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Measurement of Depreciation Rates based on Disposal Asset Data in Japan

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Abstract

This paper presents preliminary estimates of asset service lives and geometric depreciation rates for 195 assets based on the recently constructed ESRI *Survey on Capital Expenditures and Disposables* (CED). The disposal surveys in the 2005 and 2006 CED collected about 260,000 observations of disposal assets from business accounts of private corporations, of which about 26,000 transactions include sales of disposal assets with the observed sale price of the traded asset. Although further investigations of the disposal data are still required, our estimates of geometric depreciation rates for building and construction are much higher than those assumed in the current JSNA.

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1 Introduction

Japan's system of national accounts (JSNA) is moving toward a comprehensive revision of the measurement of capital stock in its wealth accounts.[1] In this reframing work, obtaining empirical evidence of service lives and depreciation rates is a key in the measurement of net/wealth capital stock estimates. The objective of this paper is to report a first set of the estimates of asset service lives and a constant geometric depreciation rates, based on the results of surveys on disposal assets conducted by Economic and Social Research Institute (ESRI) Cabinet Office of Japan.

Gross capital stock can be estimated either by a direct survey or by an indirect approach based on the Perpetual Inventory Method (PIM) using long-term investment data, assumptions about duration of assets and an initial level of capital stock. Japan has a long history of a direct survey on gross capital stock, as *National Wealth Survey* (NWS).[2] The NWS investigates gross book values of assets surviving from past investment and re-evaluates them at the purchaser's prices of new assets as of the current period. Although the gross concept of capital stock is hardly used in economic analysis, it can be a starting point to estimate productive and net/wealth capital stock, since it enables us to skip assumptions on discard and provides the benchmark stock. The NWS approach, however, does not provide estimates of actual patterns of deterioration and depreciation that are required for productive and net/wealth capital stock estimates.

In the current JSNA, the rates of depreciation are defined at too broad of a level to accurately capture actual depreciation patterns and therefore may be inappropriate to employ in net capital stock estimates.[3] This paper estimates the Weibull survival function and geometric depreciation rates for 195 assets based on the results of a newly available disposal survey in *Survey on Capital Expenditures and Disposals* (CED) conducted in 2005 and 2006. The two surveys collected about

[†] This study was implemented as a part of the JSNA Capital Project for revising capital stock estimates in wealth accounts at ESRI, Cabinet Office of Japan. The authors thank our colleagues, Hiroki Owaki, Shuji Hasegawa, Tadao Futakami, Miyuki Watanabe, Hidemine Sekino, and Norikazu Yamashita (ESRI), Yuji Onuki and Shinichi Shimakita (Statistics Bureau) for their supports.

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[1] See Nomura (2005a) and Nomura and Futakami (2005).

[2] The NWS directly investigates the past investment (gross book values) of the assets surviving at the period of investigation, owned by corporations, government, and households. It was implemented in Japan twelve times from 1905 to 1970, by the different ministries and Bank of Japan. In particular, two surveys in 1955 and 1970 conducted by Economic Planning Agency (EPA: the predecessor of ESRI) were the largest-scale surveys. The current JSNA has used the 1970 NWS as their benchmark.

[3] The current JSNA assumes straight-line depreciation for infrastructure and software and geometric depreciation for other assets that consists of only seven types of asset: dwellings, non-residential buildings, other structures, transportation equipment, agriculture machinery, other machinery, and cultivated assets. The assumed constant rates of depreciation are defined as the average of the tax-lives weighed of capital stock by type of assets at the 1970 NWS.

260,000 observations of disposal assets from business accounts of private corporations, of which about 26,000 transactions include sales of disposal assets with the observed sale price of the traded asset.

Japan's CED follows the *Capital and Repair Expenditures Survey* conducted by the Investment and Capital Stock Division, Statistics Canada.[4] In comparison with similar surveys conducted in Canada and the Netherlands[5], our disposal survey has unique characteristics. First, our database provides more complete information on characteristics of disposal assets as of the periods of disposal and acquisition. With each disposal data observation, it is identified whether it was sold as a second-hand good for continued use or discarded (scrapped) as of the period of disposal. The survey also includes information on whether it was a new asset, second-hand asset, or capital expenditure to renovate or improve as of the past period of acquisition of this asset. Thus, a disposal asset can actually be identified to be sold or discarded, as opposed to determining whether it has been sold or discarded based on the observed sales price. This allows us to identify the prices received by seller as either the selling prices of second-hand assets or the scrap value.[6] Second, the CED has a very detailed classification of assets, more than 600 assets at the most detailed level for better homogeneity in duration of assets. Third, the acquisition and disposal periods are investigated monthly, thus capturing the profiles of assets with relatively short services lives.[7]

In section 2, we introduce the properties of disposal assets collected in CED and provide some descriptive statistics. The methodological framework to estimate age-price profile with survival rates based on the Weibull function is in section3. Section 4 reports the estimated results of asset service lives and geometric depreciation rates and Section 5 concludes

2 Disposal Asset Database

The first disposal survey in *Survey on Capital Expenditures and Disposals* (CED) was conducted by ESRI as of the end of 2006, for fiscal year 2005 (April 2004- March 2005).[8] The CED consists of three kinds of questionnaires on capital and repair expenditures, financial leases, and

[4] See comprehensive studies based on this micro database; Gellatly, Tanguay and Yan (2002) and Statistics Canada (2007) prepared by Marc Tanguay, Guy Gellatly and John R. Baldwin.

[5] See Meinen, Verbiest and Wolf (1998), Bergen, Haan, Hij and Horsten (2005), and Erumban (2008).

[6] Statistics Canada (2007) classifies non-zero prices near zero to discards assuming a lower bound of 0.06 below, since discarded assets are not exactly identified from disposal assets.

[7] The questionnaire of *Capital and Repair Expenditures Survey* by Statistics Canada directly investigates age of a disposal asset, rather than periods of disposal/acquisition. Gellatly, Tanguay and Yan (2002) adopted the correction for digit preference in the respondents, since they found a concentration of asset durations on rounding values like 5, 10, 15, and 20 years. The result of our CED does not have such biases since the duration period of asset is not required to be directly reported.

[8] Thus we call it as the 2005 CED. In the 2005 CED, survey subjects are about 133,000 firms that have a capital of 30 million yen or more, of which the numbers of survey objects and the effective responses are 30,000 (the sampling rate is 22.6 percent) and 12,173 (the response rate is 40.6 percent), respectively. The questionnaire was developed based on the results of our pilot survey conducted by ESRI in 2003: *Survey of Actual Capital Stock and Discard* (SASD) for 5,880 firms as survey objects (the effective responses are 2,903). Nomura (2005b) provides the estimates of the Weibull distribution to approximate discard patterns by 66 types of asset based on this micro data. In the CED questionnaire, it was designed to enable to remove some potential biases found in SASD.

disposals. In a disposal survey of CED, assets are classified into four broad asset groups; buildings and accompanying equipment, machinery and equipment, transportation equipment, and other equipment. In each category of assets, fifteen observations of disposal assets are randomly selected; thus sixty observations of disposal assets are collected in the case that a firm fully responds.[9]

In the survey, disposal assets are reported with (1) the 5-digit asset code, (2) explanation of asset, (3) date of disposal (month/year), (4) classification of disposal as (b: 1.sold, 2.discarded, 3.unidentified), and (5) selling price received by seller (c: 1.available[10], 2.not available.), accompanying information on (6) date of acquisition (month/year), (7) acquisition cost (gross book value), (8) classification of acquisition as (a: 1.new, 2.second-hand, 3.renovation/large scale repairs/remodeling, 4.unidentified) as of the period of acquisition of this asset.[11] Each of the disposal assets is classified into 24 (=4*3*2) types, depending on the properties in a, b, and c. We describe a set of samples as S(a,b,c). For example, S(1,2,1) stands for a set of samples of the discarded assets (b=2), the prices of which are available (c=1), that were new assets as of the period of purchase of these assets (a=1). S(*,*,*) represents all samples of disposal assets.

Table 1: Number of Collected Sample Asset Observations

Period of Acquisition	Period of Disposal						sum
	sold		discarded		unidentified		
	price	n.a.	price	n.a.	price	n.a.	
new	21,645	9,155	23,072	159,409	579	2,524	216,384
second-hand	3,000	990	1,323	8,232	69	187	13,801
renovation	835	1,066	2,426	14,563	64	310	19,264
unidentified	818	406	976	6,838	343	1,432	10,813
sum	26,298	11,617	27,797	189,042	1,055	4,453	260,262

Note: Disposal surveys in 2005 and 2006 CED.

A summary table of the number of samples collected in the 2005 and 2006 surveys is presented in Table 1.[12] Empirical studies of survival functions based on a disposal survey are frequently use all samples of disposal assets belongs to S(*,*,*); there are 260,262 samples in our database. However,

[9] Following OECD manuals on measuring capital (Blades, 2001; Schreyer forthcoming), this paper uses "discard" 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 "disposal" which includes sales of assets as second-hand goods for continued use in production. Discard is used with "retirement" and "scrap" synonymously.

[10] The prices should be reported at current prices as of the selling period, not the residue value in account ledgers.

[11] As a final column, a free space is prepared to make any remarks, for example, for the case land where the selling price is not extracted from the selling prices of second-hand building.

[12] The samples that were missing information on the periods of acquisition and discard and the acquisition costs are removed. In addition, we omit observations in which the periods (year and month) of acquisition and discard are identical. The collected data was 295,588, but 12% of the samples are removed due to incompleteness. With a very laborious works to check consistency of reporting values, periods, figure units, and misclassification of assets, we constructed the disposal asset database used in this paper.

by including the samples of assets sold as second-hand goods for continued use in production, 37,915 (=26,298+11,617) samples belong to S(*,1,*), the estimates on asset service lives may be biased upward. Moreover, by including the 13,801 samples of second-hand goods as of the acquisition period in S(2,*,*) may also lead to upward-bias in the estimated service lives. The appropriate set of the samples to investigate discard patterns is S(1,2,*). The number of samples in S(1,2,*) is 182,481(=23,072+ 159,409), thus 16% of S(*,*,*) are not used to estimate discard profiles by aging.

On estimating the age-price profile (APP), the ratio of the value of the aged asset relative to the initial acquisition cost is required. This ratio can be estimated based on 22,480 (21,645+835) samples that belong to S(1,1,1) and S(3,1,1), or 26,298 samples in S(*,1,1) in the case if we assume a constant rate of depreciation. Finally, S(*,2,1) may provide appropriate samples to be used to estimate the scrap value ratio relative to initial acquisition cost.

Another property of our disposal survey is the detail classification of assets: we constructed the asset classification covering about 600 types of asset for CED.[13] The classification of produced assets can differ from the product classification system. On classifying produced assets, it may be valuable to regard properties as assets, rather than products; e.g. durability of assets, expected utilization, and embedment. An identical asset can have a considerably different duration depending on purpose of use or expected utilization. Also, it may be reasonable to expect that building structures and building accompanying equipment (e.g. water supply systems or elevator systems) may have considerably different durations. The latter assets are embedded, not embodied, as in the former, thus they may be replaced or improved separately. The ideal classification system would separate components of assets. Doing so would improve capital stock estimates when using a PIM using constant depreciation rates that would take into account the different rates of embedded assets.[14]

Based on the 2005 and 2006 CED, even in the structure of buildings of S(1,2,*) excluding the second-hand assets that may have shorter durations, 10.9 % and 5.9% assets in this sample still have service lives with shorter than 5 years and 3 years, respectively. The increasing number of temporally constructed buildings for exhibition (e.g. model houses) or short-term events may provide a possible explanation. In the CED, classification is set to better homogenize durations of assets.

[13] Note that a capital expenditure survey in CED uses only 10 types of assets to reduce the burden on respondents. In a disposal survey, the assets consists of 66 types for buildings, 41 for buildings accompanying equipment, 47 for construction, 172 for machineries, 56 for transportation equipment, and 257 for other machinery and equipment. This asset classification can connect to the products as machineries and equipment (about 350 types) in the most detail classification of Commodity Flow Data, in which about the flows by 2200 products are treated, in JSNA. The current classification system was constructed by Koji Nomura, Yuji Onuki, and Shinichi Shimakita at ESRI in 2006. Through further studies, the asset classification system will be revised accompanying the product classification system.

[14] In standard exercises of measuring capital stock, a composite asset including embedded assets is defined as one asset in GFCF. In revision of stock estimates in Japan, we plan to extract embedded assets based on intermediate inputs information which records the embedment.

We developed the asset-code search system so that respondents could search the 5-digit code in our asset classification using some keywords on the website. To enable us to check the classification concordance, respondents are also expected to write a concrete explanation on each asset in as much detail as possible so that its contents can be understood clearly in each disposal asset. Based on this, we fixed misclassifications.

Table 2: Number of Types of Asset by Sample Size

Period of Disposal	Period of Acquisition		Number of Samples in Each Asset	10≦	30≦	100≦	300≦
sold	new	S(1,1,1)	505	270	133	46	9
	second-hand	S(2,1,1)	280	68	18	5	0
	renovation	S(3,1,1)	178	22	2	0	0
	total	S(*,1,1)	513	296	159	58	11
discarded	new	S(1,2,*)	595	509	420	284	129
	second-hand	S(2,2,*)	458	202	77	16	4
	renovation	S(3,2,*)	468	228	119	42	8
	total	S(*,2,*)	598	530	449	306	152
disposal	total	S(*,*,*)	603	545	467	334	181

Note: Disposal surveys in 2005 and 2006 CED.

Table 2 presents the maximum number of types of assets that could be used for estimating discard or depreciation patterns based on the 2005 and 2006 CED. It is categorized by the size of samples in each asset. The number of assets in all disposal samples in S(*,*,*) is 603,[15] of which 467 assets have a sample size of at least 30. To obtain these samples more than 50 samples of each type of asset in measuring discard patterns using S(1,2,*) or depreciation patterns using S(*,1,1), 420 or 159 assets are available, respectively.

3 Methodology

Our purpose of this paper to obtain a first set of estimates on average service life and a constant geometric rate based on disposal data in CED. The pioneering empirical studies by Hulten and Wykoff (1981a, 1981b, and 1981c) advocated the geometric approach to approximate the age-price profiles (APP) using information on market prices of second-hand assets in the U.S. In the revision of wealth accounts in the U.S. National Accounts (NIPA), the geometric approach was accepted as the default by Bureau of Economic Analysis (BEA).[16]

Statistics Canada also assumes a constant geometric rate to estimate capital stock from a stream of investment flows in CSNA, supported by their comprehensive studies using the large-scale micro database that includes disposal surveys over the period 1985 to 2001. Reflecting these empirical

[15] Some assets in our classification are not owned by private corporations: e.g. institutional structure or weapons.
[16] See Fraumeni (1997) and Katz and Herman (1997). Jorgenson (1996) indicated the U.S. National Income and Product Accounts have failed to provide internally consistent measures of capital stock and depreciation.

studies, OECD Manual on Capital Measurement being revised by Paul Schreyer will recommend the use of geometric patterns for depreciation because they tend to be empirically supported, conceptually correct, and easy to implement. The geometric approach will be accepted as the default in the revision of capital stock measurement in JSNA.

Let us begin with two prices collected in a disposal survey, assuming i observations for a single type of asset are collected (i=1,2,…,N). In each type of asset, let (D_{ni}^{m} and A_i^{m-n}) be a set of the selling prices of disposal asset with age (n) as of the period of disposal (m) and the acquisition cost (gross book value) as of the period of (m-n). Both of them are evaluated at historical prices, but the former may be observed by the prices received by seller and the latter may be measured by the prices paid by the purchaser.

To let these two prices be comparable, we rebuild (D_{ni}^{m} and A_i^{m-n}) to (V_{ni}^{t} and V_{0i}^{t}), as the purchaser's prices of age-n and age-0, respectively, as of the same year (t):

(1) $V_{ni}^{t} \equiv D_{ni}^{m} (P_0^{t}/ P_0^{m}) (1+m^{t})$

and

(2) $V_{0i}^{t} \equiv A_i^{m-n} (P_0^{t}/ P_0^{m-n})$,

where P_0^{t} stands for the price index of this asset (with age-0). The prices received by seller are adjusted to be prices paid by purchaser using the average rate of wholesale margin (also with small retail margin) and transportation cost by type of asset (m^{t}).[17]

Based on the theory on vintage price models in Jorgenson (1973, 1989) and Diewert and Wykoff (2007), the age-price profiles, APP_n^{t} are defined as:

(3) $APP_n^{t} \equiv P_n^{t}/ P_0^{t}$.

Following the Hulten-Wykoff studies correcting the potential sampling biases, we assume the actual APP_{ni}^{t} as a weighted average of the price of surviving assets used in production and the price of scrap value for discarded assets.

(4) $APP_{ni}^{t} = s_n * (V_{ni(s)}^{t}/ V_{0i(s)}^{t}) + (1-s_n) * (\Sigma_{i(d),n}{}^{t} V_{ni(d)}^{t} / \Sigma_{i(d)}{}^{t} V_{0i(d)}^{t})$,

where the samples i(s) belongs to the following sets of samples as defined in the previous section:

(5) $i(s) \in S(*,1,1)$ and $i(d) \in S(*,2,1)$.

The left-side of equation (4) describes that the value of surviving asset relative to its initial acquisition cost is assumed to be identical with that of sold asset for continued use in production, in which the selling prices are available in S(*,1,1). The right-side of equation (4) is the scrap values of discarded assets. A number of studies assumed this price is zero, due to lack of the information on net scrap value (gross scrap value less demolition costs) although including this component was recommended in Hulten and Wykoff (1981b). Our database enable us to estimate the average ratio of

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[17] We used the by-type-of-asset margin and transportation rates to the producer's price based on the 2000 Benchmark Input-Output Table in Japan. An average rate for machinery and equipment is 26.3% for trade and 1.9% for transportation. The adjustments on the disposal-acquisition prices to be comparable at the purchaser's prices may have significant impacts on the estimates of depreciation rates, although such adjustments may be conducted in similar studies.

scrap value of discarded asset relative to its initial acquisition cost, based on the discarded assets with selling prices in S(*,2,1).[18]

In equation (4), s_n stands for the estimated probability of surviving to age n using samples i(d1):

(5) $\quad i(d1) \in S(1,2,*)$.

When we take a view of physical durations, the use of S(1,2,*) that excludes the sold assets may be appropriate to estimate the discard profile. There may be another view. It is sometimes unknown for respondents whether the disposal assets were sold or discarded because it may be meaningless for them to recognize it.[19] Statistics Canada (2007) estimates survival probabilities using information on discard (that is transactions characterized by zero prices in their database) and sales of used assets. In our terminology, the sample set they use is S(*,*,*): i.e. disposal assets. We use discard samples to estimate the survival probability and the transaction of second-hand assets is separately described in our stock measurement.

A number of empirical studies on survival function of produced assets have assumed the Weibull family of distributions to approximate discards patterns.[20] The Weibull survival function is formulated as:

(6) $\quad s_n \equiv EXP[-(n/\lambda)^{\alpha}]$,

where λ and α are the scale and shape parameters (both are greater than 0).[21] We approximate the actual survival probability using the durations of discarded assets in S(1,2,*), weighted by the acquisition costs as a proxy for quantities. The estimates of survival functions using a disposal survey can be biased depending on past investment patterns which may differ among assets. To ease this, we apply the inverse of the quantity index of investment to the acquisition costs.[22]

Taking logarithm of the Weibull cumulative hazard function (H_n), we can obtain a log-linear relationship with age as follows:

(7) $\quad \ln H_n = \beta + \alpha \ln n, \quad$ where $\beta = -\alpha \ln \lambda$.

In this paper we assume the APP in equation (4) as the time-invariant geometric function: $(1-\delta)^n$. A constant rate of depreciation δ is estimated based on the weighted least squares method using the acquisition costs at constant prices in equation (2).

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[18] We found the estimated ratios by type of asset seemed too high. It may imply some sold assets are incorrectly reported as discarded assets. In this paper, the net scrap ratios by types of asset are assumed using samples with age n>T*2, where T is the average service life estimated in the Weibull distribution, with the upper limits of 5% of initial acquisition costs. The 1st moment of the Weibull probability density function gives the average service life $T = \lambda\Gamma(1+\alpha\text{-}1)$, where $\Gamma()$ is the gamma function.

[19] Steel ships give an example. It can be sold as second-hand goods and exported to foreign countries, and would be scrapped in the imported country.

[20] See Meinen, et al (1998), Nomura (2005b), Erumban (2008), and Statistics Canada (2008).

[21] The Weibull distribution is more flexible than the exponential distribution, since it is the exponential distribution of the power transformed age: n^{α}. In the special case of $\alpha=1$, the Weibull distribution is identical with the exponential distribution, which has the constant rate of retirement.

[22] The quantity index of investment by vintage and asset is computed by the long-term investment series at current prices and its deflators by asset. Since it reflects quality changes in investment, we applied 0.3th power of the quantity index.

4 Estimates Results

4.1 Average Service Lives

Using the discard samples belonging to S(1,2,*) that exclude second-hand assets as of the period of acquisition, our database allows us to estimate the average service lives based on about 280-400 assets in which more than 30-100 samples are available at least, as shown in Table 2. This paper picks up 195 assets so that we can estimate depreciation rates based on the same asset classifications.

Table 3 presents a summary of the average service lives based on the Weibull distribution parameters estimated by 195 types of asset.[23] It also provides a crude comparison with the estimates in Statistics Canada (2007). The estimated length of average service life for building and construction is 28.5 years. This is very similar to their ex post length of life (27.2 years) in Canada. For machinery and equipment, 16.3 years on average is somewhat higher than that in Canada (14.1 years).

Table 3: Summary of Estimated Asset Service Lives

	195 assets code	Manufacturing	Non-Manufacturing	Total	(ref) Canada
A. Building and construction	(1-12, 34-45)	29.8	27.8	28.5	27.2
A-1. Dwellings owned by firms	(1-2)	32.9	32.9	32.9	
A-2. Plants for manufacturing	(3)	31.0		31.0	29.2
A-3. Warehouses	(4)	27.4	27.4	27.4	32.1
A-4. Office buildings	(5)	31.7	31.7	31.7	34.2
A-5. Hotels, stores and restaurants	(6-8)	25.2	24.1	24.2	16.1
A-6. Other buildings	(9-12)	29.4	24.5	25.6	24.3
A-7. Electric power plants	(34)		23.5	23.5	
A-8. Water suppy and sewage facilities	(35-37)		23.2	23.9	25.4
A-9. Communication and broadcasting faci	(38)		13.3	13.3	20.8
A-10. Other construction	(39-45)	21.3	20.4	20.8	31.8
B. Machinery and Equipment	(13-33, 46-195)	16.4	16.3	16.3	14.1
B-1. Buildings accompanying facilities	(13-33)	16.4	15.6	15.9	
B-2. Machinery	(46-107)	17.4	17.4	17.4	14.1
B-3. Transport equipment	(108-141)	14.3	17.3	17.0	17.6
B-4. Other machinery and equipment	(142-195)	12.1	11.2	11.6	13.5
(regrouped) Computers and copy machines	(149, 158-161)	7.6	7.7	7.6	
(regrouped) Communications equipment	(162-167)	9.3	9.4	9.4	

Notes: The average service lives are based on the estimates by 195 assets using the samples in S(1,2,*) and weighted using the total acquisition costs of discarded assets. The estimate in Canada is a simple average value of the ex post estimates across assets for a crude comparison. See Statistics Canada (2007) for the details.

Table 4 provides a comparison of the asset service lives estimates for machineries and construction for four countries: Canada, the U.S., the Netherlands, and Japan.[24] Note that the classification is different with that in Table 3. Our estimates for machinery and equipment and

[23] For measuring the aggregated measures, we tentatively use the acquisition costs collected in CED as the weights. The cross-industry differences reflect the weights by 195 types of asset.

[24] We added our new estimates in Table 9 in Erumban (2008). For comparison, we reclassified the assets (112-140) to transport (motor vehicles), (13-33, 46-107, 142-157, and 162-182) to machinery and equipment, and (158-161) to computers.

computers are very similar to the estimates by BEA in the U.S. In Canada and the Netherlands, the service life for computers is somewhat longer that in the U.S. and Japan. [25] Machinery and equipment in the Netherlands has a considerably longer service life as 26-35 years. In our estimates, the service lives that are longer than 30 years (in the case of new assets and renovation) are only two metal processing machineries out of 120 machineries and equipment: i.e. 84.Boring machines and 87.Gear cutting and gear finishing machines. The assets that have over-20-year service lives are limited to 25 assets in 120.

Table 4: Comparison of the Estimated Service Lives

	Transport (Motor Vehicle)	Machinery and Equipment	Computers
Canada (Baldwin et al)**			
ex post	11	14	10
ex ante	7	12	9
U.S. (BLS)*	10	21	6
U.S. (BEA)**	9	18	7
Netherlands (Meinen)***	10	35	12
Netherlands (Bergen et al)*	5	29	9
Netherlands (Erumban)*	6	26	9
Japan (Nomura)**	13.9	17.8	7.1
Japan (this paper)**			
1) new assets: S(1,2,*)	12.5	16.5	7.8
2) second-hand: S(2,2,*)	10.4	10.5	4.4
3) renovation: S(3,2,*)	12.8	14.6	8.7
4) 1)+3): S(1 or 3,2,*)	12.4	16.4	7.8
5) all: S(*,2,*)	12.3	16.3	7.7
Japan (this paper)W			
1) new assets: S(1,2,*)	12.9	16.7	7.6
2) second-hand: S(2,2,*)	9.6	9.6	4.5
3) renovation: S(3,2,*)	8.3	13.5	7.5
4) 1)+3): S(1 or 3,2,*)	12.9	16.5	7.6
5) all: S(*,2,*)	12.8	16.5	7.5

Notes: This table was constructed based on Table 9 in Erumban (2008). *Simple average across industries. **Simple average across asset types. ***Estimate for total manufacturing. WWeighted average using the total acquisition costs of discarded assets.

On transport equipment (motor vehicles), the Netherlands estimates by Bergen et al (2005) and Erumban (2008)[26] indicate the estimates show a lifetime of 5-6 years that are less than half of the Japan's estimates (13.9 years, as an average of 3 types of vehicles whose service lives range from10.2 to 20.3) in Nomura (2005b). Our estimates in this paper are based on a new database with much larger samples, but they still provide the similar estimates: 12.9 years (as an average of 29

[25] Note that 10 years for computer in Canadian estimates in Erumban (2008) may be a simple average of Computers, associated hardware and word processors (4.4 years) and Computer-assisted process for production process (15.5 years).

[26] These estimates based on the surveys conducted by Statistics Netherlands (CBS), the capital stock survey and the discard survey.

types of vehicles whose service lives range from 7.2 to 17.8). The service lives of motor vehicles are somewhat longer than the estimates in comparison with Canada and the U.S.

Let us focus on the impacts by sample selection of discard data. Although the samples belong to S(1,2,*) may be preferred to estimate discard patterns, a number of exercises have been obliged to use the samples S(*,2,*) that includes second-hand assets as of the period of acquisition. Our dataset allows us to separately estimate the Weibull distributions for second-hand goods in S(2,2,*) or renovation/large improvement as recorded capital expenditures in S(3,2,*).

Table 4 also presents the estimates using different discard samples for second-hand goods and capital expenditures to renovate. We found the service lives of second-hand assets are 9.6 years (by 26% lower than 12.9 years of the new assets) for transport equipment, 9.6 years (43% lower than 16.7 years) for other machinery and equipment, and 4.5 years (41% lower than 7.6 years) for computers. Similarly, the service lengths for capital expenditure to renovate or develop capacity are 8.3 years (36% lower), 13.5 years (19% lower), and 7.5 years (1% lower), for each category of assets, respectively. These significantly different service lives are to be considered in measuring capital stock by PIM and the transaction matrices of second-hand assets. The investment composition by industry estimated by the capital expenditure and lease survey in the 2005 CED is presented in Table 7. At the aggregate level, the acquisition cost shares of second-hand goods and renovation are still modest at 2.0% and 4.6%, respectively, and financial lease has a 9.7% share. At industry level, however, they have significant shares in the total investment.

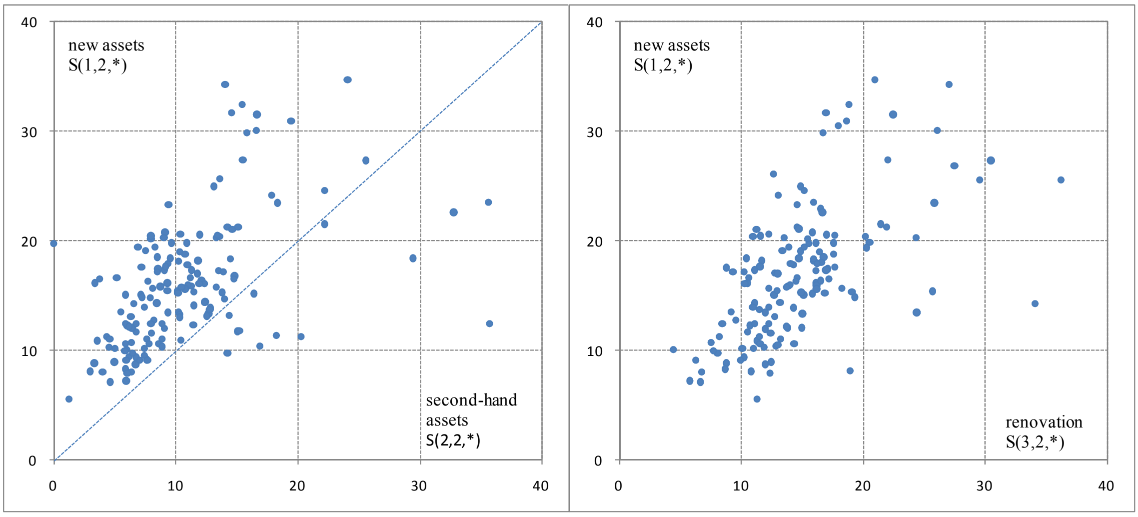

Figure 1: Comparison of Average Lives among New and Second-hand Assets

Figure 1 compares the differences in the average service lives estimated using different sets of samples for each single type of asset. The left figure presents the comparison between the estimates using new assets in S(1,2,*) and the estimates using second-hand assets in S(2,2,*). We found that second-hand assets (x-axis) clearly shorter service lives in comparison with new assets (y-axis). In buildings (1-12), the second-hand assets have 48.0% of the service lives of new assets on average. Although the ages of second-hand assets as of the period of acquisition are unknown (and respondents may not know it), it may be reasonable to assume they age by about a half of the average service lives. Similarly, the renovation/improvement capital expenditures have shorter lives. In building, it has 72.9% of the service lives of new assets. Recognizing them may contribute to make the PIM stock estimates more realistic.

From the view of the measuring the Weibull distribution, however, the estimated results using the mixed samples as S(*,2,*) generates very minor differences, in comparison with the estimates using S(1,2,*), as shown in

Table 4. In the case of Japan, the impacts of using the discard samples including the second-hand assets are not significant reflecting the small share of second-hand assets.

The estimated Weibull parameters and the average service lives by 195 types of asset are presented in Table 8. The estimated service lives range from 5.5 year to 44.1 year. The asset with the shortest duration surprisingly belongs to a category of Buildings (1-12 by asset codes in this paper): 9. Model houses/rooms, in which business policy may play a main role on choice of discard, rather physical durability. Similarly, in a category of building accompanying equipment (13-33), 31.Display facilities for shops (8.8 year) and 32.Movable partitions (9.3 year) have shorter lives.

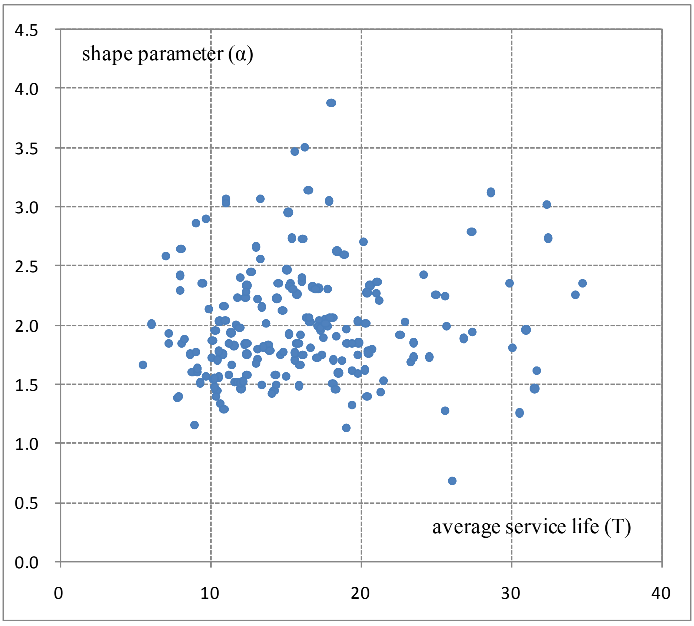

Figure 2: The Weibull Shape Parameter and ASL: S(1,2,*)

The shape parameter (α) determines the hazard rate of assets. In the special case of the shape parameter is one, the Weibull distribution is identical with the exponential distribution that has a constant hazard rate (and a constant rate of discard). The Weibull distribution estimated in the Netherlands by Meinen, Verbiest, and Wolf (1998) found the hazard rates in many assets tended to be regressively increasing ($1<\alpha<2$), except in computers that have a progressively increasing hazard rate ($\alpha>2$). Figure 2 shows the plot of the estimated shape parameters and average service lives by 195 types of asset. Unlike the estimates in the Netherlands, Japan's results indicate that 41.0% of the assets (80 assets) have progressively increasing hazard rates.[27] On the other hand, similarly to the Netherland's estimates, it would be clearly found in Japan that IT hardware like 149.Copying machines (2.29), 158.Personal computers (2.58), 159.General purpose computers (2.64), 160.Printing device (2.42), and 163.Facsimile machines (2.89) has a progressively increasing hazard rates.

4.2 Geometric Depreciation Rates

Statistics Canada (2007) shows that the estimate on depreciation rates based on their large-scale micro database is quite similar to the U.S. estimates for the machinery and equipment asset classes on average: the U.S. average is 18% and the Canadian rate averaged 20%. In contrast, a considerable difference was found for buildings and construction: the U.S. average is 3% and the Canadian average is 8%. They indicate these differences occurred mainly because of the very low declining-balances rates (DBR) that are used in the U.S. estimates.[28] Their results show that the DBRs for these long-lived assets are much higher than those derived from the historical U.S. studies.

Table 5: Summary of Estimated Rates of Depreciation

	195 assets code	Manufacturing	Non-Manufacturing	Total	(ref)Canada	(ref) U.S.
A. Building and construction	(1-12, 34-45)	0.108	0.109	0.109	0.083	0.032
A-1. Dwellings owned by firms	(1-2)	0.101	0.100	0.101		
A-2. Plants for manufacturing	(3)	0.107		0.107	0.090	0.030
A-3. Warehouses	(4)	0.090	0.090	0.090	0.075	0.030
A-4. Office buildings	(5)	0.103	0.103	0.103	0.070	0.030
A-5. Hotels, stores and restaurants	(6-8)	0.129	0.111	0.111	0.100	0.030
A-6. Other buildings	(9-12)	0.106	0.126	0.122	0.070	0.030
A-7. Electric power plants	(34)		0.122	0.122	0.090	0.020
A-8. Water suppy and sewage facilities	(35-37)		0.131	0.133		
A-9. Communication and broadcasting faci	(38)		0.104	0.104	0.120	0.020
A-10. Other construction	(39-45)	0.145	0.147	0.146	0.130	0.020
B. Machinery and Equipment	(13-33, 46-195)	0.189	0.199	0.195	0.200	0.180
B-1. Buildings accompanying facilities	(13-33)	0.141	0.136	0.138		
B-2. Machinery	(46-107)	0.183	0.182	0.182	0.148	0.155
B-3. Transport equipment	(108-141)	0.254	0.218	0.222	0.193	0.170
B-4. Other machinery and equipment	(142-195)	0.224	0.260	0.243	0.194	0.168
(regrouped) Computers and copy machines	(149, 158-161)	0.364	0.363	0.363	0.450	0.500
(regrouped) Communications equipment	(162-167)	0.322	0.310	0.313	0.230	0.140

Notes: The constaht geometric rate is based on the estimates by 195 assets using the samples in S(*,1,1) and weighted using the total acquisition costs of discarded assets. For a crude comparison, the estimates in Canada and the U.S. are defined as simple average values of the ex post estimates across assets by Statistics Canada and BEA, respectively, reported in Statistics Canada (2007).

A summary of our estimates for geometric depreciation rate is presented in Table 5,

27 This result is similar to Nomura (2005b) used much smaller samples collected in our pilot survey of CED.

28 BEA assumes 1.65 for machinery and equipment and 0.91 for structures, based on Hulten-Wykoff studies.

accompanied by a comparison with the Canadian and the U.S. estimates reported in Statistics Canada (2007). Our average is 10.9% for buildings and construction and 19.9% for machinery and equipment. For machinery and equipment, our estimates in Japan are quite similar to the estimates in Canada. Also, the difference with the U.S. estimate is not large. However, the estimated rate of depreciation for buildings and construction is higher by 2.6% point than the Canadian average and more than three times higher than the U.S. average. Also, these estimates are much higher that the rates used in the current stock estimates in JSNA: 6.0% for non-residential buildings and 6.6 % for other structures.[29]

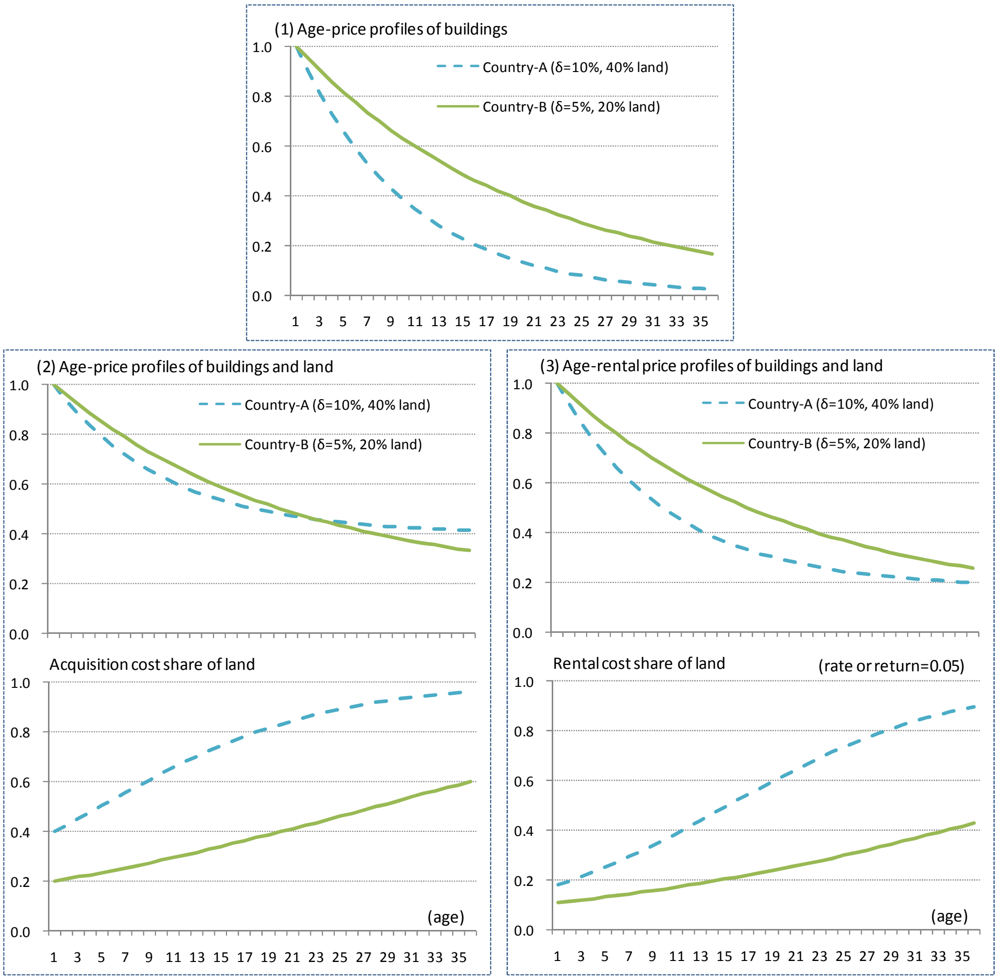

Figure 3: Age-Price Profiles for Buildings and Land

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[29] Note that the samples of dwellings are limited to that owned by firms for company housing or recreation. In the current JSNA, we assume 7.9% for all dwellings, regardless of its owner. We believe 7.9% is too high for dwellings owned by household. Although assets owned by household are not covered by our CED, there are some reliable approaches to estimate duration and depreciation. Based on registration data covering all wooden houses in some selected cities in Japan, Komatsu (2000) indicated that the dwellings owned by household have service lives of 37.7 years in the early 1980s and 41.2-43.5 years in late 1990s. These service lives are about ten years larger than our estimates in Table 3. Nomura (2004, chapter 4) measures the estimates of geometric rate of depreciation based on rental market prices. The estimated rates are 5.6-6.1% for wooden dwellings and 3.1-3.8% for non-wooden one.

In the case of building and construction, the reality may depend on second-hand or rental prices of a composite asset consisting of buildings and land. We implement a simple calculation assuming two countries: country-A with higher depreciation rate (10%) and larger value share of land (40%) and country-B with lower depreciation (5%) and smaller value share of land (20%). Figure 3 shows (1) age-price profile of buildings, (2) age-price profile of a composite asset of buildings and land, and (3) age-rental price profile of the composite asset. Reflecting the differences in depreciation rates between two countries, the prices of aged asset would be considerably different as shown in Figure 3 (1). The 15-year-old office (excluding land) depreciates to 21% of the initial costs in country-A and 46% in country–B.

Other things being equal, however, the 15-year-old price of a composite asset are quite similar as 52% and 57%, respectively, regardless of the considerably different cost share of the composite asset, as shown in two figures in Figure 3 (2). In country-B, 65% of their asset price is supported by value of building, but in country-A 76% of the remaining value is supported by land that is independent of aging. In a measure of rental prices, there are still some differences (35% and 52%), but the difference is smaller than that of a measure in (1). Although our current estimates need further investigations by examining the market prices of buildings, the higher depreciation rates may not be unrealistic in country with relatively higher price of land on average like Japan.

Figure 4 shows the 195 types of assets sorted by the depreciation rates. The assets with the higher rates of depreciation are used in production confronting the frequently changing demands or technologies or used with very high utilizations: 151.Servicing machinery (48.1%), 103.Flat panel and display manufacturing equipment (semiconductor manufacturing equipment) (47.9%), 121.Taxies (40.6%), 165.Digital transmission equipment (39.4%), 158.Personal computers (including PC servers) (38.5%), 159.General purpose computers (37.8%), 192.Information recording materials (37.7%), 161.Other computer peripheral equipment (37.4%). On the other hand, the smaller rates are found in building and structure or very durable machines and tools: 31.Display facilities for shops (8.3%), 4.Warehouses (9.0%), 12.Other buildings (9.4%), 8.Stores (9.6%), 2.Complex housing (9.7%), 11.Recreation/training facilities (9.9%), 83.Drilling machines (10.2%), and 5.Office buildings (10.3%).

Table 6 focuses on the depreciation rates for motor vehicles by type of use. Our asset classification allows us to compare the differences of depreciation rates by type of use: firm-own use, passengers, and freight. We do not find clear differences between vehicles for firm-own use and freight; however the vehicles for passengers have larger rates of depreciation than that for other uses. These estimates are possible to compare with other empirical studies using information the second-hand market of motor vehicle in Japan. The geometric rates of depreciation estimated using a hedonic approach in Nomura (2004) range 16.3-25.5%, using about 3,000 observations in the second-hand market of motor vehicles. Our estimate with larger samples (about 9,400) for motor vehicle in this paper ranges from 21.8-42.4%, considerable higher than his estimates. It may be reasonable the depreciation rates can differ based on household use or firm use.

Table 6: Depreciation Rates for Motor Vehicles by Type of Use

	for own use	for passengers	for freight
Light-duty vehicles (less 660ml)	0.362		0.332
Compact vehicles (660ml-2000ml)	0.363		0.347
Ordinary passenger cars (over 2000ml)	0.316		0.317
Taxies		0.424	
Small-size buses	0.218	0.242	
Motor coaches	0.241	0.255	
Trucks (light-duty cars)	0.290		0.316
Trucks (small cars)	0.309		0.297
Trucks (ordinary vehicles)	0.296		0.284
Other vehicles for own use	0.248		

Notes: Trucks (small cars and ordinary vehicles) for freight is a simple average of gas-powered cars and diesel cars.

6. Concluding Remarks

This paper provided a first look at our database of disposal assets collected in the *Survey on Capital Expenditures and Disposals* (CED) conducted by ESRI, Cabinet Office of Japan. The first estimates for service life and a geometric depreciation rate by 195 types of asset are presented. To construct the database of disposal assets, rigorous checking of reporting figure units, disposal and acquisition values, and their periods or misclassification of assets was employed to sustain internal consistency of the database. Further work in the future may enable us to revise our estimates in this paper. Note that the third CED will be implemented as of the end of 2009.

Our goal at ESRI is reframing capital measurement in JSNA. To obtain the final estimates on asset service lives and depreciation rates, further studies including other approaches based on second-hand and rental market prices or administrative records are required to complement the estimates using disposal survey in CED presented here. International comparisons of service lives and depreciation illuminate the points of focus lead to improvement in our estimates and better comparability in resulting measures of capital stocks, capital services, and productivity.

Table 7: Share of Acquisition of Old Assets, Repair, and Leased Assets

	Building and Structure			Machnery and Equipment			Transportation Equipment			Total		
	second-hand	renovation	financial lease	second-hand	renovation	financial lease	second-hand	renovation	financial lease	second-hand	renovation	financial lease
Agriculture, forestry and fisheries	5.5	13.7	0.2	1.6	0.1	17.7	16.8	2.1	26.1	3.3	5.0	11.7
Mining	5.3	21.5	0.2	0.4	3.1	8.9	6.7	0.0	4.8	2.8	11.9	4.7
Construction	8.5	7.3	3.1	4.8	2.4	32.4	7.4	1.7	57.0	7.4	5.5	15.7
Manufacturing	1.8	4.2	0.2	1.0	6.2	9.0	2.6	1.7	31.5	1.3	5.4	5.8
Food	5.6	6.2	2.3	0.9	4.9	12.8	1.7	2.9	44.6	2.9	5.4	8.9
Textile	4.2	8.1	0.4	2.1	6.5	7.7	0.6	0.1	83.1	2.9	6.8	8.6
Pulp/paper	0.7	1.9	0.0	0.8	10.5	9.3	3.5	0.1	32.8	0.8	6.6	5.7
Publishing/Printing	2.0	3.1	0.2	3.2	0.5	12.1	0.6	0.1	44.5	2.9	1.1	9.7
Chemical	1.2	3.5	0.1	1.4	15.7	6.2	2.0	1.9	52.0	1.3	8.8	3.0
Petroleum and coal products	2.5	11.9	0.0	0.7	49.0	1.3	0.3	3.7	28.5	1.9	24.1	0.6
stone and clay products	3.5	3.0	0.1	1.5	6.9	10.2	7.6	1.1	39.1	2.2	5.5	7.2
Iron and steel	8.3	1.7	0.1	0.3	2.1	3.2	1.7	0.5	15.2	2.6	2.0	2.4
Nonferrous metal	2.5	2.1	0.0	0.6	8.1	4.7	0.4	1.8	38.5	1.7	4.5	2.1
Metal products	0.7	9.9	0.2	2.4	3.2	12.0	0.6	1.6	44.2	1.9	4.8	10.1
General machinery	1.8	11.9	0.2	1.1	6.4	17.3	11.0	0.4	34.5	1.5	8.0	12.2
Electric machinery	0.2	4.4	0.1	0.2	6.6	11.0	0.9	0.0	34.5	0.2	5.8	7.4
Communication equipment	1.6	2.3	0.0	2.2	6.4	5.0	4.5	0.0	29.3	1.9	4.4	2.6
Electronic components	1.3	3.5	0.1	0.4	3.1	8.3	5.0	0.3	33.6	0.7	3.2	5.7
Transport machinery	0.3	3.2	0.1	0.6	4.7	8.5	0.5	3.2	9.9	0.5	4.1	5.4
Precision machinery	1.1	10.5	1.0	0.5	1.1	22.4	0.2	0.0	63.8	0.7	4.6	15.0
Other manufacturing	2.6	5.8	0.4	1.0	3.7	8.9	2.9	0.5	41.1	1.5	4.3	6.9
Electricity industry	0.0	2.3	0.0	0.3	5.5	2.0	0.0	0.0	84.1	0.0	3.9	0.7
Gas/heat/water	5.5	1.4	0.0	0.0	6.5	1.5	0.3	0.0	72.4	2.6	0.7	4.0
Information communications	0.6	1.3	0.3	1.6	0.4	4.2	2.3	1.0	52.1	0.5	2.2	21.0
Transportation	2.4	5.2	0.0	0.4	2.7	34.2	6.4	6.0	23.2	3.2	6.2	8.7
Wholesale	3.4	5.4	3.1	0.7	12.6	26.1	6.1	0.1	35.4	2.7	5.6	17.0
Retail	1.7	5.8	9.1	1.2	5.5	29.8	1.3	0.7	4.8	1.4	4.7	14.8
Finance and insurance	13.2	12.5	0.1	1.6	6.6	25.2	1.2	0.1	23.3	4.8	5.0	10.3
Real estate	12.3	11.9	0.8	0.5	3.8	37.6	2.0	0.8	18.5	11.4	11.3	4.2
Restaurant and lodging	8.3	12.2	0.4	0.1	0.9	15.5	37.8	2.4	17.5	10.8	11.5	6.2
Medical care and welfare	0.9	2.5	0.7	4.1	7.7	33.2	1.0	0.0	76.6	0.9	1.6	13.3
Education and learning support	0.3	37.5	0.4	18.5	9.2	27.2	2.5	1.2	50.5	0.3	31.6	11.3
Business services	11.7	1.7	3.5	0.8	0.2	31.7	2.1	0.0	8.6	2.1	0.3	14.4
Entertainment	2.8	2.6	1.4	0.1	13.2	48.3	1.8	0.0	46.7	1.5	1.4	12.0
Other services	2.9	5.5	0.8	0.9	0.2	17.0	4.5	6.9	9.3	6.6	4.4	5.2
Total	3.0	4.9	1.5	0.4	0.1	16.9	4.2	2.6	20.4	2.0	4.6	9.7

Unit: shares (%) in total investment that is defined as a sum of acuisition of new and second-hand assets, renovation, and financial lease assets.

Source: Survey on Capital Expenditures and Disposals for 2005, (ESRI, Japan)

Table 8: Estimated Weibull Distribution and Average Service Lives

	α	(t-value)	β	(t-value)	λ	T	adj R^2	N
1.Housing	2.25	60.7	-8.2	-67.0	38.7	34.2	.927	291
2.Complex housing	2.73	80.5	-9.8	-86.6	36.4	32.4	.950	340
3.Plants for manufacturing	1.96	337.5	-7.0	-401.4	34.9	31.0	.981	2167
4.Warehouses	1.94	347.7	-6.7	-406.1	30.9	27.4	.986	1680
5.Office buildings	1.61	217.5	-5.7	-279.7	35.4	31.7	.964	1757
6.Hotels	2.35	36.6	-8.3	-47.1	33.7	29.9	.949	73
7.Eating and drinking places, restaurants	1.62	67.4	-5.0	-93.4	22.6	20.2	.963	174
8.Stores	1.69	267.4	-5.5	-362.6	26.1	23.3	.986	1039
9.Model houses/rooms	1.66	29.9	-3.0	-34.7	6.2	5.5	.892	109
10.Sports facilities	0.68	10.3	-2.0	-11.6	20.0	26.1	.672	52
11.Recreation/training facilities	1.87	12.4	-7.2	-15.3	46.5	41.3	.721	60
12.Other buildings	1.80	243.3	-5.7	-276.3	23.3	20.7	.984	957
13.Accumulator/power supply systems	1.74	231.9	-5.2	-269.2	19.6	17.4	.990	550
14.Power wiring systems	1.59	220.7	-4.8	-260.2	20.6	18.5	.977	1143
15.Power outlet wiring systems	1.49	624.2	-4.0	-755.3	14.9	13.4	.995	2072
16.Telephone switchboards systems	1.56	208.3	-3.7	-241.3	10.8	9.7	.987	583
17.Other electric systems	1.48	410.2	-4.3	-495.4	17.5	15.9	.989	1822
18.Water supply systems	1.74	499.0	-5.4	-573.0	22.2	19.8	.995	1359
19.Hot water/water cooler systems	1.84	70.6	-5.7	-82.0	21.4	19.1	.920	433
20.Water drainage systems	1.70	253.3	-5.2	-283.1	21.0	18.7	.991	614
21.Sanitary systems	1.70	305.3	-5.1	-346.1	20.4	18.2	.993	638
22.Gas systems	1.58	210.0	-4.9	-235.9	22.0	19.8	.990	434
23.Freezer systems	1.85	36.7	-5.7	-41.7	22.3	19.8	.878	187
24.Coolers/heater systems	2.06	446.0	-6.2	-504.7	20.5	18.1	.979	4307
25.Ventilation systems	1.74	401.8	-5.0	-458.5	18.1	16.1	.994	1019
26.Fire fighting systems	1.39	211.0	-4.3	-249.3	22.3	20.4	.988	553
27.Smoke control systems	1.66	68.8	-4.8	-82.4	17.8	15.9	.955	226
28.Disaster alarm systems	1.75	225.7	-5.5	-258.6	23.1	20.5	.988	627
29.Refuge facilities	1.50	30.0	-4.5	-34.3	20.1	18.1	.948	50
30.Air curtains and automatic door facilities	1.79	315.6	-4.9	-351.1	15.6	13.9	.994	596
31.Display facilities for shops	1.60	337.7	-3.6	-384.1	9.8	8.8	.991	1006
32.Movable partitions	1.51	431.8	-3.5	-476.4	10.4	9.3	.982	3406
33.Other accompanying facilities	1.52	703.7	-3.9	-802.9	12.9	11.6	.991	4451
34.Electric power plants	1.73	135.6	-5.6	-151.9	26.3	23.5	.982	342
35.Water supply facilities	2.24	50.7	-7.5	-57.3	28.8	25.6	.964	96
36.Industrial water facilities	1.89	129.5	-6.4	-148.9	30.2	26.8	.985	251
37.Sewage facilities	1.43	99.2	-4.5	-110.7	23.4	21.3	.970	309
38.Communication and broadcasting facilities	2.56	203.0	-6.9	-235.6	15.0	13.3	.983	709
39.Oil/gas tank facilities and pipelines	1.81	69.9	-6.4	-80.9	33.8	30.1	.905	515
40.Waste disposal facilities	1.89	121.9	-5.6	-136.4	19.7	17.5	.981	288
41.Advertisement facilities	1.57	497.1	-4.4	-574.5	15.9	14.3	.994	1542
42.Greenery facilities	1.91	164.5	-5.8	-181.1	20.7	18.4	.987	345
43.Paved roadways	1.52	305.8	-4.8	-349.4	23.9	21.5	.987	1198
44.Automobile parking	1.56	298.3	-4.4	-339.1	16.7	15.0	.992	737
45.Other facilities	1.78	748.9	-5.6	-835.6	23.0	20.5	.995	3025
46.Boilers/turbines	2.01	230.0	-6.3	-260.0	22.9	20.3	.983	894
47.Engines and turbines	2.03	42.4	-6.3	-46.0	22.3	19.8	.908	183
48.Elevators and escalators	1.46	72.3	-5.2	-89.3	34.8	31.5	.938	346
49.Overhead travelling cranes	2.25	171.8	-7.5	-191.5	28.2	25.0	.988	352
50.Other cranes	1.85	48.4	-6.1	-53.5	26.4	23.5	.914	221
51.Other conveyers and conveying equipment	2.02	392.0	-5.9	-433.3	18.7	16.6	.987	1996
52.Refrigerators/air conditioners	2.04	430.0	-6.1	-497.5	19.9	17.6	.993	1332
53.Pumps/compressors	1.97	611.8	-6.0	-672.5	21.4	19.0	.994	2213
54.Transmissions	1.45	60.3	-4.4	-65.0	20.2	18.3	.934	259
55.Mechanical parking equipment	1.12	23.0	-3.4	-28.4	19.9	19.0	.898	61
56.Inner packaging/outer packaging machines	2.47	169.6	-7.0	-183.0	17.0	15.1	.980	577
57.Other general industrial machinery and equipment	1.91	988.4	-5.5	-1088.4	18.0	16.0	.992	8354
58.Agricultural machinery and equipment	1.95	126.6	-5.8	-141.8	19.5	17.3	.979	348
59.Excavators	1.71	58.7	-4.6	-63.4	14.7	13.1	.980	73
60.Construction cranes/tractors	2.35	21.5	-6.6	-21.7	16.4	14.5	.895	55
61.Ground leveling machinery	1.66	13.1	-4.2	-13.9	12.8	11.4	.864	28
62.Asphalt paving machinery	3.88	12.5	-11.6	-13.4	19.9	18.0	.886	21
63.Concrete machinery	3.05	54.1	-9.1	-58.4	20.0	17.9	.969	93
64.Shovel trucks	2.22	12.7	-6.0	-13.8	14.8	13.1	.910	17
65.Other machinery for construction and mining	2.06	180.5	-6.0	-196.3	18.4	16.3	.981	623

Table 8: Estimated Weibull Distribution and Average Service Lives (continued)

	α	(t-value)	β	(t-value)	λ	T	adj R^2	N
66.Grain processing machinery	3.12	74.2	-10.8	-83.9	32.0	28.6	.975	145
67.Bread-making and confectionery machinery	1.84	125.7	-5.7	-146.2	21.8	19.4	.972	453
68.Meat and seafood products machinery	2.95	161.4	-8.4	-177.3	17.0	15.2	.983	454
69.Other food processing machinery	1.61	187.2	-5.0	-220.4	21.7	19.4	.946	2018
70.Industrial sewing machinery	2.32	51.2	-6.8	-53.5	18.9	16.8	.962	104
71.Other weaving machinery	1.73	78.8	-5.7	-88.8	27.5	24.5	.922	526
72.Lumber sawing machinery	1.25	14.6	-4.4	-18.4	32.8	30.5	.782	60
73.Wood sawing machinery	2.63	47.3	-8.0	-52.0	20.7	18.4	.938	149
74.Plywood/fiber board working machinery	3.46	33.2	-9.9	-35.8	17.4	15.6	.895	130
75.Pulp manufacturing/paper machinery	2.02	116.1	-6.6	-134.9	25.9	22.9	.977	324
76.Printing machinery	2.73	136.2	-7.9	-154.5	18.1	16.1	.974	497
77.Bookbinding machinery	1.99	961.9	-6.0	-1048.2	20.1	17.8	.996	3706
78.Injection molding machinery	2.03	173.8	-6.0	-196.3	19.4	17.2	.985	459
79.Engraving machinery	2.35	177.6	-6.7	-200.4	17.3	15.3	.985	486
80.Other plastic working machinery	2.33	349.6	-6.6	-387.6	17.2	15.3	.991	1151
81.Numerically controlled lathes	2.27	56.4	-7.2	-62.8	23.7	21.0	.938	213
82.Other lathes	2.42	113.7	-8.0	-120.8	27.2	24.2	.981	256
83.Drilling machines	1.99	97.6	-6.7	-103.1	29.0	25.7	.978	213
84.Boring machines	3.02	19.3	-10.8	-21.2	36.2	32.4	.896	44
85.Milling machines	2.79	53.5	-9.5	-58.2	30.7	27.3	.944	171
86.Grinding machines	2.21	118.2	-7.0	-125.6	24.0	21.2	.978	322
87.Gear cutting and gear finishing machines	2.04	18.0	-8.0	-21.2	49.8	44.1	.868	50
88.Special purpose machines	1.99	95.5	-5.9	-108.4	19.3	17.1	.975	231
89.Machining centers	2.70	41.7	-8.4	-47.4	22.6	20.1	.920	151
90.Other metal machine tools	1.97	138.0	-5.9	-148.9	19.5	17.3	.955	894
91.Rolling mills and auxiliary equipment	2.33	78.3	-7.3	-88.2	23.2	20.6	.971	184
92.Washing and finishing devices	1.70	28.8	-4.9	-33.2	17.5	15.6	.868	127
93.Hydraulic presses	2.36	45.7	-7.5	-49.6	23.8	21.1	.937	141
94.Mechanical presses	1.76	201.0	-5.5	-216.7	23.0	20.4	.990	422
95.Shearing machines	1.28	29.0	-4.2	-33.0	27.6	25.5	.877	119
96.Forging machines	1.91	39.2	-6.2	-45.5	25.5	22.6	.947	87
97.Gas welding and melting machines	2.06	131.4	-6.0	-134.5	18.6	16.5	.957	778
98.Other metal working machinery	2.06	411.8	-6.2	-457.2	20.2	17.9	.989	1973
99.Industrial robots	2.45	113.1	-6.5	-120.0	14.3	12.7	.971	376
100.Wafer processing equipment	1.72	42.2	-4.2	-44.8	11.3	10.1	.904	189
101.Semiconductor assembly equipment	2.13	124.4	-5.1	-136.2	11.2	9.9	.986	213
102.Associated equipment for manufacturing semiconduc	1.75	144.9	-4.4	-149.2	12.2	10.9	.980	423
103.Flat panel and display manufacturing equipment	1.84	34.8	-4.1	-38.8	9.1	8.1	.932	90
104.Other semiconductor manufacturing equipment	1.82	192.7	-4.7	-203.8	13.0	11.5	.979	813
105.Rubber industrial machinery and equipment	2.27	119.0	-7.1	-139.7	23.0	20.4	.980	285
106.Special machinery for chemical and medical products	1.80	117.2	-5.3	-128.5	18.7	16.6	.958	605
107.Other special industrial machinery	1.76	509.1	-5.0	-556.9	17.5	15.6	.983	4556
108.Steel vessels	1.72	21.1	-5.1	-24.8	19.1	17.1	.927	36
109.Other vessels	1.84	24.8	-4.7	-26.8	12.6	11.2	.888	78
110.Aircraft and helicopters	2.00	7.1	-3.9	-7.0	6.8	6.1	.691	23
111.Rail cars	2.35	58.4	-8.6	-73.2	39.1	34.7	.896	396
112.Light-duty vehicles (less 660ml) for own use	1.60	74.0	-3.7	-79.8	10.2	9.1	.907	562
113.Compact vehicles (660ml-2000ml) for own use	1.75	179.0	-4.0	-194.6	9.7	8.7	.930	2419
114.Ordinary passenger cars (over 2000ml) for own use	1.63	145.2	-3.8	-156.0	10.2	9.1	.938	1393
115.Small-size buses for own use	3.07	25.4	-8.3	-27.2	14.9	13.3	.896	76
116.Motor coaches for own use	2.37	11.4	-6.9	-13.3	18.1	16.1	.860	22
117.Trucks (light-duty cars) for own use	3.07	87.3	-7.7	-92.7	12.3	11.0	.980	154
118.Trucks (small cars) for own use	1.77	42.7	-4.4	-45.4	11.9	10.6	.908	186
119.Trucks (ordinary vehicles) for own use	1.95	58.1	-4.8	-62.8	11.6	10.3	.928	261
120.Other vehicles for own use	2.31	70.7	-6.8	-84.0	19.4	17.2	.964	188
121.Taxies	1.84	18.1	-3.9	-20.2	8.2	7.2	.689	148
122.Small-size buses for passengers	3.14	20.1	-9.2	-22.1	18.4	16.5	.939	27
123.Motor coaches for passengers	3.51	59.5	-10.2	-62.2	18.1	16.3	.931	265
124.Light-duty vehicles (less 660ml) for freight	2.35	98.3	-5.6	-106.2	10.8	9.5	.956	442
125.Compact vehicles (660ml-2000ml) for freight	2.86	230.0	-6.6	-246.5	10.2	9.0	.980	1060
126.Ordinary passenger cars (over 2000ml) for freight	2.35	120.7	-5.5	-129.0	10.6	9.4	.977	346
127.Trucks (light-duty) for freight	2.40	43.1	-6.2	-46.1	13.5	12.0	.926	150
128.Trucks (small, gas-powered cars) for freight	2.00	18.7	-5.2	-20.0	13.2	11.7	.763	109
129.Trucks (small, diesel cars) for freight	1.93	33.5	-4.9	-36.1	12.8	11.4	.843	210
130.Trucks (ordinary, gas-powered cars) for freight	2.15	30.4	-5.4	-32.8	12.3	10.9	.902	101

Table 8: Estimated Weibull Distribution and Average Service Lives (continued)

	α	(t-value)	β	(t-value)	λ	T	adj R^2	N
131.Trucks (ordinary, diesel cars) for freight	3.03	126.4	-7.6	-135.0	12.4	11.0	.977	377
132.Trucks (tractors) for freight	2.23	27.7	-5.8	-29.8	13.3	11.8	.934	55
133.Special-use cars and auxiliary cars	2.73	83.4	-7.8	-93.0	17.3	15.4	.959	297
134.Two-wheel vehicles	1.38	83.3	-3.0	-86.7	8.5	7.8	.954	339
135.Bicycles and manually operated wheel chairs	1.75	25.6	-4.9	-27.8	16.5	14.7	.932	49
136.Platform trucks, including trailers	2.01	157.7	-6.0	-171.8	19.9	17.6	.973	683
137.Forklift trucks	2.40	609.8	-7.0	-664.0	18.1	16.1	.992	3095
138.Shovel trucks	2.66	47.9	-7.1	-51.1	14.6	13.0	.972	68
139.Industrial trailers, including agricultural trailers	2.31	36.0	-6.9	-37.0	20.1	17.8	.966	46
140.Other industrial trucks	2.30	169.5	-6.8	-188.5	19.2	17.0	.985	446
141.Other transport equipment	1.84	449.9	-5.3	-481.2	17.7	15.7	.994	1319
142.Machinists' precision tools	1.46	894.9	-3.8	-949.5	13.3	12.0	.996	3109
143.Molds for pressing	1.57	534.9	-4.0	-584.9	12.5	11.2	.993	2089
144.Molds for forging and casting	1.33	180.2	-3.3	-196.1	11.6	10.7	.963	1265
145.Molds for plastics	1.44	259.9	-3.5	-280.4	11.5	10.4	.984	1124
146.Molds for rubber and glass	1.52	83.0	-3.9	-87.8	13.1	11.8	.967	237
147.Other molds and dies	1.56	368.6	-3.8	-397.6	11.8	10.6	.991	1202
148.Other general machines and equipment	1.83	327.9	-5.0	-341.6	15.6	13.8	.987	1385
149.Copying machines	2.29	200.6	-5.0	-209.7	9.0	8.0	.950	2111
150.Other office machines	2.03	678.7	-5.0	-680.8	12.0	10.6	.993	3044
151.Servicing machines	1.15	185.6	-2.6	-176.8	9.4	8.9	.944	2053
152.Electric audio equipment	2.23	141.2	-5.9	-143.9	13.9	12.3	.980	414
153.Radio/television receivers	1.75	198.5	-4.6	-197.1	13.9	12.4	.982	735
154.Video equipment	1.86	200.8	-4.5	-202.6	11.4	10.1	.972	1183
155.Consumer-use air conditioners	2.01	440.4	-5.5	-466.4	15.5	13.7	.982	3625
156.Electric refrigerators	1.83	460.9	-4.8	-471.4	13.8	12.3	.995	1122
157.Other household electric appliances	1.84	541.8	-4.8	-565.6	14.0	12.4	.991	2562
158.Personal computers (including PC servers)	2.58	543.4	-5.3	-579.3	8.0	7.1	.947	16488
159.General purpose computers	2.64	174.7	-5.8	-182.9	9.1	8.0	.961	1239
160.Printing device	2.42	269.9	-5.3	-281.0	9.0	8.0	.973	1998
161.Other computer peripheral equipment	1.88	335.7	-4.2	-346.5	9.3	8.3	.977	2637
162.Telephone equipment	1.54	538.8	-3.7	-559.7	11.3	10.2	.995	1440
163.Facsimile machines	2.89	256.1	-6.9	-270.4	10.9	9.7	.981	1266
164.Electronic automatic exchange switchboards	2.04	124.0	-5.1	-136.3	12.4	11.0	.972	437
165.Digital transmission equipment	1.92	363.0	-4.0	-405.7	8.1	7.2	.990	1361
166.Other carriers and auxiliary equipment	1.77	172.7	-4.1	-196.5	10.2	9.1	.987	384
167.Radio communication equipment	1.51	83.8	-3.9	-86.4	13.3	12.0	.876	993
168.Electronic appliances	2.15	137.6	-5.8	-148.8	15.2	13.4	.976	476
169.Electric measuring instruments	2.12	150.7	-6.0	-156.4	16.7	14.8	.964	848
170.Semiconductor and IC measuring instruments	2.33	61.3	-6.2	-65.0	14.0	12.4	.967	130
171.Other electric measuring instruments	2.22	161.8	-6.2	-167.3	16.3	14.4	.982	488
172.Generators and motors	1.55	35.7	-3.8	-32.9	11.4	10.3	.924	106
173.Switching control equipment/switchboards	1.32	39.0	-4.0	-46.2	21.0	19.4	.901	168
174.Other industrial electric equipment	1.44	274.2	-4.0	-281.2	15.7	14.2	.993	562
175.Electric lighting fixtures	1.49	656.1	-4.1	-773.4	15.9	14.4	.996	1657
176.Optical machinery	1.79	290.3	-4.8	-296.5	14.7	13.1	.989	948
177.Physical and chemical instruments	2.26	64.2	-6.5	-66.4	17.8	15.7	.934	290
178.Other measuring instruments	1.92	430.2	-5.5	-446.3	17.1	15.2	.978	4187
179.Precision measuring instruments	1.84	124.2	-5.3	-132.7	17.8	15.8	.969	502
180.Other analytical instruments	2.30	150.4	-6.6	-159.7	17.4	15.4	.955	1060
181.Testing machines	1.77	245.0	-5.0	-255.1	16.7	14.8	.986	832
182.Medical instruments	2.28	115.3	-6.0	-124.7	14.0	12.4	.978	307
183.Carpets and rugs	1.98	254.0	-5.1	-276.9	13.5	11.9	.991	560
184.Other textile products	1.70	104.4	-4.2	-113.1	11.7	10.5	.966	387
185.Wooden furniture and fixtures	1.57	1211.7	-4.1	-1288.5	13.8	12.4	.997	3851
186.Metal furniture and furnishings, fixtures	1.68	693.9	-4.5	-741.5	14.6	13.0	.993	3543
187.Fabricated construction-use metal products	1.28	29.2	-3.2	-30.8	11.8	10.9	.886	111
188.Gas/petrol heaters and cooking appliances	1.78	104.9	-4.9	-113.2	15.7	13.9	.969	357
189.Metallic containers, fabricated metal products	1.42	70.5	-3.9	-71.6	15.5	14.1	.953	244
190.Other metal products	1.81	156.6	-4.9	-160.8	15.2	13.5	.968	821
191.Musical instruments	2.59	53.1	-7.9	-60.6	21.2	18.9	.986	42
192.Information recording materials	1.39	92.3	-3.0	-87.7	8.6	7.9	.959	364
193.Advertising/sign/display equipment	1.47	367.2	-3.6	-403.7	11.4	10.3	.989	1569
194.Unit housing	1.40	27.7	-3.4	-29.2	11.4	10.4	.889	96
195.Other products	1.52	613.0	-4.0	-658.7	13.5	12.1	.991	3383

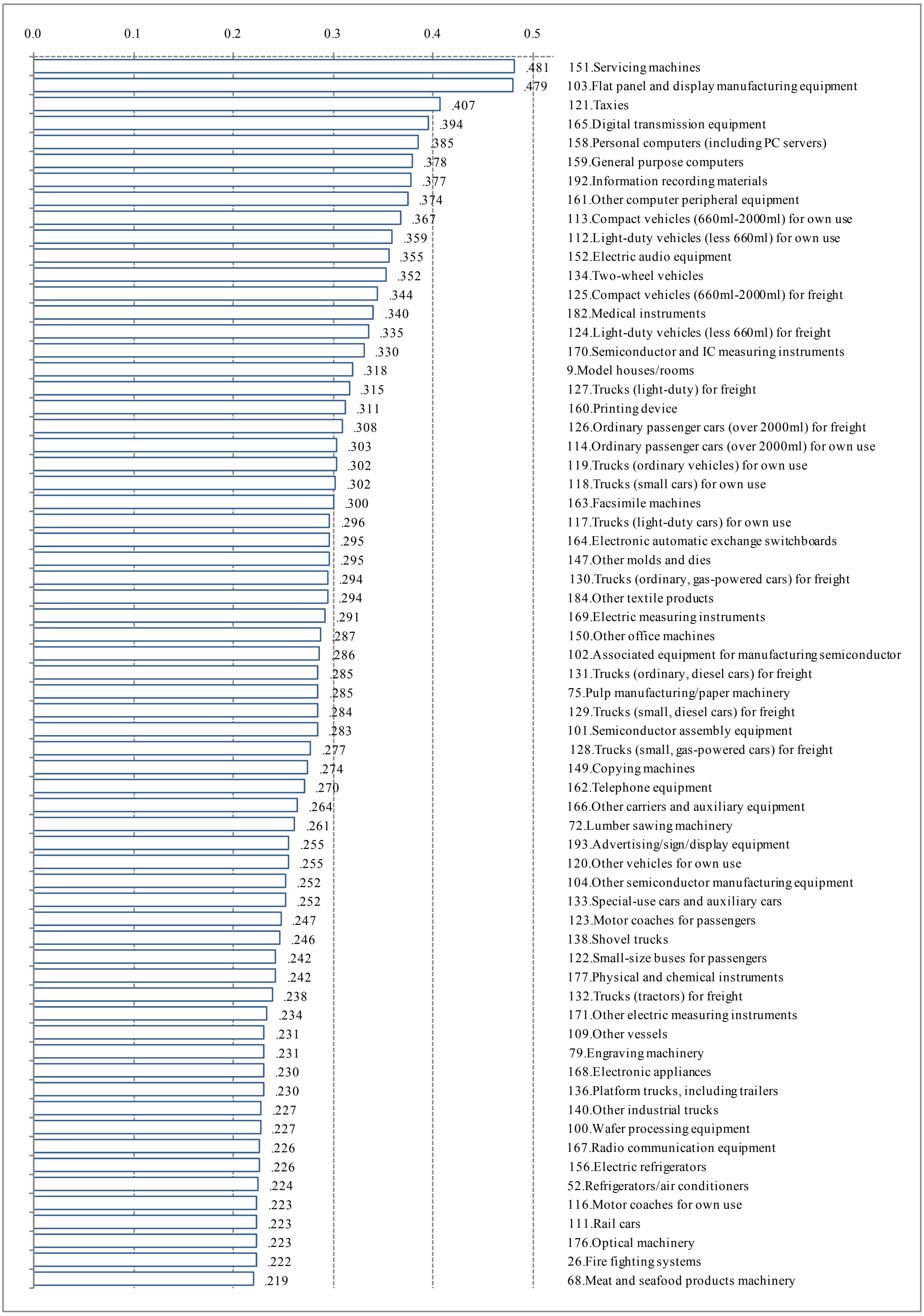

Figure 4: Geometric Rate of Depreciation by Asset

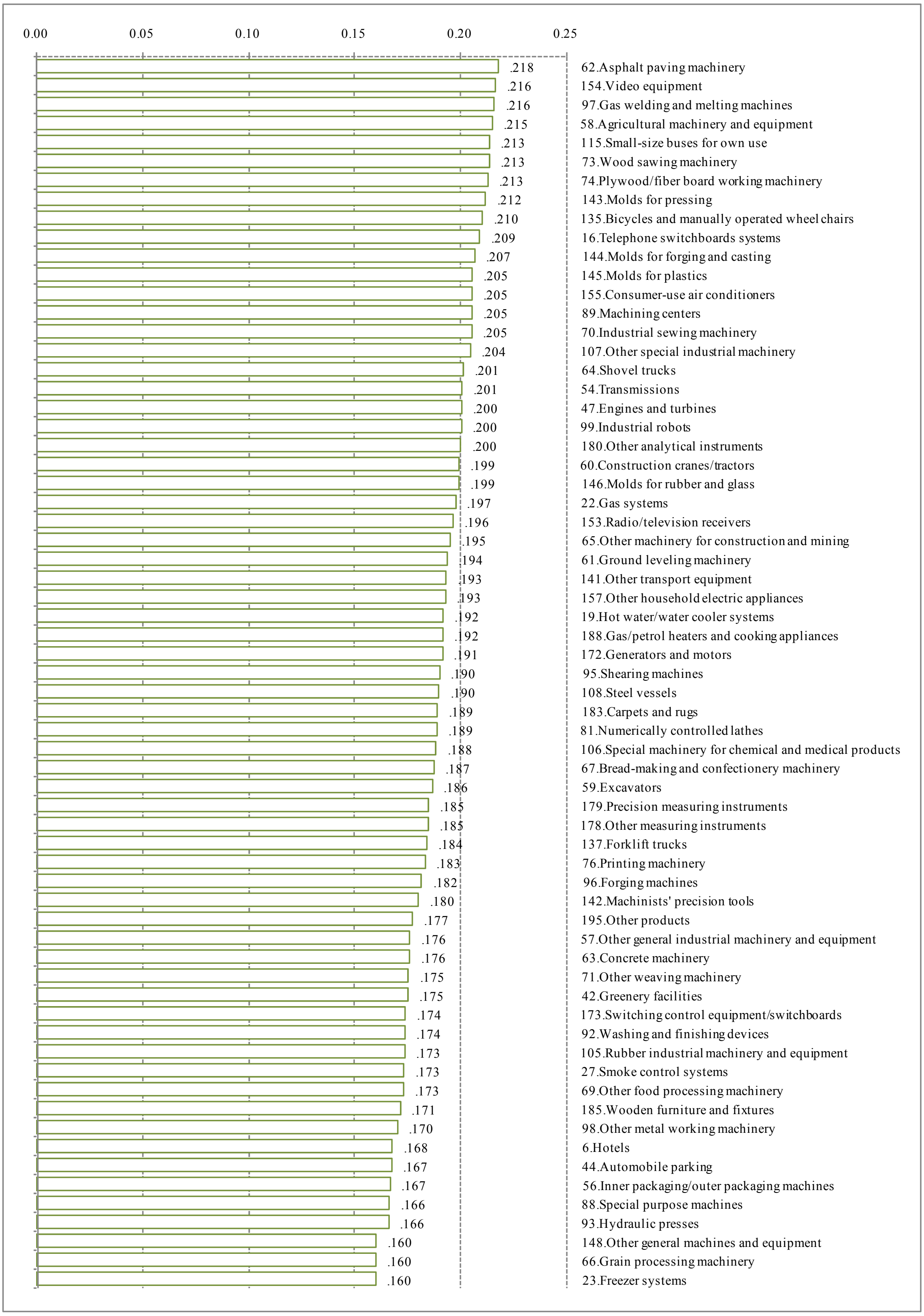

Figure 4: Geometric Rate of Depreciation by Asset (continued)

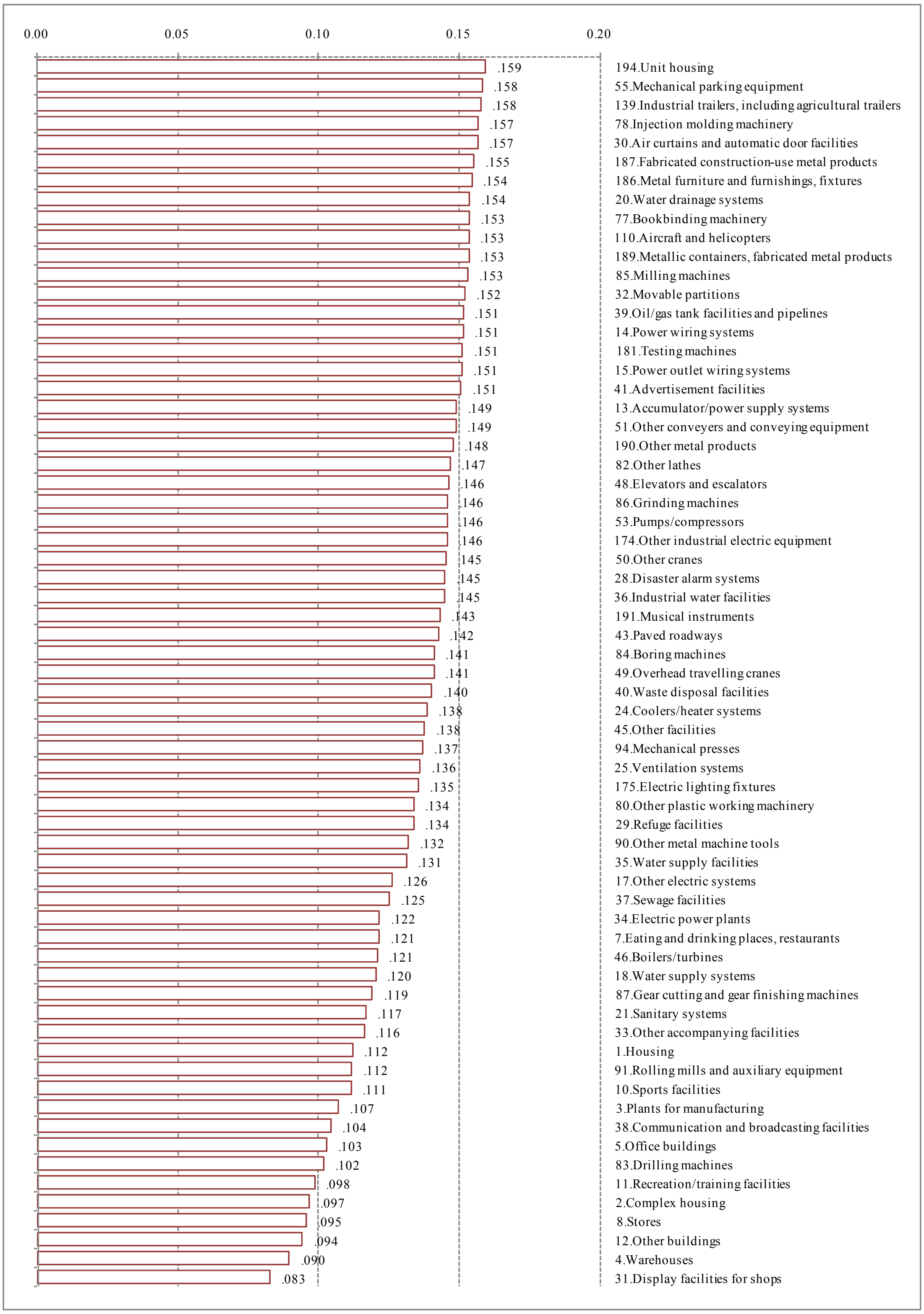

Figure 4: Geometric Rate of Depreciation by Asset (continued)

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