estimates depreciation rates based on a Box-Cox transformed APP, using data in the second-hand market for motor vehicles, and an AEP using data in the rental markets for housing in Japan. The geometric approach is accepted as an approximation for these assets. In the Hulten-Wykoff methodology, the AEP represents a "combined" profile of discard and decay. In other words, it is a profile of age-deterioration by Triplett's terminology.

For moving to our goal of measuring the PCS $S_{t,\tau}^{P,k,j}$ and the NCS $S_{t,\tau}^{N,k,j}$, we may have two routes. At the starting point, we prepare quantities of investment measured in "efficiency units" among the assets k with different vintages $(t-\tau)$, regardless of the two routes. Here, let us assume the quantities of investment $A_{t-\tau}^{kj}$ are given for industry j.

In the first route, the AEP and APP pitch a complete game from the opening $A_{t-\tau}^{kj}$ to the ending $S_{t,\tau}^{P,k,j}$ and $S_{t,\tau}^{N,k,j}$. Figure 1 displays the first route to our goal. Assuming no change of the AEP over time, we write the AEP as d_τ^k, independently of time t. It satisfies the conditions below,

$$d_0^k = 1, \;\; d_1^k > 0, \;\; d_\tau^k - d_{\tau-1}^k \leq 0, \;\; \lim_{\tau\to\infty} d_\tau^k = 0. \tag{1}$$

These four conditions represent, respectively, normalization of AEP at $\tau = 0$, durability of the asset, monotonic decreases of relative efficiency, and finite durability. Again, note that the AEP is defined as the combined distribution of the survival distribution of an asset and the efficiency distribution for the surviving asset.

Applying the AEP to assets with different ages, the quantity of investment with different vintages $(t-\tau)$ is transformed to the productive capital stock (PCS), as

$$S_{t,\tau}^{P,k,j} = d_\tau^k A_{t-\tau}^{k,j}. \tag{2}$$

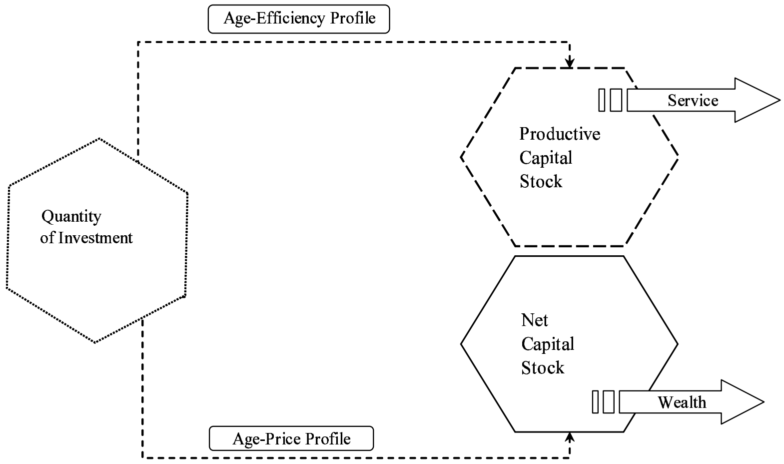

Fig. 1 Measuring Capital Stock: Route-1 (No Middle Reliever)

The PCS is evaluated in the same efficiency unit among assets with different ages τ. Capital services can be produced from the PCS, as shown in Figure 1. The AEP transforms assets with different ages to be perfectly substitutable, so that the PCSs with different ages can be simply added: $S_t^{P,k,j} = \sum_{\tau=0}^{\infty} S_{t,\tau}^{P,k,j}$.[*4] By the dual approach of capital, the capital service prices of assets with different ages have perfect complementary, so that they are equivalent: $P_t^{K,k} = P_{t,\tau}^{K,k}$, (Jorgenson, 1989).

Next, let us move to the value concept of capital. The schedule of the capital value in the APP depends on future capital services described in the AEP, the expected capital service price, and the expected discount rate. Here, we write the APP as $d_{t,\tau}^{P,k}$. Assets with different ages normally have a different value because of a finite service life of the asset, even if the productive capacity the asset has is exactly same. We assume the conditions for the APP as:

$$d_{t,0}^{P,k} = 1, \;\; d_{t,1}^{P,k} > 0, \;\; d_{t,\tau}^{P,k} - d_{t,\tau-1}^{P,k} \leq 0, \;\; \lim_{\tau\to\infty} d_{t,\tau}^{P,k} = 0, \;\; \lim_{r_t\to\infty} d_{t,\tau}^{P,k} = d_{\tau}^{k}. \tag{3}$$

The conditions required for the APP are similar to Equation (1) for the AEP. The fifth condition represents that the APP converging with the AEP, when the discount rate r_t approaches infinity. Applying the APP to assets with different ages, the GCS will be transformed to the net capital stock (NCS):

$$S_{t,\tau}^{N,k,j} = d_{t,\tau}^{P,k} A_{t-\tau}^{k,j}. \tag{4}$$

[*4] Diewert and Lawrence (2000) and Diewert (2001) provide a new approach in measuring capital and propose the use of a superlative index number formula to aggregate assets with different ages (or vintages, under the fixed point of time). In this paper, we assume perfect substitution in the PCSs with different ages, as if the AEP were specified independently.

Based on the NCS in Equation (4), the nominal value of assets with different ages is written as:

$$V_{t,\tau}^{S,k,j} = P_t^{A,k} S_{t,\tau}^{N,k,j}, \tag{5}$$

where $P_t^{A,k}$ is investment price for acquisition of new assets in time t and $V_{t,\tau}^{S,k,j}$ represents nominal value of net capital stock, which is capital wealth to be described in the balance sheet of the capital holders. The price for net capital stock $S_{t,\tau}^{N,k,j}$ is $P_t^{A,k}$.

Economic researchers frequently, and sometimes unconsciously, assume the geometric distribution as the AEP in the model for economic growth. Theoretically, the geometric distribution alone has the desirable property that the AEP and the APP are identical. Also, therefore, the PCS and the NCS are identical, as

$$S_{t,\tau}^{N,k,j} = S_{t,\tau}^{P,k,j}, \tag{6}$$

where

$$d_\tau^k = d_{t,\tau}^{P,k} = (1 - \delta^k)^\tau. \tag{7}$$

This assumption is called the "best geometric approach" (BGA). The two aspects of one entity of capital are captured by only one measure, based on the assumption of the BGA. Accepting the BGA makes it possible to neglect the age structure for aggregating assets with different ages, like a familiar perpetual inventory method (PIM),

$$S_t^{P,k,j} = (1 - \delta^k) S_{t-1}^{P,k,j} + A_t^{k,j} = \sum_{\tau=0}^{\infty} (1 - \delta^k)^\tau A_{t-\tau}^{k,j}. \tag{8}$$

As a part of the comprehensive revision of NIPA, the U.S. Bureau of Economic Analysis (BEA) revised the methodology for estimating their capital stock and depreciation in 1997.[*5] The revised methodology reflects the results of empirical studies, which have shown that depreciation for most types of equipment and structures does not follow a straight-line, but approximates the BGA. The improvement for the measurement of depreciation involves the use of the BGA as the default, instead of the use of combination of the straight-line depreciation and the survival distribution.[*6]

The outstanding property of the first route is that there is no role of gross capital stock. The BEA no longer produces estimates of gross capital stock and discard, after their revision.

[*5] See Fraumeni (1997), Katz and Herman (1997), and BEA (2003). The BEA defines depreciation as "the decline in value due to wear and tear, obsolescence, accidental damage, and aging," which included discards (Katz and Herman, 1997; Fraumeni, 1997).

[*6] Exceptionally, the BEA uses non-geometric patterns of depreciation for autos, computers, missiles, and nuclear fuel (Fraumeni, 1997). Therefore, the use of BEA's stock as the productive capital stock is not appropriate.

2.2.2 Middle Reliever

Next, we examine the second route. Here, the gross capital stock (GCD) has a role of a middle reliever. The GCS $S_{t,\tau}^{G,k,j}$ is defined as:

$$S_{t,\tau}^{G,k,j} = s_\tau^k A_{t-\tau}^{k,j}, \tag{9}$$

where s_τ^k is known as a survival distribution, which has same properties as d_τ^k represented in equation (1). We also call it as age-survival profile (ASP) in this paper. The GCS permits the difference of quality of assets with different ages τ, although the assets retired until t are excluded. In other words, the assets with different ages are evaluated at "as new" prices in the GCS, described in Blades (2001).

In the three capital stocks, the GCS may have very limited purposes to be used. If we assume a vintage production function, the GCS may give an appropriate concept as the factor input. However, for the economic analysis using an aggregate measure of capital with different ages, it may be no longer easy to find an appropriate role of the GCS, except under unrealistic assumptions. [*7] The role can be found in the process of measuring the PCS and the NCS, as a middle reliever. When we reach the goal, the GCS ends its role.

Figure 2 displays the second route to our goal. In the second route, the AEP and APP are narrowly defined as the profiles of surviving assets. Let $\hat{d}_\tau^k$ denote the AEP of surviving asset, to satisfy

$$d_\tau^k = s_\tau^k \hat{d}_\tau^k. \tag{10}$$

If the geometric approach for d_τ^k can adequately approximate the AEP, there is no need to decompose it into s_τ^k and $\hat{d}_\tau^k$. Practically, however, the decomposition may be useful, partly because it is sometimes difficult to investigate d_τ^k for many kinds of assets, due to the lack of the market data for aged assets. In fact, there is sometimes no actual market for aged assets. Moreover, to estimate d_τ^k, some assumption for discard patterns, more concretely the functional form and its parameters of the distribution, are required, since the observed data at the market of aged assets is censored due to the lack of data for the assets that already retired at the period of the investigation. In the comprehensive studies of Hulten and Wykoff, they assume the Winfrey distributions to adjust the censored samples.

[*7] The GCS is interpreted as a special case of the PCS, which is an appropriate concept for the productive capacity of capital stock. Only if the AEP is "one-hoss shay," where the relative efficiency of capital is constant throughout the lifetime T^k, the GCS is identical with the PCS: $S_{t,\tau}^{P,k,j} = S_{t,\tau}^{G,k,j}$, where $d_\tau^k = 1(\tau < T^k)$ and $d_\tau^k = 0(\tau = T^k)$. Only some exceptional assets like electric light bulbs provide an example. The one-hoss shay distribution can hardly be observed in the empirical studies for measuring the AEP. Also, for new assets with $\tau = 0$, the three measures of capital stock are identical: $S_{t,0}^{N,k,j} = S_{t,0}^{P,k,j} = S_{t,0}^{G,k,j}$, since $d_{t,0}^{P,k} = d_0^k = 1$. The difference in the three measures occurs because of the durability of assets.

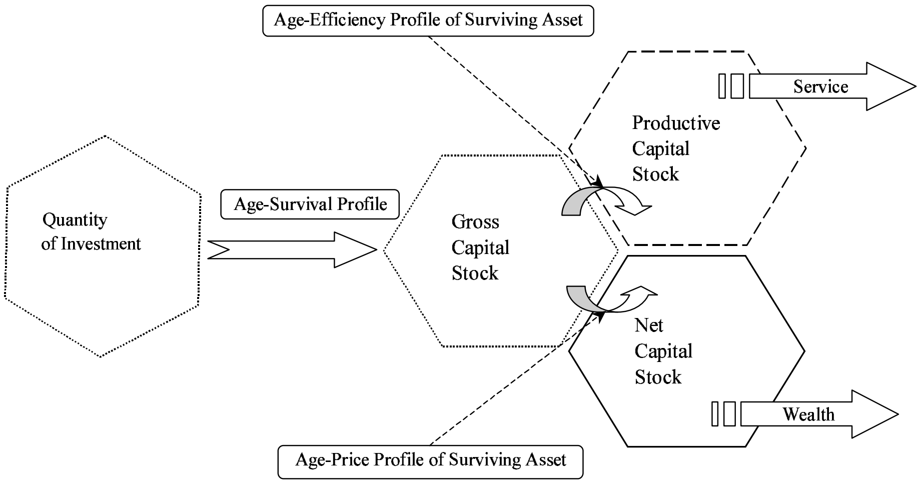

Fig. 2 Measuring Capital Stock: Route-2 (Middle Reliever)

The second route closes to the traditional methodology for measuring capital based on the "gross-net" capital dichotomy. Although the BEA has stopped using the middle reliever, many other countries still continue to use it. The representative may be the estimates by Statistics Netherlands, which investigates the directly observed capital stock and discards (Meinen, Verbiest, and Wolf, 1998).

There are few empirical studies using Japanese data for the rates of depreciation or deterioration of assets. Lee (1978) for fishing fleets, Kuninori (1988) for construction machinery, Nomura (2004a, ch.2) for motor vehicles and housing give a few examples. Many studies of the Japanese economy use the depreciation rates of the BEA (Fraumeni, 1997). However, depreciation rates can differ between the U.S. and Japan, reflecting the difference in natural and environmental conditions, utilization, maintenance, and composition of capital goods. Base on Nomura's estimates, the estimated depreciation rates are 16.3 percent for passenger motor vehicles, 22.4-23.8 percent for trucks, and 3.1-4.8 percent for housing. In comparison with the U.S. depreciation rates that the BEA uses, passenger vehicles and housing are less durable and trucks are more durable in Japan. The differences in durability of assets among countries must be reflected in the stock measurement in each country.

Moreover, in Japan, there is no discard survey for detailed assets after the large-scale survey for the directly observed capital stock and discard at the National Wealth Survey in 1970. As Japan's revision, we are now moving to the second route, since it is important to accumulate empirical evidence for discard and decay in Japan. Nomura (2005b) reports the preliminary estimates for the ASP s^k_τ, based on Japan's directly observed discard data investigated by Economic and Social Research Institution (ESRI) of the Cabinet Office (CAO) in 2003.

3 Problems in Current Capital Stock

3.1 Stock Estimates

We briefly introduce the measurement of capital stock in the present Japanese national accounts and discuss some problems to be overcome. ESRI, which is the producer of the Japanese national accounts, publishes two main estimates for capital stock.

Figure 3 shows the concepts and rough coverage of stock measurement in Japan. The first estimate is net capital stock, which is described in the balance sheet of the Japanese national accounts. We refer to this measure as "JSNA-NCS." The second estimate is Gross Capital Stock of Private Enterprises (GCSPE), which is frequently the main data source for analysis of production by industry. In addition, the CAO irregularly publishes gross capital stock for infrastructure, which is estimated almost separately from JSNA-NCS and GCSPE.

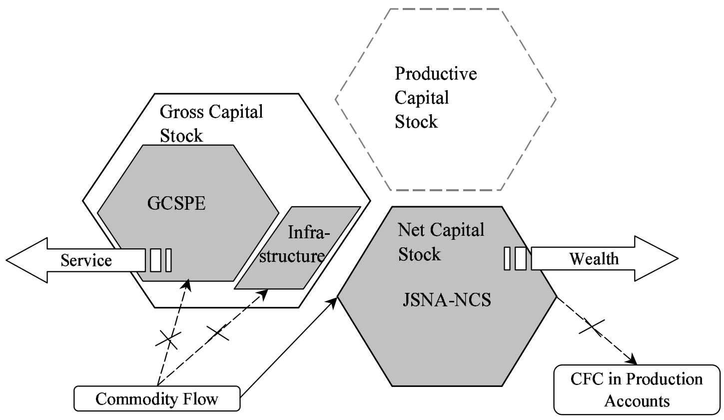

Fig. 3 Current Capital Stock in the Japanese National Accounts

3.2 Net Capital Stock

Depreciation in JSNA-NCS is based on the straight-line method for infrastructure and custom software, and on the geometric method for other assets. Conceptually, JSNA-NCS provides capital wealth in the Japanese economy. At the ESRI conference in March 2005, Nomura (2005a) indicated JSNA-NCS may be considerably underestimated because of the too-high depreciation rates. The gap that he tentatively computed was more than 30 percent in 2000. Ervin Diewert also pointed out that the official rates may be much too high for some assets in Japan, based on his own examination. Although the service lives assumed in JSNA-NCS had been not published, ESRI showed the rates and that the depreciation rates assumed in JSNA-NCS were computed using the tax-lives in the 1970 Japanese National Wealth Survey (NWS), after the conference.

Table. 1 Service Lives and Depreciation Rates Used in the Present National Accounts

	T	δ	JSNA-NCS*
By Asstes			
dwellings	28.0	7.9	251163
other buildings	37.4	6.0	250712
other structures	33.7	6.6	190913
tranportation equipment	7.6	26.2	26332
agriculture machinery	9.2	22.2	2902
other machinery	10.6	19.5	175055
cultivated assets	5.4	12.1	1674
total	27.8	9.9	898749
By Institutional Sectors			
private non-financial corporations	15.4	13.9	469400
public non-financial corporations	27.1	8.1	92103
private financial corporations	25.9	8.5	24095
public financial corporations	35.5	6.3	553
general government	23.5	9.3	51172
private non-profit institutions	26.1	8.5	15510
households (including private unincorporated enterprises)	17.8	12.1	246368
total	18.2	12.3	898749

T: retirement age, δ: depreciation rate to satisfy $(1-\delta) = V^{1/T}$ (V=0.5 for cultivated asset, 0.1 for other assets.).
JSNA-NCS* is the adjusted value from the JSNA-NCS fixed assets in the end of 2000 (billion yen),
excluding consumption tax and the stock of infrastructure and custom software.

Table 1 reports the service lives and geometric depreciation rates by asset and institutional sector, assumed in JSNA-NCS. To define the aggreagte depreciation rate, we describe the corresponding capital stock in 2000, excluding infrastucture and custom software, for which the straight-line depreciation method is used. Let us introduce the current methodology to estimate JSNA-NCS. Oddly enough, the JSNA-NCS is tentatively estimated in two ways: the stock by asset S_k using the service lives in each asset δ_k and the stock by institutional sector $\hat{S}_j$ using the service lives in each institutional sector δ_j. Finally, the sum of capital stock is defined by $\sum_k S_k$ and the stock by institutional sector is redefined as the $S_j = \hat{S}_j / \sum_j \hat{S}_j * \sum_k S_k$. Therefore, the estimates S_j may be biased, since the asset composition has changed considerably until present, even if S_k could be estimated accurately.

In Table 1, we compute the average rate of depreciation at the aggregate level as a weighted average of depreciation rates by assets, using the capital stock shares as the weights. The average value is 9.9

percent defined by δ_k.[*8] This rate is higher than Nomura (2004a)'s estimates: 7.8 percent for the secondary industries and 9.2 percent for electric machinery industry, which has the relatively higher depreciation rate.

For dwellings, the geometric depreciation rates are 5.8 percent for wooden building and 3.8 percent for non-wooden building in 1988, estimated using the rental market data in Nomura (2004a). Although these estimates are much higher than the BEA's depreciation rate for dwellings: 1.1-1.4 percent, they are much lower than 7.9 percent assumed in JSNA-NCS. The depreciation rate for transportation equipment (26.2 percent) may be too high. Nomura's estimates are 16.3 percent for passenger cars, 22.4-25.5 percent for trucks, based on the second-hand market data in Japan. Probably, other transportation equipment like ships and trains may have lower depreciation rates. For the results, we have to not only revise the current inappropriate methodology to estimate the JSNA-NCS, but also replace the current depreciation rates to a more appropriate one based on empirical studies in Japan.

3.3 Consumption of Fixed Capital

We choose "JSNA-CFC" to label the consumption of fixed capital in Japan's national accounts. The main difficulty to be revised is that the JSNA-CFC is defined by historical prices, based on the book value in the corporate sector business accounts, and on similar estimates for private unincorporated enterprises and general government. For the estimates by industry, JSNA-CFC distributes the total CFC to industries, using the estimated industry shares, which are based on the share of CFC in gross output and the estimated values of gross output by industry (ESRI, 2000). It is significantly important to note that the assumptions to estimate JSNA-CFC are not consistent with those in JSNA-NCS.

Conceptually, CFC evaluated by historical prices has to be revised. To determine the value of the CFC, the 1993 SNA points out: "Its value may deviate considerably from depreciation as recorded in business accounts or as allowed for taxation purposes, especially when there is inflation." (paragraph 6.179). The JSNA-CFC evaluated by historical prices generates a large bias when estimating net domestic product (NDP), which is a key concept as an appropriate measure of economic growth.

3.4 Gross Capital Stock

For industry analysis of the Japanese economy, a main data source for the Japanese capital stock is GCSPE, which covers all fixed assets, excluding residential buildings owned by private corporations and unincorporated enterprises and fixed assets owned by private non-profit institutions. GCSPE is frequently

[*8] The aggregate depreciation rate defined by δ_j is 12.3 percent, as shown in Table 1. The gap between two aggregate rates represents the biases on the measurement of stock by institutional sector S_j.

used as a measure of the productive capacity of the private sector in Japan.[*9]

However, it is misleading to use this data as a measure of productive capacity, for conceptual and empirical reasons. First, GCSPE is defined by a traditional gross concept of capital stock. As we discussed the concepts for capital stock in section 2.1.1, the gross concept does not provide an appropriate measure for the productive capacity of capital. Second, the nominal investment in GCSPE is not related to the "commodity flow" data, and GCSPE does not have asset categories. This makes it difficult for GCSPE to measure quantity of investment $A_t^{k,j}$ in "efficiency units" and to consider the appropriate aggregation procedure for heterogeneous capital. Moreover, although GCSPE publishes the estimates of gross capital stock and investment by industry at constant prices, it does not publish nominal investment or investment prices by industry. The lack of reproducibility of the capital stock data does not allow the users of GCSPE to test different assumptions for measuring capital.

Nomura (2005a) indicates that GCSPE is 16-20 percent higher than proper estimates of the productive capital stock (PCS) during 1995-2000, when GCSPE is interpreted as a special case of the PCS. We can observe this by noting that the average rate of retirement in GCSPE is 4.6 percent in the 1990s. The retirement rate is 1.3 percentage points lower than the average rate of deterioration, which consists of retirement and decay in Triplett's terminology, in his estimates of productive capital stock. To be an appropriate measure of productive capacity, GCSPE should be reformed to the PCS by asset and industry, sustaining the consistency with the JSNA-NCS in the national accounts.

3.5 Classification

The JSNA-NCS covers fixed assets, land, inventories, and consumer durables of all capital holders in Japan. Although nominal investment in the JSNA-NCS is consistent with the commodity flow for certain aggregates, it has only six classifications for tangible assets and one intangible asset. The tangible assets consist of (1) dwellings, (2) other buildings, (3) other structures, (4) transport equipment, (5) other machinery and equipment, and (6) cultivated assets.[*10] Erwin Diewert indicated that the current very

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[*9] To estimate productive capacity, the GCSPE intentionally excludes the residential capital owned by private sectors. There may be no longer any reason to exclude it, since the capital service produced by the residence owned by a company may be described as the consumption of fixed capital and operating surplus in the company. Also, it is difficult to identify it in practice. The primary statistics to estimate nominal investment for corporations in GCSPE is the Annual Report of Financial Statements of Corporations (ARFSC), by the Ministry of Finance. However, ARFSC does not investigate the investment for residence the company has, in particular.

[*10] As shown in Table 1, the stock for agriculture machinery is estimated separately, although it is not published. The classification for consumer durables consists of (1) furniture and floor coverings, (2) household appliances, (3) personal transport equipment, (4) information transmission equipment, and (5) others.

aggregated asset classification is not very satisfactory at all, since high and low depreciation assets are bundled together in some of the classifications.

The only intangible asset included is custom software.*[11] Although the conceptual expansion of capital recommended in the 1993 SNA was applied in the national accounts of many countries, it was not fully incorporated into the Japanese national accounts. As is widely known, the Japanese national accounts still do not capitalize own-account software and prepackaged software. In international comparisons of economic growth and productivity based on the 1993 SNA, Japan must be treated as an exception.

Finally, the JSNA-NCS is not estimated by industry, but by only seven institutional sectors described in Table 1. Also, it is not related to the industry classification in the GCSPE.

4 Challenges and Future Directions

4.1 Toward Reframing

As we examine the Japanese official stock statistics in the previous section, there are a number of problems to be revised. They may be caused from the lack of

- internal consistency,
- empirical verification,
- and reproducibility.

The internal consistency in the estimates gives a key criterion to evaluate the accuracy on the framework of capital measurement. One important area is the consistency between the NCS and the CFC, as BEA resolved it. The importance for sustaining internal consistency in the measurement of NCS and CFC became a common objective in the national accounts, as in the international methodological standards recommended by the OECD (Schreyer, 2001; Blades, 2001). Also, the internal consistency among three measures in capital stock has to be sustained. As we displayed in Figure 3, we could scarcely find the consistency between the JSNA-NCS and the GCSPE.

The current official stock estimates depends on the 1970 National Wealth Survey, not only for the benchmark capital stock, but for some parameters like service lives. These key parameters have already been obsolescent or conceptually inadequate. To revise the estimates with a detailed asset classification,

*[11] In Japan's national accounts, expenditures for plant engineering, mineral exploration, and custom software are treated as gross fixed capital formation (GFCF) of intangible assets, although plant engineering is not recommended to be treated as an intangible asset in the 1993 SNA. Furthermore, it is added to ”tangible” assets in the Japanese stock accounts, so the treatment is a halfway measure. Also, mineral exploration is not treated in the Japanese stock accounts, based on the assumption that it has just a one-year service life. Both these issues should be revised.

empirical studies for approximating discard and decay have to be newly developed in Japan.

Finally, the reproducibility of capital stock may be required. It assures that the users of stock estimates could test different assumptions for measuring capital, so that it may contribute to a more open discussion. Also, the reproducibility could make it easy to revise the estimates, if additional empirical facts are discovered. We are pursuing these three criteria on reframing the capital measurement in Japan.

4.2 Plans for Revision

ESRI is now preparing the 2000-year-based Japanese national accounts for its publication at the ending of 2005, based on, for example, the benchmark input-output table and the population census in 2000. As the next benchmark revision, the 2005 benchmark IO will be published in 2009, and the 2005-year-based Japanese national accounts is planned to be released in the end of 2010. At this time, we aim to revise the measurement of capital stocks and CFC.

For the sweeping revision of capital measurement in the Japanese national accounts, Nomura (2005a) suggested five proposals to catch up to international standards: (i) capitalization of software, (ii) reframing NCS and CFC, (iii) reframing GCS to the PCS, (iv) constant-quality prices, (v) empirical studies for AEP and APP, and three proposals to be prepared for the next revision of SNA in 2008 (1993 SNA Revision 1) or further revisions: (vi) measurement of price and quantity of capital service, (vii) land as capital, (viii) capital service cost for non-market production.

Here, we report more concrete plans for the revision. Our plans are divided into two groups: revision on measuring capital stock and research for more complete production accounts. Table 2 represents the plans for our challenges and future directions in Japan.

First, (1) capitalization of own-account and prepackaged software is the most urgent requirement. As Nomura (2004b) examined, 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 (Lequiller, Ahmad, Varjonen, Cave, and Ahn, 2003; Ahmad, 2003) and the industry approach used by the BEA (Grimm, Moulton, and Wasshausen, 2003). To estimate it, a time allocation survey for programmers is planned.

Our plans: (2)-(4), are highly desired to improve the measurement of investment in the Japanese national accounts. We plan to estimate time-series fixed capital formation matrixes (FCFM) in a detailed asset and almost three-digit industry classifications. Moreover, it is important to estimate the long-term constant-quality prices, as in our plan (5). The main purpose of price statistics is to measure current movement of prices, which can only be captured with constant-quality prices. However, the national accounts, and in particular measurement of capital, requires the constant-quality prices be extrapolated backward, sustaining the consistency with newly developed methodology, if possible. Although this function is carried out by BEA in the U.S. (see Wasshausen, 2000 for computer equipment), we may not find any similar function in the Japanese statistical system, as pointed out by Nomura (2005a).

The traditional "gross-net" capital dichotomy is incapable of portraying the two different aspects of capital: the productive capacity and the value of capital, except under unrealistic assumptions. To estimate proper measures for the PCS, further empirical studies for approximating discard and decay in the Japanese economy is required. To recognize the discard patters by asset, ESRI investigates directly observed discard data in 2003 as the first trial. Nomura (2005b) reports the measurement results. We show the tentative results in the next section. Now, we are examining the use of complete records of assets in some particular companies and the registration data for particular assets, to chase the service life of individual assets. Also, for approximating decay patterns of particular assets, we examine the second-hand market data. A few years will be spent for the empirical studies of age-efficiency profile.

The theory for measuring capital 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, Canada, and the United States - produce time series of capital services as a part of their official statistics. Recently, work has also been taken up in the United Kingdom and New Zealand (Schreyer, 2003).

We are researching the introduction of capital services in production account. The Canberra II Group supports 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). 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 most empirical studies for the Japanese economy do not fully recognize its importance.[*12]

Measuring capital service leads to the additional imputation of capital service cost for non-market production. In the 1993 SNA and also in NIPA, 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. We try to evaluate capital service cost for non-market production.[*13] Although our plans are divided into two

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[*12] 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 50 percent if land and inventories are ignored.

[*13] See Jorgenson and Landefeld (2005) for the U.S. economy and Jorgenson and Nomura (2005) for the Japanese economy.

groups in Table 2, we proceed with them simultaneously. We hope to accomplish sweeping improvement by overcoming all our plans, thereby anticipating the SNA 2008 (1993 SNA Revision 1) or further revision.

4.3 Duration of Assets

In this final section, we briefly introduce our tentative estimates for average service lives by asset, based on the directly observed data for discards. ESRI implemented the Survey of Actual Capital Stock and Discard of Private Enterprises (SACD) in 2003, as the first step for revising capital measurement. Figure 4 shows the average service lives for 66 assets, based on the estimated Weibull distribution.[*14] Asset 38, personal computers, has the shortest average service life (6.5 years) and asset 61, storehouse, has the longest one (39.9 years). The estimates for some assets may be still inappropriate. Although asset 22, semiconductor making equipment, has a relatively short service life (9.4 years), it seems too long. To examine more accurate estimates, we plan to make a pooled data of discards. We also plan to examine the use of service life of individual assets.

5 Concluding Remarks

Japan's national accounts are moving toward reframing capital measurement, which is one of the most problematic areas today regarding the national accounts. We reported current problems on the official measurement of capital and our challenges and future directions in concepts and methodology for a "sweeping" revision, where the estimates should be internally-consistent, empirically verified, and reproducible. We will spend the following three to five years reframing the measurement of capital stock and construct more complete production accounts.

[*14] The SACD consists of two kinds of investigations. The first is the survey of capital stock, investment, depreciation, purchases of second-hand assets, and discards by five capital groups and by eight asset groups of the private enterprises, which are classified to 29 industries. The second investigation of the 2003-SACD provides more detailed data for discards of assets. Here, assets are classified into eight asset groups. In each asset group, the three major assets retired in the 2002 fiscal year are investigated, with the periods of the purchase and the retirement, and the asset value at the period of the purchases. Moreover, the assets sold as second-hand goods for continued use in production are identified. The tentative estimation in Figure 4 does not include the sold assets. See Nomura (2005b) for details.

Table. 2 Challenges and Future Directions for Measuring Capital in Japan

		works	schedule*
Revisions on Measuring Capital Stock (until 2008)			
(1)	Capitalization of Software	capitalization of pre-packaged and own-account software by industry. time allocation survey for programmers is planned.	2005-06
(2)	Investment by Asset	long-term investment data by a detailed asset classification, sustaining the consistency with the commodity flows in the national accounts.	2005-07
(3)	Industry Investment and Infrastructure	investment by industry (corporation, non-corporation, public, non-profit institutions, and government) and infrastructure.	2005-07
(4)	Fixed Capital Formation Matrix	estimation of time-series gross FCFM. survey for investment composition is planned.	2006-07
(5)	Long-term Constant-Quality Prices	long-term price indexes, especially for IT-related hardware and software prices, construction prices.	2005-07
(6)	Empirical Studies for Discard	direct observation for stock and discard patterns by asset (age-survival profile) was implemented in 2003. continuous surveys are planned. in addition, a special investigation for a particular company and the use of registration data are examined.	2005-07
(7)	Empirical Studies for Decay	studies using market data (age-efficiency profile and age-price profile of surviving assets): motor vehicle, dwellings, machinery, and so forth.	2005-07
(8)	Scraps and Second-hand Assets	examination of second-hand assets (sold and purchased) and scraps.	2005-07
(9)	Installation	direct observation for lag-distribution of installation by asset (especially for buildings and construction) is planned.	2006-07
(10)	Fixed Capital Stock and CFC	estimation of time-series gross FCSM, productive FCSM, and net FCSM. consideration of a discount factor. consistent estimates of the CFC.	2007-08
(11)	Consumer Durables	purchases and stocks for detailed consumer durables.	2006-08
(12)	Invetory Stock	matrix for inventory increase and stock. deflators for types of inventory, sustaining consistency with the commodity prices.	2006-08
Research for More Complete Production Accounts (until 2010)			
(1)	Measurement of Capital Services	considerlation of taxes and rate of returns (ex-ante, ex-post), to compute user costs of capital. surveys for labor income for self-employed and family workers. relationship with FISM.	2007-10
(2)	Land as a Capital	land stock and services by industry, government, and household. land price index will be examined.	2006-09
(3)	Rentals	survey for rental assets that are treated as intermediate inputs, to clarify the true capital contribution by industry.	2008-10
(4)	Capital for Non-Market Production	user cost for publicly owned capital and household owned capital is estimated.	2008-10
(5)	Expanding Boundary of Capital	research and development, and others.	2009-10

* the schedule is our preferable target.

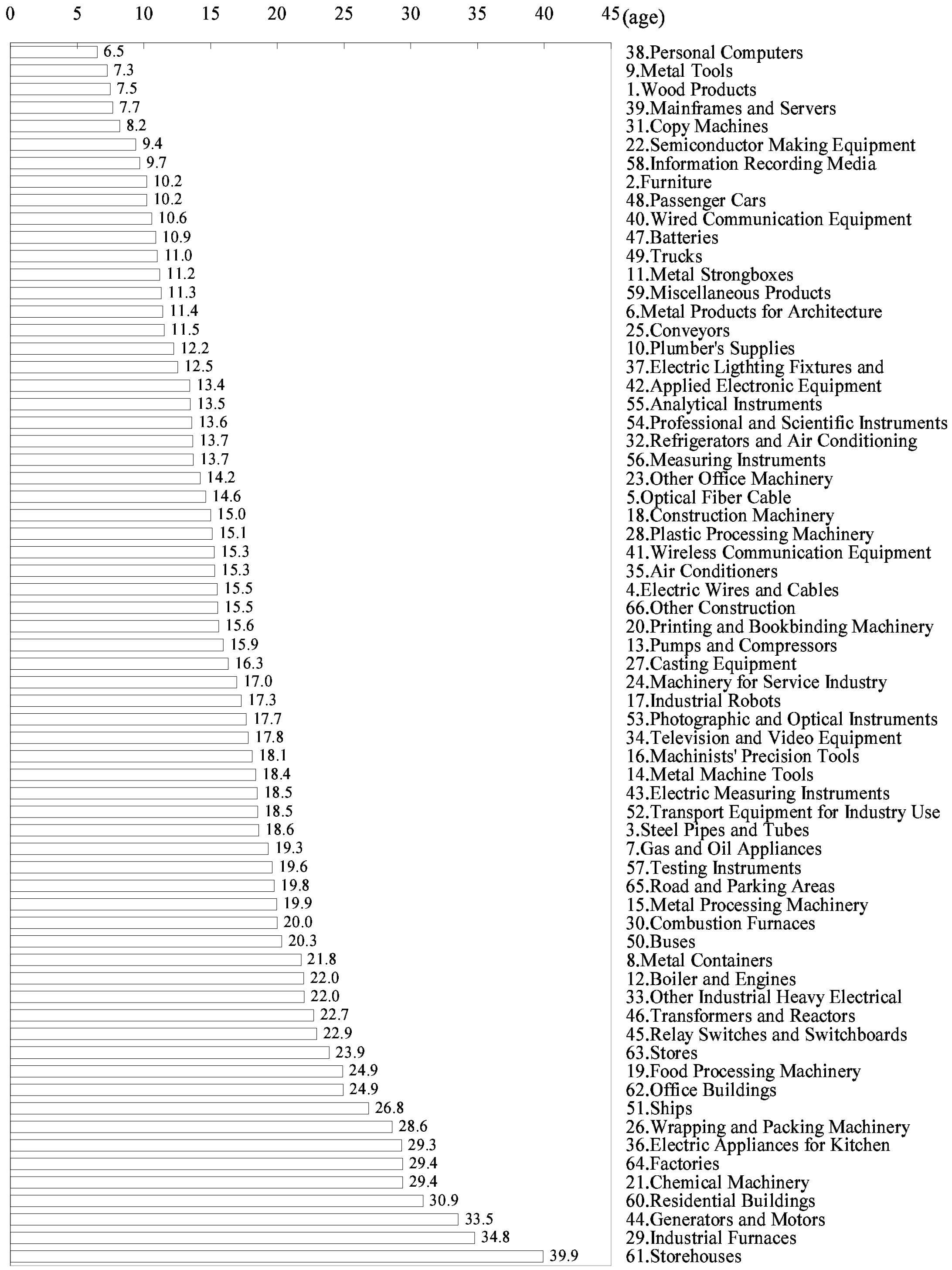

Fig. 4 Average Service Lives in Japan based on the Estimated Weibull Distribution

References

[1] Ahmad, Nadim (2003), Measuring Investment in Software, STI Working Paper Series, OECD, May.
[2] _____(2004). Introducing Capital Services into the Production Account, Meeting of the Advisory Expert Group on National Accounts, December.
[3] Biørn, Erik (1989). *Taxation, Technology and the User Cost of Capital*, Amsterdam: North-Holland, 325p.
[4] Biørn, Erik, Erling Holmoy, and Oystein Olsen (1989). Gross and Net Capital, and the Form of the Survival Function: Theory and Some Norwegian Evidence, *Review of Income and Wealth*, 35, 133-149.
[5] Blades, Derek (2001), *Measuring Capital: A Manual on the Measurement of Capital Stocks, Consumption of Fixed Capital, and Capital Services*, Paris, OECD, April.
[6] Bureau of Economic Analysis (2003), Fixed Assets and Consumer Durable Goods in the United States, 1925-99, Washington, DC: U.S. Government Printing Office, September.
[7] Diewert, Erwin W. (2001). Measuring the Price and Quantity as Capital Service Under Alternative Assumptions, Department of Economics, University of British Columbia, Discussion Paper No.01-24, June.
[8] Diewert, Erwin W. and Denis Lawrence A. (2000). Progress in Measuring the Price and Quantity of Capital, in Lawrence J. Lau eds., *Econometrics and the Cost of Capital: Essays in honor of Dale W. Jorgenson*, Chapter 11, Cambridge, The MIT Press, 273-326.
[9] Diewert, Erwin W. Anne Harrison, and Paul Schreyer (2004). Cost of Capital Services in the Production Account, 20p.
[10] Economic and Social Research Institute (2000). The Explanation of the Japanese National Accounts Based on the 1993 SNA, November (in Japanese).
[11] Fraumeni, Barbara (1997). The Measurement of Depreciation in the U.S. National Income and Product Accounts, *Survey of Current Business*, July, 7-23.
[12] Grimm, Bruce T., Brent R. Moulton, and David B. Wasshausen (2003). Information Processing Equipment and Software in the National Accounts, revision of the paper prepared for the Conference on Measuring Capital in the New Economy, NBER/CRIW, April 26-27, 2002, Federal Reserve Board, Washington, D.C., March.
[13] Hermans, Tim (2002). Measurement of GFCF in Software in the Belgian National Accounts, Joint ECE/Eurostat/OECD Meeting on National Accounts, April.
[14] Hill, Peter (1998). Gross, Productive, Net Capital Stock, Second Meeting of the Canberra Group on Capital Stock Statistics, 20p.
[15] _____(1999). The Productive Capital Stock and the Quantity Index for Flow of Capital, Third Meeting of the Canberra Group on Capital Stock Statistics, 5p.
[16] Hulten, Charles R. and Frank C. Wykoff (1981a), Economic Depreciation and the Taxation of Structures in United States Manufacturing Industries: An Empirical Analysis, in D. Usher eds., *The Measurement of Capital*, Chicago: University of Chicago Press, 83-120.
[17] _____(1981b), The Estimation of Economic Depreciation Using Vintage Asset Prices: An Application of the Box-Cox Power Transformation, *Journal of Econometrics*, April, 367-396.
[18] _____(1981c), The Measurement of Economic Depreciation, in C. R. Hulten eds., Depreciation, Inflation, and the Taxation of Income from Capital, Washington, D.C.: The Urban Institute Press, 81-125.
[19] Jorgenson, Dale W. (1989). Capital as a Factor of Production, in D. W. Jorgenson and R. Landau, eds., *Technology and Capital Formation*, Cambridge: The MIT Press, 1-35.
[20] Jorgenson, Dale W., and Zvi Griliches (1972). Issues in Growth Accounting: A Reply to Edward F. Denison, *Survey of Current Business*, Vol.52, No.4, 65-94.
[21] Jorgenson, Dale W. and J. Steven Landefeld (2005). Blueprint for Expanded and Integrated U.S. National Accounts: Review, Assessment, and Next Steps, in D.W. Jorgenson, J.S. Landefeld, and W.D. Nordhaus, eds., *A New Architecture for the U.S. National Accounts*, Chicago, University of Chicago Press.
[22] Jorgenson, Dale W. and Koji Nomura (2005). Industry Origins of Japanese Economic Growth, *Journal of the Japanese and International Economics*, Vol.19, No.4.
[23] Kuninori, Morio (1988). Measurement of Depreciation of Japanese Construction Machinery, *Keizai Keiei Kenkyu*, Vol.9 (in Japanese).
[24] Lee, Bun S. (1978). Measurement of Capital Depreciation within the Japanese Fishing Fleet, *Review of Economics and Statistics*, 255-273.
[25] Lequiller, Francois, Nadim Ahmad, Seppo Varjonen, William Cave, and Kil-Hyo Ahn (2003): Report of the OECD Task Force on Software Measurement in the National Accounts, *OECD Statistics Working Paper Series*, OECD, March.
[26] Meinen, Gerhard, Piet Verbiest and Peter-Paul de Wolf (1998). Perpetual Inventory Method - Service lives, DIscard Patterns and Depreciation Methods, Canberra Group on Capital Stock Statistics, September.
[27] Nomura, Koji (2004a). *Measurement of Capital and Productivity*, Tokyo: Keio University Press. (in Japanese) , 633p.
[28] _____(2005a). Turn the Tables! Reframing Measurement of Capital in Japanese National Accounts, presented at the ESRI Conference on Next Steps for the Japanese SNA:"Towards More Accurate Measurement and More Comprehensive Accounts," Tokyo, March 25, 2005, 43p.
[29] _____(2005b). Duration of Assets: Examination of Directly Observed Discard Data in Japan Tokyo, September, mimeo.
[30] Schreyer, Paul (2001), *OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth*, OECD, Paris, March.
[31] _____(2003). Capital Stocks, Capital Services and Multi-Factor Productivity Measures, OECD Draft Paper Economic Studies , 22p.
[32] Triplett, Jack E. (1996). Depreciation in Production Analysis and in Income and Wealth Accounts: Resolution of an OLD Debate, *Economic Inquiry*, 34(1), 93-115.
[33] _____(1997). Concepts of Capital for Production Accounts and for Wealth Accounts: The Implications for Statistical Programs, First Meeting of the Canberra Group on Capital Stock Statistics, 57p.
[34] United Nations (1993). *System of National Accounts 1993*, New York, United Nations.
[35] Wasshausen, David (2000), Computer Prices in the National Income and Product Accounts, Draft Methodology Paper, Bureau of Economic Analysis, 24p.