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Duration of Assets: Examination of Directly Observed Discard Data in Japan *

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Abstract

Comprehensive investigation for discard and decay of assets has not been sufficiently implemented in Japan. As the first step for reframing measurement of capital stock in Japanese national accounts, we investigate discard patterns of asset, based on new micro data for directly observed discards (*Survey of Actual Capital Stock and Discard of Private Enterprises*: SASD), which is newly developed by ESRI (Economic and Social Research Institute, Cabinet Office) in 2003.

In this paper, we report the preliminary results of the Weibull family of distributions to approximate the discard patterns of 66 assets. The results indicate that almost half of assets have a progressively increasing hazard rate. For further investigations of discards, we provide some proposals to improve the design of questionnaire in the present SASD.

* This study is implemented in our project for revising capital measurement at ESRI (Economic and Social Research Institute, Cabinet Office). I thank Tadao Futakami (Director of National Wealth Division, ESRI) for his support. The results we report in this paper are preliminary. Comments are welcome.

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1 Introduction

Japan's national accounts are moving toward a sweeping improvement of capital measurement, which may be one of the most problematic areas in the current accounts[*1]. On reframing it, assumptions for duration of assets and decay of the surviving assets are the key factors to determine the accuracy of capital stock estimates. The objective of this paper is to examine actual survival distribution and asset service lives, based on the directly observed discard data that is newly implemented in 2003 by Economic and Social Research Institute (ESRI), the Cabinet Office (CAO), Japan.

In the *National Wealth Survey* (NWS), the Japanese government directly investigated detailed capital stocks owned by corporations, government, and households. The NWSs in 1955 and 1970 are the largest-scale surveys for direct observation of capital stock (DOC). [*2] The NWS is a unique method to directly attain actual gross capital stock and net capital stock in business account. However, at present, it may be difficult to finance an additional large-scale NWS. In addition, from the point of view of the theory of capital measurement, the 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 significant role of the NWS may be the measurement of benchmark "gross" capital stocks that are surviving in the production process at the period of the investigation.

In order to measure gross capital stock without large-scale survey of DOC, we have to investigate

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[*1] See Nomura and Futakami (2005) for the current problems in official estimates of consumption of fixed capital (CFC) and capital stock in the Japan's national accounts.

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

Survey 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).

duration of assets. One approach to recognize the durability is a sample survey for actual discards of assets in business account. In Japan, ESRI implemented the *Survey of Actual Capital Stock and Discard of Private Enterprises* (SASD) in 2003, as the first trial towards the revision of capital stock. In this paper, we report the results of our examination using this sample survey. In addition, for the future investigations of discards, we provide some proposals to improve the design of questionnaire in the present SASD.

Another approach to recognize discard patterns is the use of registration data for some particular assets (e.g. motor vehicles), which are obligated to be registered to government for its usage. It can provide complete dataset to describe the number of surviving assets used by companies or households. In this paper, we also report the estimates based on the registration data for motor vehicles to compare with our results based on the SASD.

In section 2, we start to clarify the terminologies used in this paper. The methodology to approximate discard patterns is briefly introduced in section 3. In this paper, the Weibull distribution with two parameters is assumed. We introduce newly implemented data for directly observed discard and examined its properties in section 4. Our preliminary results based on SASD for 66 assets and registration data for motor vehicles are reported in section 5. Section 6 concludes briefly, with the proposals for improving the directly observed discard survey for further research.

2 Terminology

2.1 Capital Stock: Gross, Productive, and Net

The terminologies to represent capital stock and discard/decay may still confuse readers. In this section, we begin with the clarification of the terminologies used in this paper.

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 (see Fraumeni, 1997; Katz and Herman, 1997; and BEA, 2003), 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 the empirical results. The theory of capital measurement clarifies the distinction of these two aspects of capital, based on the concepts of age-efficiency profile (AEP) and age-price profile (APP). We use three distinctive stock concepts in this paper: gross, productive, and net capital stocks.[*3]

2.2 Aging of Assets: Discard and Decay

There may be a consensus about the use of "retirement" or "discard," which are used synonymously. Here, we describe the distinction between discard and decay, to clarify the objective of this paper in our reframing measurement of capital stock.

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.[*4]

Jack E. Triplett (1997) also gives the definition. He defines the term "deterioration" to represent the relative efficiency in the age-efficiency profile (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. Also, he uses "discards" or "scrapping" synonymously.

In the framework for measuring productive capital stock, the key idea is the AEP. Based on the comprehensive empirical studies of Hulten and Wykoff (1981a, 1981b, 1981c), the geometric distribution as the

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[*3] We use the name of productive capital stock after Triplett (1996, 1997) and Hill (1998, 1999). Biørn (1989) and Biørn, Holmoy, and Oystein (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.

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.

[*4] 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).

AEP or APP is approximately accepted for many assets in the U.S. Also, Nomura (2004, ch-2) estimates depreciation rates based on the Box-Cox transformed APP, using data in the second-hand market for motor vehicles, and the 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 or the distribution of deterioration by Triplett's terminology.

Our measurement on duration of assets has two meanings in this context. Firstly, if the geometric approach can adequately approximate the AEP, the investigation only for the discards may have less meaning. However, it may be usually difficult to investigate the AEP for many kinds of assets, due to the lack of adequate market data for aged assets. In fact, there is sometimes no actual market for aged assets. Second, some assumption for discards is required to estimate the AEP using market price data for aged assets, since the observed data at the market is censored because of the lack of the 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.

3 Methodology

3.1 Distribution for Discard Pattern

Discard patterns of assets are frequently approximated by some probability distribution function, due to the difficulties of directly observed data to attain actual gross capital stock.[*5] This section briefly depicts particular functions used to approximate discard pattern and outlines the Weibull family of distributions that is mainly assumed in this paper.

Blades (2001) discusses four types of distribution – simultaneous exit (SE), linear (LR), delayed-linear (DL), and bell-shaped (BS). As the BS-type functions, logistic, Winfrey, hyperbolic, Weibull, log-normal, and so forth are widely used. In Japan, at the *Gross Capital Stock of Private Enterprises* (GCSPE) that describes gross capital stock by industry, ESRI assume the SE, in which all assets will be simultaneously retired when the age of asset reaches the end of its service life.[*6] However, the SE is widely recognized that it may be the most inappropriate retirement pattern. Blades (2001) indicates that the SE and LR are

[*5] "The best results are obtained where the retirement observations are made on large numbers of units at regular intervals over several years, and where records of the units in service, as well as those retired from service are available. Because of small numbers of units or infrequent and irregular observations, or both, the resulting curves possess irregularities which are not natural to the general behavior of large properties. These poorly shaped curves must be used, however, but their use is made easier and the results more plausible by an initial smoothing process."(Winfrey, 1935, p.37).

[*6] Also, for the measurement of infrastructure in Japan, CAO assumes the SE as a discard distribution. See *Infrastructure in Japan* (in Japanese) in 1986 and 1998.

clearly unrealistic and that the DL and BL gives more realistic model.[*7]

At the second meeting of Canberra Group on Capital Stock Statistics in September 1998, Meinen, Verbiest, and Wolf (1998) reports their examination on the alternative estimates of gross capital stock assuming the SE, DL, hyperbolic, logistic, and Weibull distributions, compared with actual measurement of capital stock in the Netherlands. They conclude the estimates assumed the SE does not reproduce the older vintage classes sufficiently enough and that the DL or the BS-type survival functions with a longer tail perform better.

3.2 Weibull Distribution

To approximate discard patterns, we assume the Weibull family of distributions. The probability density (mortality) function $f(\tau)$, cumulative distribution function $F(\tau)$, and survival function $S(\tau)$ of the Weibull distribution are:

$$f(\tau) = \alpha\lambda^{-\alpha}\tau^{\alpha-1}e^{-(\frac{\tau}{\lambda})^{\alpha}}, \tag{1}$$

$$F(\tau) = \int_0^{\tau} f(t)dt = 1 - e^{-(\frac{\tau}{\lambda})^{\alpha}}, \tag{2}$$

$$S(\tau) = 1 - F(\tau) = e^{-(\frac{\tau}{\lambda})^{\alpha}}, \tag{3}$$

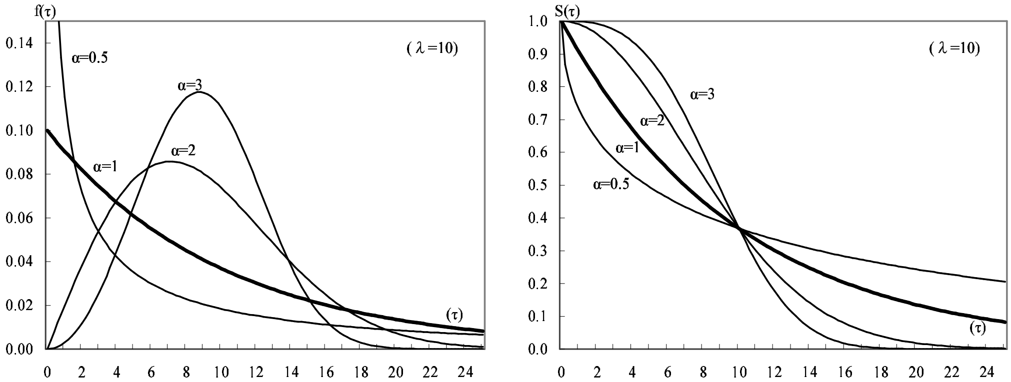
where τ is the continuous age and λ and α are known as the scale and shape parameters ($\lambda > 0$ and $\alpha > 0$).[*8] The Weibull distribution is more flexible than the exponential distribution, since it is the exponential distribution of the power transformed age: τ^{α}. In the special case of $\alpha = 1$, the Weibull distribution is identical with the exponential distribution, which has the constant rate of retirement. Figure 1 displays $f(\tau)$ and $S(\tau)$ for the cases of α =0.5, 1, 2, 3, under $\lambda = 10$.

The k-th moment m_k of the Weibull probability density function $f(\tau)$ is given as:

$$m_k = \lambda^k\Gamma(1 + k\alpha^{-1}), \tag{4}$$

[*7] In the old OECD Manual on measuring capital, Ward (1976) wrote "The gross stock estimates appear to be more sensitive to changes in the assumed average lives of assets than to variations in the survival functions. Studies made by OECD have shown that perpetual inventory models based in turn on Winfray S-3, gamma-probability density and rectangular survival distributions [this is identical with the SE] generate capital stock estimates which rarely differ by more than ten percent in any one year and in most cases the differences were very small. Furthermore no one set of estimates appears to be consistently greater than another."(p.35) This old description still provides an evidence for CAO to assume the SE. A quarter of a century later, it is clearly described that the use of the SE is unrealistic in the newly revised OECD manual (Blades, 2001).

[*8] The Weibull distribution function is more generally given as $F(\tau) = 1 - e^{-(\frac{\tau-\phi}{\lambda})^{\alpha}}$, where ϕ is the location parameter ($\tau > \phi$). In this paper, we set $\phi = 0$. A generalized Weibull family of distributions for survival studies is proposed in Mudholkar, Srivastava, and Kollia (1996).



(a) Density Fuction: $f(\tau)$ (b) Survival Function: $S(\tau)$

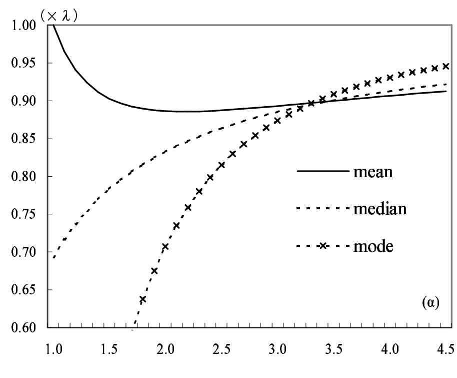
Fig. 1 The Weibull Density and Survival Functions

where $\Gamma(\ )$ is the gamma function, which is defined as $\Gamma(x) = \int_0^\infty e^\mu \mu^{x-1} d\mu$. The 1st moment gives the average service life $\bar{T}$:

$$\bar{T} = m_1 = \lambda\Gamma(1 + \alpha^{-1}). \tag{5}$$

For the case of $\alpha = 1$ or $\alpha = \infty$, average service life $\bar{T}$ is identical with the scale parameter λ since $\Gamma(2) = \Gamma(1) = 1$. For the cases of $\alpha = 1/2, 1/3, 1/4$, average service life $\bar{T}$ is 2λ, 6λ, 24λ, respectively, using the property of the gamma function: $\Gamma(x + 1) = x\Gamma(x)$. Roughly, $f(\tau)$ is positively skewed (left-skewed) for $\alpha < 2.6$, approximately symmetric for $2.6 < \alpha < 3.7$, and negatively skewed (right-skewed) for $3.7 < \alpha$. [*9]

[*9] The median and mode of $f(\tau)$ are given by $\lambda(\ln 2)^{\alpha^{-1}}$ and $\lambda(1-\alpha^{-1})^{\alpha^{-1}}$, respectively. The figure below displays the comparison of the mean, median, and mode of the Weibull density function. The y-axis scale times λ represents each value.



As retirement patterns of assets, the shape parameter α may be mostly between 1 and 3, so that the average service lives are a little bit small value of the scale parameter λ, since $\Gamma(1+\alpha^{-1})$ has its minimum value 0.8856 for $\alpha = 2.16$ and $0.8856\lambda \leq \bar{T} \leq \lambda$ for $1 \leq \alpha \leq \infty$.

Also, the standard deviation of asset service life: $\sigma_T$is given:

$$\sigma_T = \left(m_2 - m_1^2\right)^{1/2} = \lambda\left(\Gamma(1+2\alpha^{-1}) - \Gamma(1+\alpha^{-1})^2\right)^{1/2}. \tag{6}$$

For the case of $\alpha = 1$, σ_T is also λ. $\sigma_T = \infty$ as $\alpha \to 0$, and $\sigma_T = 0$ as $\alpha \to \infty$.

The Weibull hazard function $h(\tau)$, and cumulative hazard function $H(\tau)$ are:

$$h(\tau) = \frac{f(\tau)}{S(\tau)} = \alpha\tau^{-1}\left(\frac{\tau}{\lambda}\right)^{\alpha}, \tag{7}$$

$$H(\tau) = \int_0^{\tau} h(t)dt = -\ln(S(\tau)) = \left(\frac{\tau}{\lambda}\right)^{\alpha}. \tag{8}$$

For the case of $\alpha = 1$, the hazard rates $h(\tau)$ are constant as λ^{-1}.[*10] As τ increases, the hazard rate decreases for $\alpha < 1$ and increases for $\alpha > 1$. Figure 2 displays $h(\tau)$ and $H(\tau)$ for the cases of α =0.5, 1, 2, 3, under $\lambda = 10$. In the case of $\alpha = 2$, the hazard rate in Figure 2(a) increases linearly.

Taking logarithm of the Weibull cumulative hazard function in the equation (8), it can be written as a linear equation:

$$\ln H(\tau) = \beta + \alpha \ln \tau, \tag{9}$$

where $\beta = -\alpha \ln \lambda$. This log-linear relationship of the cumulative hazard and age makes the estimation model easy to handle.

4 Data and Actual Duration

4.1 SASD

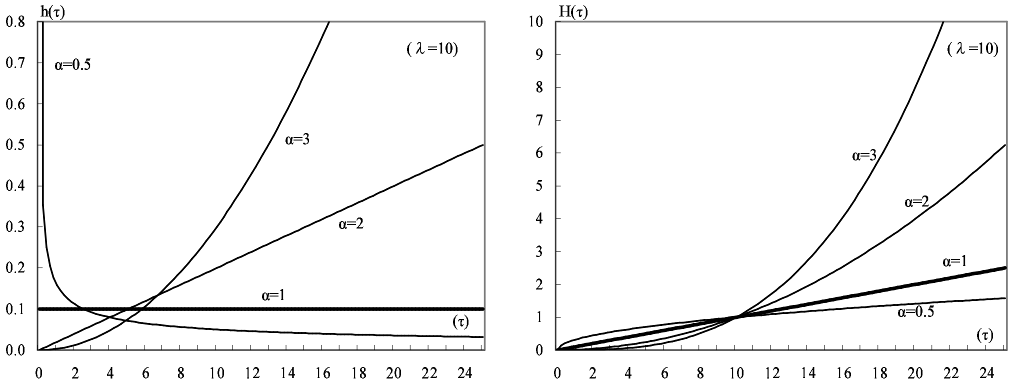
The data used in this paper is the *Survey of Actual Capital Stock and Discard of Private Enterprises* (SASD), which is newly developed by ESRI, CAO. As the first step to sweepingly revise the capital measurement

[*10] A precise definition of the hazard function in terms of probabilities is

$$h(\tau) \equiv \lim_{h\to 0} \frac{P(\tau \leq T < \tau + h | T \geq \tau)}{h}.$$

By this definition, the hazard function is also called as the conditional failure density function. To obtain the cumulative hazard function in the equation (8), the hazard function can be rewritten as

$$h(\tau) = \frac{\lim_{h\to 0}(P(\tau \leq T < \tau + h)/h)}{P(T \geq \tau)} = \frac{\lim_{h\to 0}(F(\tau+h) - F(\tau))/h)}{1 - F(\tau)} = \frac{f(\tau)}{S(\tau)} = \frac{-S'(\tau)}{S(\tau)} = -\frac{d\ln(S(\tau))}{d\tau}.$$



(a) Hazard Fuction: $h(\tau)$ (b) Cummulative Hazard Function: $H(\tau)$

Fig. 2 The Weibull Hazard and Cummulative Hazard Functions

in the Japanese national accounts, ESRI implemented the SASD in 2003. This investigates the actual capital stock and discard for the 2002 fiscal year. This survey (hereafter 2002-SASD) provides primary results as the first trial to investigate duration of assets. Hence, it is one of our objectives for this paper to locate the problems within the 2002-SASD, in order to improve the design of questionnaire for the future investigations. In this section, we introduce the outline of the 2002-SASD and its properties.

The objective of the 2002-SASD is to directly observe the capital stock and discards of private enterprises. The target population is the private enterprises with over thirty million yen of the (financial) capital stock at their business accounts. The number of samples in the 2002-SASD is 5,880 companies (the sampling rate is 4.3 percent), by random sampling method from the stratified populations by five capital groups × twenty-nine industries. The number of effective responses is 2,903 (the response rate is 49.4 percent).

The 2002-SASD 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 twenty-nine industries.[*11] The first investigation is similar to the *Financial Statements Statistics of Corporations* (FSSC), produced by Policy Research Institute, Ministry of Finance (MOF), although the 2002-SASD has much smaller samples than the FSSC.[*12]

[*11] The asset classification consists of (1)buildings, (2)construction, (3)machinery and equipment, (4)ships, (5)other transportation equipment, (6)tools and other equipment, (7)miscellaneous products, and (8)construction in progress. Only for the investment survey, the ninth asset: (9)land development is added. The capital groups consist of (1) 30 to 50 million yen, (2) 50-100 million yen, (3) 100 million -1 billion yen, (4) 1-5 billion yen, (5) over 5 billion yen.

[*12] In the FSSC for the 2002 fiscal year, the number of samples is 29,423 and the effective response is 23,840 (the response rate is

The second investigation of the 2002-SASD provides more detailed data for discards of assets owned by private enterprises. 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. It makes possible to figure out the completed duration data of assets. Moreover, the assets sold as second-hand goods for continued use in production are identified in the 2002-SASD to define relevant service lives of assets.[*13]

On the other hand, to describe appropriate discard patters, the retired assets that were originally purchased as second-hand goods should be excluded, since the mixture lets the average service lives be biased downwardly. However, in the 2002-SASD, there is no questionnaire if the retired asset was new or second-hand at the period of the purchase, as long as company does not report an additional information at the questionnaire. This point has to be revised at the future investigation.

The kinds of assets to be reported are not designated in particular at the questionnaire of the 2002-SASD. Therefore, company could choose arbitrarily three assets from the wide range of the assets within each asset group. Although this open questionnaire makes it possible to collect data for a number of assets, the non-specification of asset also makes it difficult to control the differences in quality of the asset samples, even if they might be considered as a class of asset. In fact, it is sometimes difficult to let asset samples correspond to a class of asset if the reported names are not clear. In addition, sampling bias in the 2002-SASD should be considered. We depicted it in section 4.3, after describing the actual age-survival distributions from this data.

4.2 Actual Age-Survival Distribution

Based on the directly observed discard data in the second investigation of the 2002-SASD, we estimate the actual age-survival distribution in three ways (the last one is defined in equation (20) in section 4.4, later). Let τ and $\mathbf{v}$ are column vectors denote the duration period and the value at the period of the purchase, respectively. Here, the duration period is defined only for the retired asset, excluding the assets sold as second-hand goods. τ_i and v_i are the components for asset samples i that belong to a given class of asset. The original data of v_i in business account is evaluated by the historical price at the period of the

81.0 percent) for corporations except finance and insurance. Although the number of samples is much larger than that of the 2002-SASD, the FSSC is not sufficient enough to measure capital stock, since it has no asset classification of tangible assets.

*13 Gellatly, Tanguay, and Yan (2002) estimates economic depreciation using selling or discard price of asset. Although SASD also investigates value of asset scrapped or sold, it is not clear whether the value is evaluated by the price at the period to be sold or its book value in the 2002-SASD. Improving this questionnaire at the future investigation, we may make it possible to estimate the age-price profile.

purchase. Here, we reevaluate v_i by the constant prices using the price index in each asset.[*14]

The first actual survival distribution is simply approximated as:

$$S_0(\tau) \approx \frac{\mathbf{j'i}}{\mathbf{i'i}} = \mathbf{j}'\mathbf{w}_0, \tag{10}$$

where $\mathbf{i}$ stands for the column vector consisting of 1s, so that $\mathbf{i'i}$ is the number of samples N. Hence, $\mathbf{w}_0$ is the column vector consisting of the same simple weights $1/N$. The components $j_i(\tau)$ in the column vector $\mathbf{j}$ are defined as:

$$j_i(\tau) = \begin{cases} 1 & \text{if } \tau_i \geq \tau \\ 0 & \text{otherwise.} \end{cases} \tag{11}$$

Therefore, the number of assets survived at age τ is $\mathbf{j'i}$. $S_0(\tau)$ is defined as the actual survival distribution used the simple weights for each sample, regardless of the differences in the values v_i. Here, the average service life is defined as

$$\bar{T}_0 = \tau'\mathbf{w}_0. \tag{12}$$

The second actual survival distribution $S_v(\tau)$ is approximated as

$$S_v(\tau) \approx \mathbf{j}'\mathbf{w}_v, \tag{13}$$

where $\mathbf{w}_v$ represents the weights for sample i, formed by the column vector consisting of $w_i(\tau)$, as

$$\mathbf{w}_v = \frac{\mathbf{v}}{\mathbf{i'v}}. \tag{14}$$

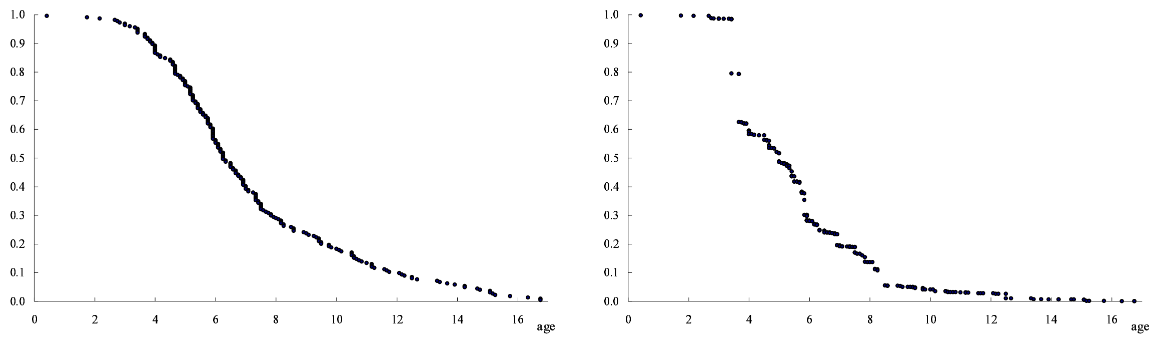
The real value weights $\mathbf{w}_v$ are expected to adjust the differences in the quality among samples i. In the questionnaire of the 2002-SASD, companies may sometimes report the total value of the retired assets, although it is expected that the assets were purchased and retired at the same periods. However, there is no questionnaire to report the number of assets in the 2002-SASD. The differences in the numbers among i may be somewhat adjusted by the use of weights $\mathbf{w}_v$. The average service life in the second definition is

$$\bar{T}_v = \tau'\mathbf{w}_v. \tag{15}$$

The two actual survival distribution $S_0(\tau)$ and $S_v(\tau)$ provide the different pictures for an asset. Figure 3 displays $S_0(\tau)$ and $S_v(\tau)$ for the case of personal computers (PC) with the sample size N=224. In $S_0(\tau)$, the samples are well apportioned. On the other hand, some samples have large impacts around 4 ages in

[*14] As well as the differences in the periods of the purchases, the months of the discards differ among the samples i although they are retired in the same fiscal year. We used the monthly price indexes of the Corporate Goods Price Index (CGPI) produced by Bank of Japan, for each asset. The CGPI was named as Wholesale Price Index (WPI) before it has been greatly revised in 2000.

$S_v(\tau)$. In the case of PC, this may be due to the large number of assets reported in a single questionnaire. Although $S_0(\tau)$ looks more appropriate as the PC's survival distribution, the average service life $\bar{T}_0$ is 7.2 years, which is 80 percent higher than the PC's tax-life of 4 years. This seems too high. On the other hand, $\bar{T}_v$ is 5.4 years, reflected the large-number of samples around 4 ages. It may be more adequate.



(a) $S_0(\tau)$ (b) $S_v(\tau)$

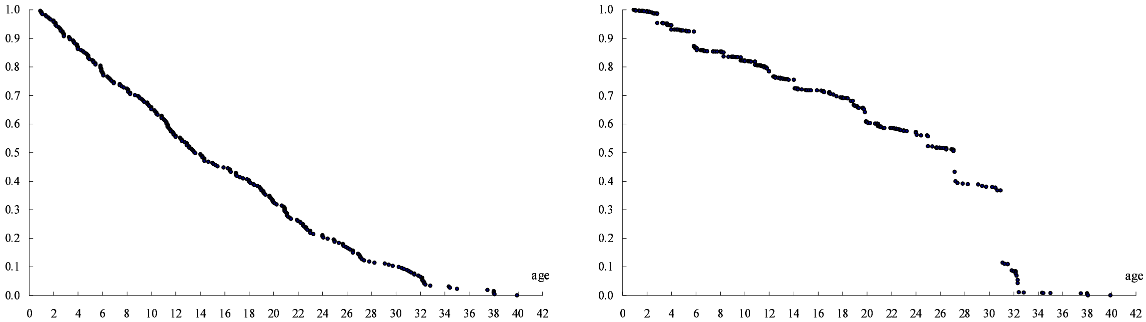
Fig. 3 Actual Survival Distribution: Personal Computers: $S_0(\tau)$ and $S_v(\tau)$

Figure 4 displays the actual survival distributions for office buildings, where N=261. $S_0(\tau)$ seems linearly distributed in Figure 4(a). However, in Figure 4(b), some samples with 31 ages have significant impacts on the shape of $S_v(\tau)$. In this case, it may be due to the large-scale office buildings. The average service lives $\bar{T}_0$ and $\bar{T}_v$ are 15.4 and 22.2 years, respectively. Contrary to the case of PC, $\bar{T}_0$ for office buildings may be too small.

For measuring gross capital stock, $S_v(\tau)$ may be preferred. If a number of assets retired at the same period, they should be counted separately. In addition, if a large-scale asset tends to provide a longer service life because of the superior durability, the difference of the scale should be considered in estimating the average service life. Or, if it is possible to measure investment by the structure and scale of an asset, the survival distribution should be distinguished based on its classification.

4.3 Sampling Bias in SASD

Next, we examine the samples in the SASD. Let I_t denote the quantity of investment of a single asset at the period t. Figure 5 represents two samples invested at the periods t_1 and t_2 and these discard patterns that are assumed to follow the identical probability density function (pdf) $f(\tau)$, regardless of the difference in their vintages. At the period of the survey t ($t \geq t_1, t_2$), $f(t-t_1)I_{t_1}$ and $f(t-t_2)I_{t_2}$ are retired for sample-1



(a) $S_0(\tau)$ (b) $S_v(\tau)$

Fig. 4 Actual Survival Distribution: Office Buildings: $S_0(\tau)$ and $S_v(\tau)$

and sample-2, respectively. By the single-period survey like the SASD, the discard data sets $f(t - t_i)I_{t_i}$ of the assets with different vintages t_i can be observed.

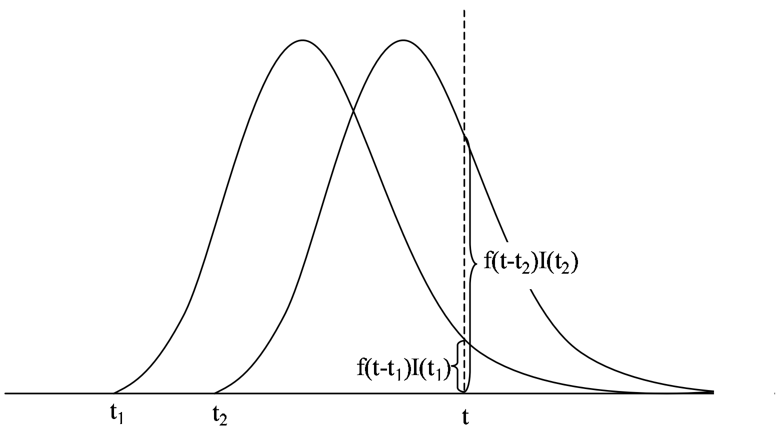


Fig. 5 Discard Data Collected at the Single-Period Survey

We define the "pseudo" pdf $f_t^*(\tau)$ based on the collected discard data at the period of t as:

$$f_t^*(\tau_i) = f(t - t_i)I_{t_i} = f(\tau_i)I_{t-\tau_i}. \tag{16}$$

If $I_{t-\tau_i}$ is constant over vintages t_i (or ages τ) as shown in Figure 5, the pseudo pdf $f_t^*(\tau)$ is proportional to the "true" pdf $f(\tau)$. If not, the pseudo $f_t^*(\tau)$ may be biased.

Figure 6 gives another picture of sampling in the SASD. The collectable samples in the 2002-SASD are the assets retired from April 2002 to March 2003. In this period of the investigation, the duration data (1) and (2) can be collected, but data (3) is not collected.[*15] The curves (a)-(e) in Figure 6 represent past investment patterns I_{t_i} at the periods $t_i(\leq t)$. In the case of (a), quantity of investment is constant, regardless of the difference in its vintage t_i. Thus the true pdf $f(\tau)$ can be estimated without biases, based on the pseudo pdf $f_t^*(\tau)$ in the equation (16).

In the case of (b), investment has a boom in the recent period. In the survey period t, the data with shorter service lives may be collected more. As the results, the average service life based on the collected samples may be underestimated. Even in this case, if the true service life of the asset is enough long not to operate the observable sample like data-(3), the bias may be negligible. In the case of (c), the data which has the linearly upward trend of investment results the downward biases in estimate for average service life. Especially, in the case of (d), the sample for a new product may be censored. Contrastively, if the actual investment has a downward trend like (e), the estimated average service life may be biased upwardly. [*16]

The method to eliminate this sample bias is to construct longitudinal data from the period of acquisition of an individual asset t_i to the period to be retired t. Companies originally have complete individual records in all assets they own. If we make use of these complete data sets, the biases except the case of (d) can be diminished. Another complete data can be provided by registration data. Some particular assets like motor vehicles are regulated to be registered. The use of the registration data makes us to describe a complete discard pattern, if we could approximately neglect the difference in qualities of the asset samples. Section 5.2 provides our preliminary results based on the complete registration data for motor vehicles, to compare our results based on the 2002-SASD.

Another solution is to make a pooling data over periods. Multi-period surveys may make it possible to identify the effects of age (τ_i) and vintage (t_i) separately, to appropriately estimate the true pdf. Or, using the samples investigated in different periods, we could define the integrated pseudo pdf, which is simply

[*15] Fortunately, there may be no length-biased sampling, which is the problem that the data with short duration are underrepresented in the sample. See Kiefer (1988) for the case of unemployment duration.

[*16] In the methodology of the Statistics Netherlands (Meinen, Verbiest, and Wolf, 1998) to estimate the retirement patters, a true pdf is approximated by the retirement value over investment, or a hazard function is approximated by the retirement value over gross capital stock. Their estimates do not be affected by the biases we depict here. Statistics Netherlands introduced in 1991 a directly observed survey for discard (Meinen, Verbiest, and Wolf, 1998; Smeets and Hove, 1997). The disinvestments inquiry 1991 was distributed to 1500 large companies in the manufacturing industry (all companies with 100 employees or more) and the response rate was higher than 90 percent (Smeets and Hove, 1997).

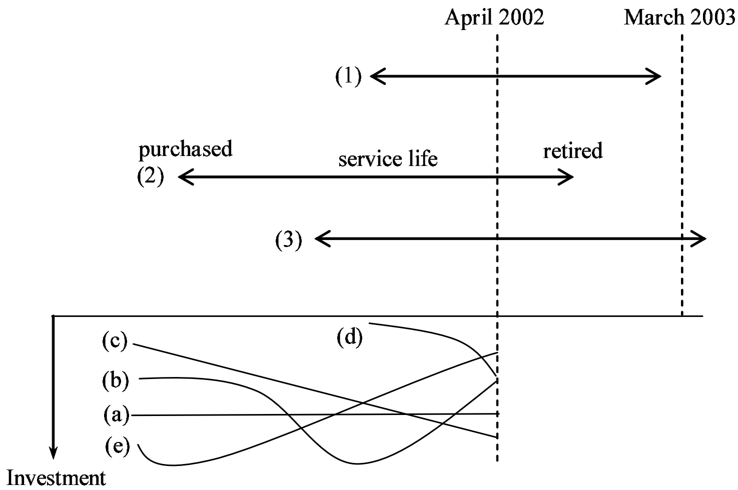


Fig. 6 Samples in the 2002-SASD and Investment Patterns

summed up among samples in different periods t, as

$$f^*_{\sum t}(\tau_i) = \sum_t f(\tau_i) I_{t-\tau_i} = f(\tau_i) \sum_t I_{t-\tau_i} = f(\tau_i)\Phi_{\tau_i}. \tag{17}$$

It can eliminate the bias to estimate the true $f(\tau)$ as $t \to \infty$, thanks to

$$\lim_{t\to\infty} \frac{\Phi_{\tau_i}}{\Phi_{\tau_i+\Delta}} = \frac{\Phi_{\tau_i}}{I_{t-(\tau_i+\Delta)} + \Phi_{\tau_i}} = \frac{1}{I_{t-(\tau_i+\Delta)}/\Phi_{\tau_i} + 1} = 1. \tag{18}$$

As the samples in different periods are pooled, Φ_{τ_i} can be treated as approximately constant and the biases may be reduced even in the case of non-stationary investment, under the assumption that the true pdf is unchanged over periods.

4.4 Adjustment to the Data from Single-Period Survey

Although multi-period survey is required to eliminate the biases, we examine a tentative adjustment to the single-period data in the 2002-SASD. We define the weights $\hat{\mathbf{w}}_v$, which consists of $\hat{w}_i(\tau)$, as

$$\hat{\mathbf{w}}_v = \frac{\mathbf{v} < \mathbf{a} >}{\mathbf{a}'\mathbf{v}}, \tag{19}$$

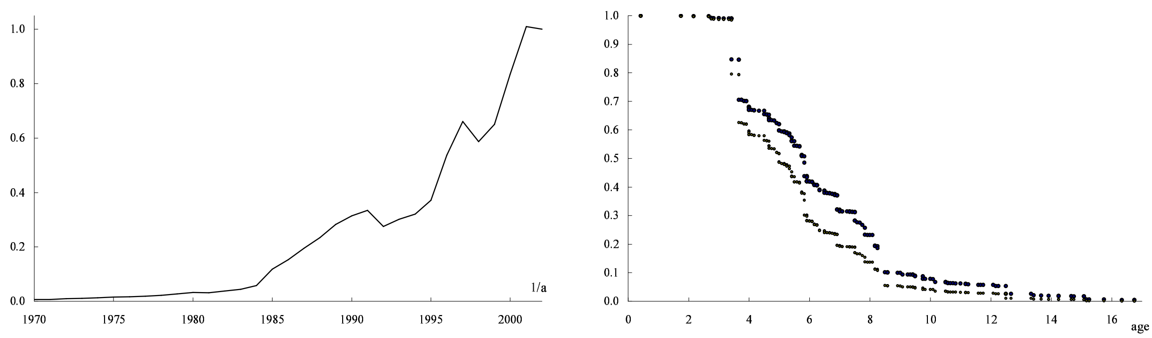
where $\mathbf{a}$ is the column vector consisting of the adjustment coefficients a_i and $< \cdot >$ is used to denote a diagonal matrix. As the adjustment coefficients a_i, we use the inverse of the quantity index of investment with the different vintages (t_i), to reduce the bias in the equation (16).

The adjusted actual age-survival distribution and average service life are :

$$S_{\widehat{v}}(\tau) \approx \mathbf{j}'\hat{\mathbf{w}}_v, \tag{20}$$

$$\bar{T}_{\widehat{v}} = \tau'\hat{\mathbf{w}}_v. \tag{21}$$

In the case of PC, we define a_i, approximately using the actual private investment of computers and peripherals at the constant price estimated in Nomura (2004). Figure 7 reports the quantity index of investment $1/a_i$ and the adjusted actual survival distribution $S_{\widehat{v}}(\tau)$ (the smaller dots represent $S_v(\tau)$ in Figure 3(b)). An upward trend in the PC's actual investment is substantial as shown in Figure 7(a). By the adjustment, the weight of the data with a shorter service life is reduced and one with a longer service life is emphasized. Thus, the adjusted distribution of the PC is more durable than $S_v(\tau)$. The adjusted measure of the asset service life $\bar{T}_{\widehat{v}}$ is 6.2 years, which is between 7.2 (for $S_0(\tau)$ in Figure 3(a)) and 5.4 years (for $S_v(\tau)$ in Figure 3(b)). [*17]



(a) Quantity Index of Investment

(b) $S_{\widehat{v}}(\tau)$

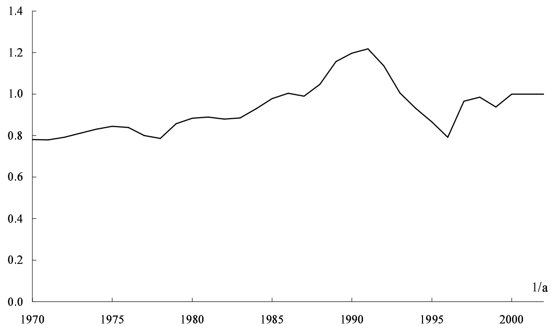
Fig. 7 Adjusted Actual Survival Distribution: Personal Computers: $S_{\widehat{v}}(\tau)$

Figure 8(a) represents the adjusted actual survival distribution of the office buildings (the smaller dots display $S_v(\tau)$ in Figure 4(b)), based on the similar adjustment procedure.[*18] The investment of the office buildings has a boom in the late 1980s, when the Japan was in the bubble economy. After this adjustment

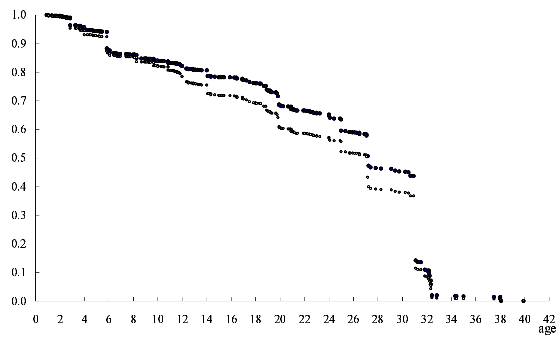
[*17] Based on more directly observed data for manufacturing, Meinen, Verbiest, and Wolf (1998) reports that it resulted in an average service life for computers of 12 years. They evaluate this estimate as too high and use 5 years as a best-practice estimate for their measurement of gross capital stock.

[*18] Here, the quantity index of investment is defined approximately as the real investment of non-residential buildings for the private sectors in Nomura (2004).

of the samples, the asset service life is 23.0 years, which is higher than 15.4 (for $S_0(\tau)$ in Figure 4(a)) and 22.2 years (for $S_v(\tau)$ in Figure 4(b)).



(a) Quantity Index of Investment



(b) $S_{\tilde{v}}(\tau)$

Fig. 8 Adjusted Actual Survival Distribution: Office Buildings: $S_{\tilde{v}}(\tau)$

4.5 Actual Average Service Lives

Next, we estimate the asset service lives for all assets, in the three definitions: $\bar{T}_0$, $\bar{T}_v$, and $\bar{T}_{\tilde{v}}$. Based on the 2002-SASD, we set 66 assets: 6-14.metal products, 15-33.general machinery, 34-47.electric machinery, 48-52.transportation equipment, 53-57.precision machinery, 60-66.buildings and construction. Table 2 reports the estimated results.

In general machinery, the assets that have shorter service lives are 31.copy machines ($\bar{T}_0$=7.9), 22.semi-conductor making equipment (9.2). In electric machinery, 38.personal computers (7.2), 39.mainframes and servers (7.4), 40.wired communication equipment (9.2), and 41.wireless communication equipment (9.8) have shorter lives.[*19] It may be reasonable that the IT-related assets have shouter service lives, reflecting the rapid technological progress.

The large differences between $\bar{T}_0$ and $\bar{T}_v$ are observed in buildings and construction and some of general machinery. That may imply that large-scale assets have a longer service life, reflecting the difference in the quality. Table 2 also represents some descriptive statistics for the service lives: median, minimum, maximum, and standard deviation. The minimum service lives for many assets are less than a few years. Even in buildings and construction, we could find a number of temporary buildings to be used

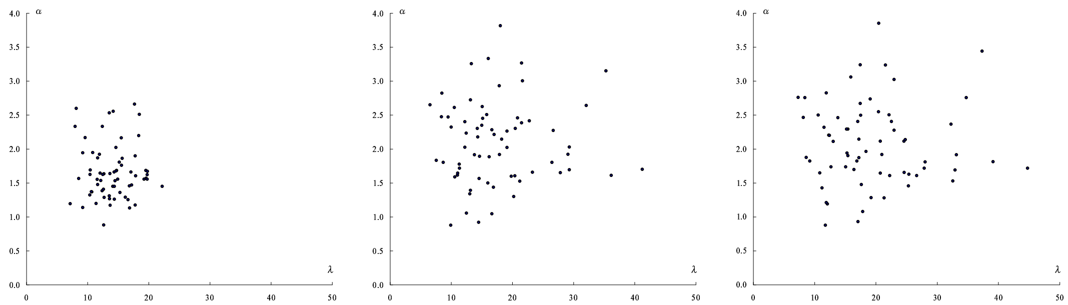
[*19] Note that there is less cellular phones in the samples. Thus, 41.wireless communication equipment almost consists of old-type radio communication equipment.

for construction or display, although they are the small-scale assets. It may be important to consider the difference in the scales among samples.

5 Measurement

5.1 Results on the 2002-SASD

Based on the actual survival distributions defined as $S_0(\tau)$, $S_v(\tau)$, and $S_{\widehat{v}}(\tau)$ in section 4, we estimate the parameters of the Weibull distribution. Equation (9) gives the estimation model of the log-linear relationship between the age and the cumulative hazard. Figures 11-16 show the actual age-survival distribution $S_0(\tau)$ and the approximation by the Weibull distribution in each asset. Undoubtedly, the simultaneous exit can not any proper approximation for all assets. Tables 3, 5, and 7 report the estimated parameters, based on $S_0(\tau)$ (Case-1), $S_v(\tau)$ (Case-2), and $S_{\widehat{v}}(\tau)$ (Case-3), respectively. Also, Tables 4, 6, and 8 represent age-survival profile of assets defined by the estimated Weibull distribution in each case.

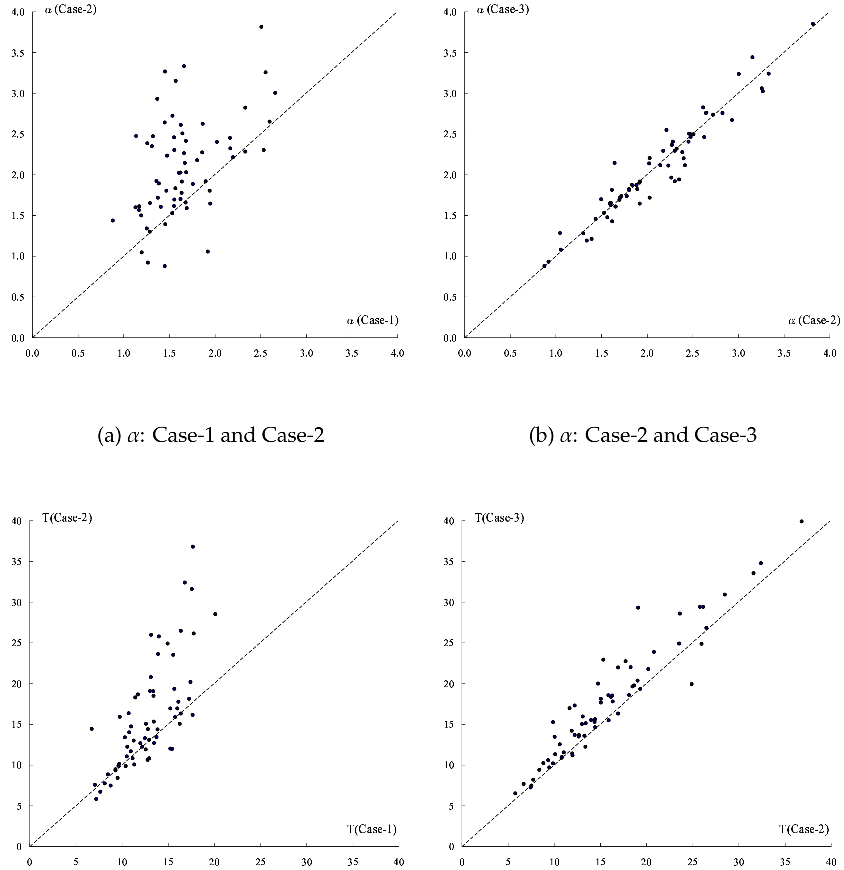


(a) Case-1 ($S_0(\tau)$) (b) Case-2 ($S_v(\tau)$) (c) Case-3 ($S_{\widehat{v}}(\tau)$)

Fig. 9 Distributions of Estimated Parameters: α and λ

Comparison of the parameters estimated in each case is reported in Figures 9 and 10. In Case-1, λ is between 10 and 20 in many assets. As we described the properties of scale parameter λ in section 3.2, average service life $\bar{T}$ is a little bit smaller than λ, where $\bar{T} = \lambda\Gamma(1 + \alpha^{-1})$. If the difference in the scales (and probably the number of assets) is considered, λ or $\bar{T}$ distributes in more wide range as represented in the comparison between Figure 9(a) and 9(b), emphasizing the large-scale assets with a longer service life. After the adjustment of the bias in the 2002-SASD, $\bar{T}$ tends to be slightly longer in Case-3, as shown in Figure 10(d).

Although α is between 1.0 and 2.5 in many assets in Case-1, it varies widely in Case-2 and Case-3. α



(a) α: Case-1 and Case-2

(b) α: Case-2 and Case-3

(c) $\bar{T}$: Case-1 and Case-2

(d) $\bar{T}$: Case-2 and Case-3

Fig. 10 Comparison of Estimated Parameters: α and $\bar{T}$

is a parameter to determine the hazard rates of assets, as represented in Figure 2(a). In the estimated results in the Netherlands (Meinen, Verbiest, and Wolf, 1998), the hazard rates in many assets tend to be regressively increasing ($1 < \alpha < 2$), except in computers. Computers have a progressively increasing hazard rate ($\alpha > 2$). In our results of Case-3, almost half of assets have a progressively increasing hazard rate. This may give properties on discard patterns in Japan, in comparison with the Netherlands.

5.2 Alternative Estimate: Registration Data

At the ESRI's National Wealth Division and Keio Economic Observatory (KEO), we are preparing the use of registration data for particular assets to recognize more adequate discard patterns in Japan. To compare the estimated results from different data sources, we introduce our preliminary results based on the Japan's registration data for passenger cars and trucks at the end of March 2004.[*20] There are two outstanding properties in the use of registration data. Firstly, all data for the motor vehicles which have a car license in Japan are collected. The number of possessed vehicles in March 2004 is 42,624,206 for passenger cars (excluding light vehicles) and 7,276,081 for trucks. Second, it can provide complete longitudinal data of duration, so that we could describe the actual picture of age-survival distribution.

Table 1 compares the estimated Weibull parameters (α and λ) and average service lives ($\bar{T}$) based on the 2002-SASD and 2004-registration data. In the estimates using registration data, the hazard rates in passenger cars and trucks are progressively increasing ($\alpha > 2$). Also, the estimates of $\bar{T}$ are very similar to our estimates in the 2002-SASD. Although the registration data includes vehicles owned by households and does not reflect the difference in the qualities of vehicles, our estimates in the 2002-SASD seems appropriate.

Table. 1 Comparison of Parameters in Motor Vehicles: 2002-SASD and 2004-Registration Data

	Passenger Cars			Trucks		
	α	λ	$\bar{T}$	α	λ	$\bar{T}$
Registration Data	2.16	12.3	10.9	2.12	12.6	11.2
2002-SASD						
Case-1	2.17	9.6	8.5	2.02	14.6	13.0
Case-2	2.32	10.0	8.8	2.40	12.2	10.8
Case-3	2.32	11.5	10.2	2.20	12.4	11.0

6 Concluding Remarks

As the first step for reframing measurement of capital in Japanese national accounts, we investigated the discard patterns by asset in this paper, based on the newly developed data for directly observed discards by ESRI: 2002-SASD. To improve our estimates and remove sample bias in the single-period survey, further continuous investigations on discards are required. Although we investigated the age-survival distributions in 66 assets, the difference in economic activities was not treated in this paper, due to the constraint of the sample size in each industry. However, we could find the average service life of PC may

[*20] We used the "Wagakuni no Jidousha Hoyuu Doukou", which means current possession status of motor vehicles in Japan, produced by Automobile Inspection and Registration Association (AIRA), supervised by Ministry of Land Infrastructure and Transport, Government of Japan. In this paper, we introduce our estimates only on the possession status in March 2004. We plan to report more detailed results of discard patterns based on some registration data in the end of 2005.

be somewhat longer in manufacturing sector than service sector.

For further investigation, the design of questionnaire in the 2002-SASD should be reconsidered: (1) It should be identified if the retired asset was originally new or second-hand at the period of the purchase. Without this identification, the asset service life may be biased downwardly; (2) The value of sold asset should be investigated based on the price at the period to be sold. It may make possible to produce estimates of age-price profile of the asset. (3) If company reports the aggregated value of retired asset, the number of asset should be investigated; (4) For some assets that considerably differ its qualities, e.g. buildings and construction, the questionnaire to recognize its characteristics is required, if it is possible; and (5) Investigation for intangible assets should be added.

In addition to the estimation based on the SASD, we plan to examine the different data sources. As we briefly report preliminary results for the passenger cars and trucks in this paper, the use of registration data may be preferable. By the use of the registration data, we may investigate the shift of age-survival distribution over periods.

Table. 2 Average Service Lives and Other Descriptive Statistics

		$\bar{T}_0$	$\bar{T}_v$	$\bar{T}_{\widehat{v}}$	smpl	median	min	max	stdev
1	Woods Products	7.2	8.0	8.0	13	6.1	3.4	18.3	3.8
2	Furniture	10.4	9.7	10.1	309	9.3	0.1	32.8	6.8
3	Steel Pipes and Tubes	17.3	17.2	17.5	47	15.8	2.3	41.3	10.6
4	Electric Wires and Cables	9.9	11.2	11.2	43	7.7	1.3	42.6	8.0
5	Optical Fiber Cable	6.2	8.7	8.9	21	5.0	0.5	12.5	3.6
6	Metal Products for Architecture	14.8	10.8	9.7	12	14.2	2.2	29.6	8.5
7	Gas and Oil Appliances	16.0	19.3	19.3	19	14.7	5.9	27.5	6.2
8	Metal Containers	17.2	19.7	20.8	72	17.3	1.4	33.8	9.0
9	Metal Tools	8.3	4.4	4.2	49	5.8	0.1	26.8	6.3
10	Plumber Supplies	10.5	13.4	12.1	20	9.6	3.8	21.3	5.9
11	Metal Strongboxes	15.6	12.6	11.6	5	13.0	5.2	28.0	8.5
12	Boiler and Engines	16.2	15.9	22.0	58	13.1	2.3	39.2	10.5
13	Pumps and Compressors	12.6	11.7	14.9	51	11.8	0.3	39.9	9.3
14	Metal Machine Tools	17.4	15.6	17.8	66	15.9	1.6	40.2	9.3
15	Metal Processing Machinery	14.3	23.6	18.5	113	12.3	0.3	40.3	9.4
16	Machinists' Precision Tools	16.6	14.9	17.7	10	16.5	6.6	29.4	6.9
17	Industrial Robots	10.8	9.9	12.1	12	9.6	3.3	18.3	5.2
18	Construction Machinery	11.2	12.6	14.3	83	10.8	0.6	33.4	7.6
19	Food Processing Machinery	13.1	19.7	18.9	78	11.7	1.3	36.3	7.9
20	Printing and Bookbinding Machinery	12.7	14.1	16.0	34	11.2	1.5	28.3	7.0
21	Chemical Machinery	13.8	22.7	25.4	155	12.0	0.7	40.9	9.4
22	Semiconductor Making Equipment	9.2	8.4	9.6	39	7.8	0.8	26.7	6.0
23	Other Office Machinery	12.8	11.7	14.8	24	12.1	4.2	25.8	5.2
24	Machinery for Service Industry	10.6	10.7	19.6	83	10.8	0.7	40.2	6.4
25	Conveyors	10.4	10.5	11.3	47	9.6	0.5	30.8	6.7
26	Wrapping and Packing Machinery	14.0	29.8	33.8	49	12.1	1.9	41.3	8.1
27	Casting Equipment	15.7	13.8	13.5	10	11.3	6.0	36.8	10.2
28	Plastic Processing Machinery	13.7	12.9	14.3	18	13.3	3.1	22.0	5.1
29	Industrial Furnaces	16.3	25.6	26.6	30	15.8	1.3	34.3	11.0
30	Combustion Furnaces	11.1	16.8	21.3	115	9.7	2.0	30.7	6.2
31	Copy Machines	7.9	7.0	7.6	39	7.2	0.6	15.3	3.2
32	Refrigerators and Air Conditioning Apparatus	13.6	10.8	12.6	72	12.0	1.9	33.3	7.8
33	Other Industrial Heavy Electrical Equipment	11.7	17.6	20.0	107	9.6	1.2	43.0	8.9
34	Television and Video Equipment	9.8	11.1	12.3	58	8.4	0.1	22.4	6.3
35	Air Conditioners	13.8	14.5	15.8	315	12.5	0.5	40.8	7.8
36	Electric Appliances for Kitchen	13.0	18.6	25.6	98	11.6	0.5	39.3	8.3
37	Electric Ligthting Fixtures and Apparatus	12.4	9.1	10.2	20	12.0	1.8	23.3	6.3
38	Personal Computers	7.2	5.4	6.2	224	6.3	0.4	19.3	3.3
39	Mainframes and Servers	7.4	6.6	7.6	134	6.8	0.1	21.4	4.3
40	Wired Communication Equipment	9.2	8.7	9.8	159	8.8	0.3	28.3	5.3
41	Wireless Communication Equipment	9.8	9.3	14.2	24	8.1	3.9	25.6	5.9
42	Applied Electronic Equipment	11.0	9.6	14.1	132	10.6	0.5	31.4	5.9
43	Electric Measuring Instruments	16.7	14.1	18.0	23	13.9	5.5	34.9	7.5
44	Generators and Motors	17.1	25.5	26.2	32	15.8	1.1	36.8	9.3
45	Relay Switches and Switchboards	12.5	15.2	20.7	22	12.7	0.8	35.6	10.4
46	Transformers and Reactors	14.9	16.3	19.6	51	13.7	0.3	37.6	9.7
47	Batteries	11.2	11.1	11.2	15	9.9	2.1	22.4	6.0
48	Passenger Cars	8.4	8.7	9.8	261	7.9	0.5	20.5	3.8
49	Trucks	12.1	10.8	10.9	54	12.1	0.6	20.3	3.6
50	Buses	11.7	15.4	16.1	31	12.8	0.7	22.3	5.3
51	Ships	16.6	21.4	21.6	43	14.8	1.9	49.0	11.6
52	Transport Equipment for Industry Use	15.3	15.4	16.3	315	14.8	0.2	37.5	7.0
53	Photographic and Optical Instruments	11.6	11.2	12.3	26	11.9	0.5	27.3	6.4
54	Professional and Scientific Instruments	12.2	11.4	11.7	41	11.1	0.5	41.4	8.6
55	Analytical Instruments	11.9	12.3	12.9	65	11.7	1.8	20.9	4.2
56	Measuring Instruments	11.9	11.7	12.8	163	11.6	0.5	32.6	6.5
57	Testing Instruments	12.9	14.9	15.4	33	12.3	1.3	29.8	6.5
58	Information Recording Media	9.3	8.2	8.5	15	9.9	2.3	16.0	4.6
59	Miscellaneous Products	9.8	10.2	11.7	299	8.0	0.3	36.1	7.2
60	Residential Buildings	19.6	27.1	28.3	21	21.0	3.1	33.0	10.4
61	Storehouses	17.3	25.5	26.2	82	14.9	0.8	40.8	9.3
62	Office Buildings	15.4	22.2	23.0	261	13.6	0.9	39.9	9.7
63	Stores	13.4	20.9	23.4	58	10.6	2.4	38.9	9.3
64	Factories	17.2	23.0	24.3	89	15.8	0.7	42.7	9.6
65	Road and Parking Areas	11.6	16.5	17.0	192	10.9	0.2	32.7	8.2
66	Other Construction	10.8	12.5	13.2	105	10.5	1.2	31.9	6.6
	Simple Average	12.6	14.3	15.8	81.3	11.5	1.6	31.4	7.3

Table. 3 Estimates of the Weibull Distribution: Case-1 ($S_0(\tau)$)

		α	(t-value)	β	(t-value)	λ	$\bar{T}$	adj R^2	smpl
1	Wood Products	2.33	7.5	-4.84	-8.1	8.0	7.1	0.823	13
2	Furniture	1.55	139.3	-3.80	-152.8	11.6	10.4	0.984	309
3	Steel Pipes and Tubes	1.55	51.9	-4.60	-56.3	19.2	17.3	0.983	47
4	Electric Wires and Cables	1.37	32.2	-3.24	-35.4	10.7	9.8	0.961	43
5	Optical Fiber Cable	1.19	13.2	-2.35	-14.5	7.1	6.7	0.897	21
6	Metal Products for Architecture	1.25	10.7	-3.52	-11.6	16.6	15.5	0.911	12
7	Gas and Oil Appliances	2.66	32.8	-7.64	-34.6	17.7	15.7	0.984	19
8	Metal Containers	1.68	62.2	-5.00	-67.4	19.5	17.4	0.982	72
9	Metal Tools	1.14	24.0	-2.53	-26.4	9.2	8.8	0.923	49
10	Plumber Supplies	1.87	15.6	-4.58	-16.9	11.6	10.3	0.928	20
11	Metal Strongboxes	1.46	6.9	-4.11	-7.4	16.8	15.2	0.922	5
12	Boiler and Engines	1.61	49.1	-4.63	-53.4	17.8	16.0	0.977	58
13	Pumps and Compressors	1.17	56.8	-3.06	-62.4	13.7	13.0	0.985	51
14	Metal Machine Tools	1.67	54.0	-4.99	-58.5	19.8	17.7	0.978	66
15	Metal Processing Machinery	1.29	65.4	-3.59	-71.8	16.2	14.9	0.974	113
16	Machinists' Precision Tools	2.20	14.1	-6.40	-14.9	18.4	16.3	0.957	10
17	Industrial Robots	1.92	16.6	-4.76	-17.8	11.9	10.6	0.961	12
18	Construction Machinery	1.39	92.7	-3.48	-101.7	12.4	11.3	0.991	83
19	Food Processing Machinery	1.68	57.9	-4.53	-63.0	14.7	13.2	0.978	78
20	Printing and Bookbinding Machinery	1.66	39.9	-4.42	-43.3	14.3	12.8	0.980	34
21	Chemical Machinery	1.36	122.9	-3.71	-134.8	15.3	14.0	0.990	155
22	Semiconductor Making Equipment	1.32	28.1	-3.09	-30.9	10.4	9.6	0.954	39
23	Other Office Machinery	2.56	35.3	-6.78	-37.5	14.2	12.6	0.982	24
24	Machinery for Service Industry	1.54	37.7	-3.84	-41.4	12.2	11.0	0.945	83
25	Conveyors	1.48	36.6	-3.62	-40.1	11.6	10.5	0.967	47
26	Wrapping and Packing Machinery	1.86	41.0	-5.12	-44.3	15.7	13.9	0.972	49
27	Casting Equipment	1.66	7.3	-4.72	-7.8	17.1	15.3	0.853	10
28	Plastic Processing Machinery	2.16	13.5	-5.94	-14.4	15.5	13.7	0.914	18
29	Industrial Furnaces	1.17	25.7	-3.38	-28.2	17.8	16.8	0.958	30
30	Combustion Furnaces	2.33	36.5	-5.87	-39.4	12.4	11.0	0.921	115
31	Copy Machines	1.94	14.6	-4.31	-15.9	9.2	8.2	0.847	39
32	Refrigerators and Air Conditioning Apparatus	1.80	97.1	-4.91	-105.3	15.2	13.5	0.993	72
33	Other Industrial Heavy Electrical Equipment	1.41	65.4	-3.57	-71.9	12.6	11.5	0.976	107
34	Television and Video Equipment	1.20	25.9	-2.91	-28.6	11.4	10.7	0.922	58
35	Air Conditioners	1.76	208.9	-4.82	-227.2	15.5	13.8	0.993	315
36	Electric Appliances for Kitchen	1.53	110.8	-4.10	-121.1	14.5	13.0	0.992	98
37	Electric Ligthting Fixtures and Apparatus	1.45	18.4	-3.84	-20.1	14.1	12.8	0.944	21
38	Personal Computers	2.60	53.3	-5.45	-57.7	8.1	7.2	0.927	224
39	Mainframes and Servers	1.57	48.6	-3.36	-53.6	8.5	7.7	0.947	134
40	Wired Communication Equipment	1.63	136.8	-3.80	-150.0	10.4	9.3	0.992	159
41	Wireless Communication Equipment	1.95	14.0	-4.64	-15.2	10.8	9.6	0.895	24
42	Applied Electronic Equipment	1.63	58.6	-4.15	-64.2	12.7	11.3	0.963	132
43	Electric Measuring Instruments	2.51	21.2	-7.32	-22.5	18.5	16.4	0.953	23
44	Generators and Motors	1.57	21.3	-4.67	-23.1	19.5	17.6	0.936	32
45	Relay Switches and Switchboards	0.88	16.7	-2.24	-18.3	12.6	13.4	0.930	22
46	Transformers and Reactors	1.13	34.8	-3.19	-38.3	16.9	16.1	0.960	51
47	Batteries	1.62	15.6	-4.10	-16.9	12.5	11.2	0.945	15
48	Passenger Cars	2.17	128.2	-4.90	-139.3	9.6	8.5	0.984	261
49	Trucks	2.02	11.3	-5.43	-12.3	14.6	13.0	0.705	54
50	Buses	1.26	11.1	-3.36	-12.3	14.4	13.4	0.804	31
51	Ships	1.45	56.3	-4.20	-61.3	14.4	16.4	0.987	43
52	Transport Equipment for Industry Use	1.90	75.4	-5.46	-81.6	17.8	15.8	0.948	315
53	Photographic and Optical Instruments	1.27	15.3	-3.30	-16.8	13.6	12.6	0.903	26
54	Professional and Scientific Instruments	1.31	37.9	-3.41	-41.6	13.6	12.5	0.973	41
55	Analytical Instruments	2.53	29.8	-6.60	-31.9	13.5	12.0	0.933	65
56	Measuring Instruments	1.64	81.1	-4.29	-88.7	13.7	12.2	0.976	163
57	Testing Instruments	1.55	21.5	-4.20	-23.4	14.9	13.4	0.935	33
58	Information Recording Media	1.69	16.7	-3.97	-18.1	10.4	9.3	0.952	15
59	Miscellaneous Products	1.37	282.1	-3.24	-309.7	10.6	9.7	0.996	299
60	Residential Buildings	1.45	17.4	-4.50	-18.9	22.2	20.1	0.938	21
61	Storehouses	1.62	47.4	-4.84	-51.5	19.7	17.7	0.965	82
62	Office Buildings	1.47	132.1	-4.18	-144.5	17.2	15.6	0.985	261
63	Stores	1.68	35.5	-4.51	-38.6	14.7	13.1	0.957	58
64	Factories	1.56	52.3	-4.64	-56.9	19.8	17.8	0.969	89
65	Road and Parking Areas	1.29	147.1	-3.27	-161.6	12.7	11.7	0.991	192
66	Other Construction	1.64	86.3	-4.09	-94.3	12.1	10.8	0.986	105

Table. 4 The Weibull Survival Rates: Case-1($S_0(\tau)$)

		0	5	10	15	20	30	40	50	60
1	Wood Products	100	71.4	18.3	1.3	0.0	0.0	0.0	0.0	0.0
2	Furniture	100	76.2	45.1	22.4	9.6	1.2	0.1	0.0	0.0
3	Steel Pipes and Tubes	100	88.4	69.6	50.7	34.5	13.6	4.4	1.2	0.3
4	Electric Wires and Cables	100	70.2	40.1	20.4	9.5	1.6	0.2	0.0	0.0
5	Optical Fiber Cable	100	52.0	22.4	8.8	3.3	0.4	0.0	0.0	0.0
6	Metal Products for Architecture	100	80.1	58.9	41.5	28.3	12.3	4.9	1.9	0.7
7	Gas and Oil Appliances	100	96.6	80.2	52.3	24.8	1.7	0.0	0.0	0.0
8	Metal Containers	100	90.4	72.3	52.6	35.2	12.7	3.5	0.8	0.1
9	Metal Tools	100	60.7	33.4	17.5	8.9	2.2	0.5	0.1	0.0
10	Plumber Supplies	100	81.3	47.1	20.1	6.4	0.3	0.0	0.0	0.0
11	Metal Strongboxes	100	84.3	62.5	42.9	27.6	9.8	2.9	0.8	0.2
12	Boiler and Engines	100	87.8	67.4	46.9	30.1	10.0	2.6	0.5	0.1
13	Pumps and Compressors	100	73.5	50.1	32.9	21.1	8.2	3.0	1.1	0.4
14	Metal Machine Tools	100	90.4	72.6	53.2	36.1	13.4	3.9	0.9	0.2
15	Metal Processing Machinery	100	80.2	58.4	40.3	26.8	10.8	4.0	1.4	0.4
16	Machinists' Precision Tools	100	94.4	76.9	52.6	29.9	5.3	0.4	0.0	0.0
17	Industrial Robots	100	82.8	49.0	21.1	6.7	0.3	0.0	0.0	0.0
18	Construction Machinery	100	75.2	47.5	27.1	14.3	3.3	0.6	0.1	0.0
19	Food Processing Machinery	100	85.0	59.4	35.7	18.8	3.6	0.5	0.0	0.0
20	Printing and Bookbinding Machinery	100	84.1	57.7	34.0	17.6	3.3	0.4	0.0	0.0
21	Chemical Machinery	100	80.4	57.0	37.7	23.7	8.2	2.5	0.7	0.2
22	Semiconductor Making Equipment	100	68.3	38.6	19.6	9.2	1.7	0.3	0.0	0.0
23	Other Office Machinery	100	93.3	66.4	31.5	9.0	0.1	0.0	0.0	0.0
24	Machinery for Service Industry	100	77.5	47.7	25.2	11.7	1.8	0.2	0.0	0.0
25	Conveyors	100	75.1	45.0	23.4	10.8	1.8	0.2	0.0	0.0
26	Wrapping and Packing Machinery	100	88.8	64.8	39.8	20.7	3.5	0.3	0.0	0.0
27	Casting Equipment	100	87.8	66.3	44.6	27.2	7.8	1.6	0.3	0.0
28	Plastic Processing Machinery	100	91.7	67.9	39.5	17.7	1.5	0.0	0.0	0.0
29	Industrial Furnaces	100	79.8	60.1	44.1	31.7	15.8	7.5	3.5	1.6
30	Combustion Furnaces	100	88.6	54.5	21.0	4.7	0.0	0.0	0.0	0.0
31	Copy Machines	100	73.6	30.8	7.5	1.1	0.0	0.0	0.0	0.0
32	Refrigerators and Air Conditioning Apparatus	100	87.4	62.4	37.6	19.3	3.3	0.3	0.0	0.0
33	Other Industrial Heavy Electrical Equipment	100	76.1	48.5	27.8	14.7	3.3	0.6	0.1	0.0
34	Television and Video Equipment	100	68.8	42.5	24.9	14.0	4.1	1.1	0.3	0.1
35	Air Conditioners	100	87.3	63.1	39.1	21.1	4.2	0.5	0.0	0.0
36	Electric Appliances for Kitchen	100	82.2	56.7	34.8	19.4	4.7	0.9	0.1	0.0
37	Electric Ligthting Fixtures and Apparatus	100	80.1	54.5	33.5	19.0	5.1	1.1	0.2	0.0
38	Personal Computers	100	75.4	18.0	0.7	0.0	0.0	0.0	0.0	0.0
39	Mainframes and Servers	100	64.8	27.7	8.9	2.2	0.1	0.0	0.0	0.0
40	Wired Communication Equipment	100	73.7	39.0	16.2	5.5	0.4	0.0	0.0	0.0
41	Wireless Communication Equipment	100	80.1	42.6	15.2	3.7	0.1	0.0	0.0	0.0
42	Applied Electronic Equipment	100	80.4	50.7	26.8	12.2	1.7	0.1	0.0	0.0
43	Electric Measuring Instruments	100	96.3	80.7	55.3	29.5	3.4	0.1	0.0	0.0
44	Generators and Motors	100	88.9	70.5	51.7	35.5	14.1	4.6	1.3	0.3
45	Relay Switches and Switchboards	100	64.3	44.3	31.2	22.3	11.7	6.3	3.5	1.9
46	Transformers and Reactors	100	77.6	57.5	41.6	29.7	14.7	7.0	3.3	1.5
47	Batteries	100	79.7	49.8	26.0	11.6	1.6	0.1	0.0	0.0
48	Passenger Cars	100	78.4	33.4	7.1	0.7	0.0	0.0	0.0	0.0
49	Trucks	100	89.2	63.0	35.0	15.3	1.4	0.0	0.0	0.0
50	Buses	100	76.8	53.1	34.9	22.0	8.0	2.7	0.8	0.2
51	Ships	100	80.6	55.5	34.6	19.9	5.5	1.2	0.2	0.0
52	Transport Equipment for Industry Use	100	91.4	71.5	48.4	28.6	6.7	0.9	0.1	0.0
53	Photographic and Optical Instruments	100	75.4	50.7	32.1	19.5	6.5	2.0	0.5	0.1
54	Professional and Scientific Instruments	100	76.3	51.1	31.9	18.9	5.9	1.6	0.4	0.1
55	Analytical Instruments	100	92.3	62.8	27.3	6.8	0.1	0.0	0.0	0.0
56	Measuring Instruments	100	82.5	54.9	31.1	15.4	2.6	0.3	0.0	0.0
57	Testing Instruments	100	83.3	58.5	36.5	20.7	5.2	1.0	0.1	0.0
58	Information Recording Media	100	75.0	39.4	15.8	4.9	0.3	0.0	0.0	0.0
59	Miscellaneous Products	100	70.1	39.8	20.0	9.2	1.6	0.2	0.0	0.0
60	Residential Buildings	100	89.1	73.0	56.7	42.3	21.2	9.5	3.9	1.4
61	Storehouses	100	89.8	71.8	52.7	36.0	13.9	4.3	1.1	0.2
62	Office Buildings	100	85.0	63.7	44.1	28.7	10.4	3.2	0.8	0.2
63	Stores	100	84.9	59.2	35.5	18.7	3.6	0.5	0.0	0.0
64	Factories	100	88.9	70.7	52.1	36.1	14.7	5.0	1.4	0.4
65	Road and Parking Areas	100	73.9	47.9	28.9	16.6	4.9	1.3	0.3	0.1
66	Other Construction	100	79.0	48.0	23.9	10.1	1.1	0.1	0.0	0.0

Table. 5 Estimates of the Weibull Distribution: Case-2 ($S_v(\tau)$)

		α	(t-value)	β	(t-value)	λ	$\bar{T}$	adj R^2	smpl
1	Wood Products	2.82	4.3	-6.03	-4.8	8.5	7.5	0.597	13
2	Furniture	1.62	77.5	-3.88	-83.3	11.0	9.9	0.951	309
3	Steel Pipes and Tubes	2.30	25.4	-6.95	-28.1	20.5	18.1	0.933	47
4	Electric Wires and Cables	2.93	12.3	-8.44	-16.4	17.8	15.9	0.781	43
5	Optical Fiber Cable	1.50	7.8	-4.16	-12.0	16.0	14.4	0.747	21
6	Metal Products for Architecture	1.34	11.6	-3.43	-11.5	13.0	12.0	0.924	12
7	Gas and Oil Appliances	3.00	18.5	-9.24	-20.8	21.7	19.3	0.950	19
8	Metal Containers	2.41	63.9	-7.55	-72.9	22.8	20.2	0.983	72
9	Metal Tools	2.48	10.3	-5.27	-10.9	8.4	7.5	0.687	49
10	Plumber Supplies	2.63	13.8	-7.12	-16.6	15.1	13.4	0.909	20
11	Metal Strongboxes	1.39	7.4	-3.59	-7.1	13.1	12.0	0.930	5
12	Boiler and Engines	2.02	31.9	-5.97	-35.5	19.1	16.9	0.947	58
13	Pumps and Compressors	1.56	23.0	-4.19	-25.8	14.6	13.1	0.913	51
14	Metal Machine Tools	2.14	40.9	-6.23	-43.2	18.2	16.2	0.963	66
15	Metal Processing Machinery	1.65	44.7	-5.49	-58.8	27.8	24.9	0.947	113
16	Machinists' Precision Tools	2.21	6.9	-6.27	-7.1	17.0	15.1	0.838	10
17	Industrial Robots	1.06	8.9	-2.67	-9.7	12.5	12.2	0.876	12
18	Construction Machinery	1.89	50.3	-5.08	-59.0	14.7	13.0	0.969	83
19	Food Processing Machinery	2.03	27.6	-6.85	-37.7	29.3	26.0	0.908	78
20	Printing and Bookbinding Machinery	3.33	14.8	-9.25	-16.7	16.1	14.4	0.868	34
21	Chemical Machinery	1.92	71.9	-6.48	-97.5	29.1	25.8	0.971	155
22	Semiconductor Making Equipment	2.47	28.8	-5.56	-30.4	9.5	8.4	0.956	39
23	Other Office Machinery	3.26	20.2	-8.42	-20.9	13.3	11.9	0.946	24
24	Machinery for Service Industry	2.72	32.1	-7.01	-36.4	13.1	11.7	0.926	83
25	Conveyors	2.23	18.4	-5.64	-20.8	12.5	11.0	0.881	47
26	Wrapping and Packing Machinery	2.27	19.0	-7.46	-24.6	26.7	23.6	0.883	49
27	Casting Equipment	2.26	3.8	-6.68	-4.2	19.1	16.9	0.600	10
28	Plastic Processing Machinery	2.45	12.2	-6.66	-12.9	15.1	13.4	0.897	18
29	Industrial Furnaces	1.61	14.0	-5.79	-19.1	36.2	32.4	0.870	30
30	Combustion Furnaces	2.28	26.0	-6.42	-31.4	16.7	14.8	0.856	115
31	Copy Machines	1.80	14.0	-3.89	-14.9	8.7	7.7	0.837	39
32	Refrigerators and Air Conditioning Apparatus	2.18	13.7	-5.80	-14.5	14.3	12.7	0.724	72
33	Other Industrial Heavy Electrical Equipment	1.60	42.5	-4.84	-55.5	20.4	18.3	0.944	107
34	Television and Video Equipment	1.05	16.4	-2.94	-21.0	16.6	16.4	0.825	58
35	Air Conditioners	1.88	129.9	-5.25	-143.4	16.2	14.4	0.982	315
36	Electric Appliances for Kitchen	1.53	45.2	-4.66	-56.5	21.2	19.1	0.955	98
37	Electric Ligthting Fixtures and Apparatus	0.88	11.4	-2.01	-13.7	9.9	10.6	0.865	21
38	Personal Computers	2.65	27.7	-4.97	-26.9	6.5	5.8	0.775	224
39	Mainframes and Servers	1.83	44.2	-3.70	-45.9	7.5	6.7	0.936	134
40	Wired Communication Equipment	2.61	80.2	-6.15	-88.4	10.5	9.4	0.976	159
41	Wireless Communication Equipment	1.65	10.5	-3.95	-11.5	11.1	9.9	0.826	24
42	Applied Electronic Equipment	1.78	43.4	-4.31	-45.4	11.3	10.1	0.935	132
43	Electric Measuring Instruments	3.82	9.0	-11.04	-9.4	18.0	16.3	0.784	23
44	Generators and Motors	3.15	13.2	-11.24	-17.1	35.3	31.6	0.847	32
45	Relay Switches and Switchboards	1.44	22.0	-4.06	-26.7	16.9	15.3	0.958	22
46	Transformers and Reactors	1.60	20.2	-4.78	-23.4	19.8	17.8	0.890	51
47	Batteries	2.03	9.6	-5.07	-10.3	12.2	10.8	0.867	15
48	Passenger Cars	2.32	102.2	-5.35	-113.1	10.0	8.8	0.976	261
49	Trucks	2.40	15.0	-6.01	-15.2	12.2	10.8	0.809	54
50	Buses	2.38	11.1	-7.31	-14.2	21.5	19.0	0.803	31
51	Ships	3.27	26.7	-11.06	-34.0	21.5	26.5	0.944	43
52	Transport Equipment for Industry Use	1.92	76.2	-5.53	-82.7	17.9	15.9	0.949	315
53	Photographic and Optical Instruments	0.92	9.5	-2.46	-10.7	14.5	15.1	0.780	26
54	Professional and Scientific Instruments	2.35	20.7	-6.36	-23.6	15.0	13.3	0.914	41
55	Analytical Instruments	2.30	27.4	-6.12	-29.9	14.3	12.7	0.921	65
56	Measuring Instruments	1.92	73.3	-5.02	-80.4	13.8	12.2	0.971	163
57	Testing Instruments	2.46	10.9	-7.46	-13.4	20.8	18.5	0.787	33
58	Information Recording Media	1.59	5.7	-3.75	-6.3	10.6	9.5	0.696	15
59	Miscellaneous Products	1.72	120.0	-4.17	-135.6	11.4	10.1	0.980	299
60	Residential Buildings	2.64	15.4	-9.16	-18.7	32.1	28.5	0.922	21
61	Storehouses	1.70	22.4	-6.33	-30.3	41.2	36.8	0.861	82
62	Office Buildings	1.80	52.0	-5.90	-65.5	26.5	23.5	0.912	261
63	Stores	1.66	33.2	-5.21	-42.3	23.3	20.8	0.951	58
64	Factories	1.70	31.2	-5.73	-38.4	29.3	26.1	0.917	89
65	Road and Parking Areas	1.30	41.7	-3.91	-54.1	20.2	18.7	0.901	192
66	Other Construction	2.51	25.4	-6.92	-30.8	15.8	14.0	0.861	105

Table. 6 The Weibull Survival Rates: Case-2($S_v(\tau)$)

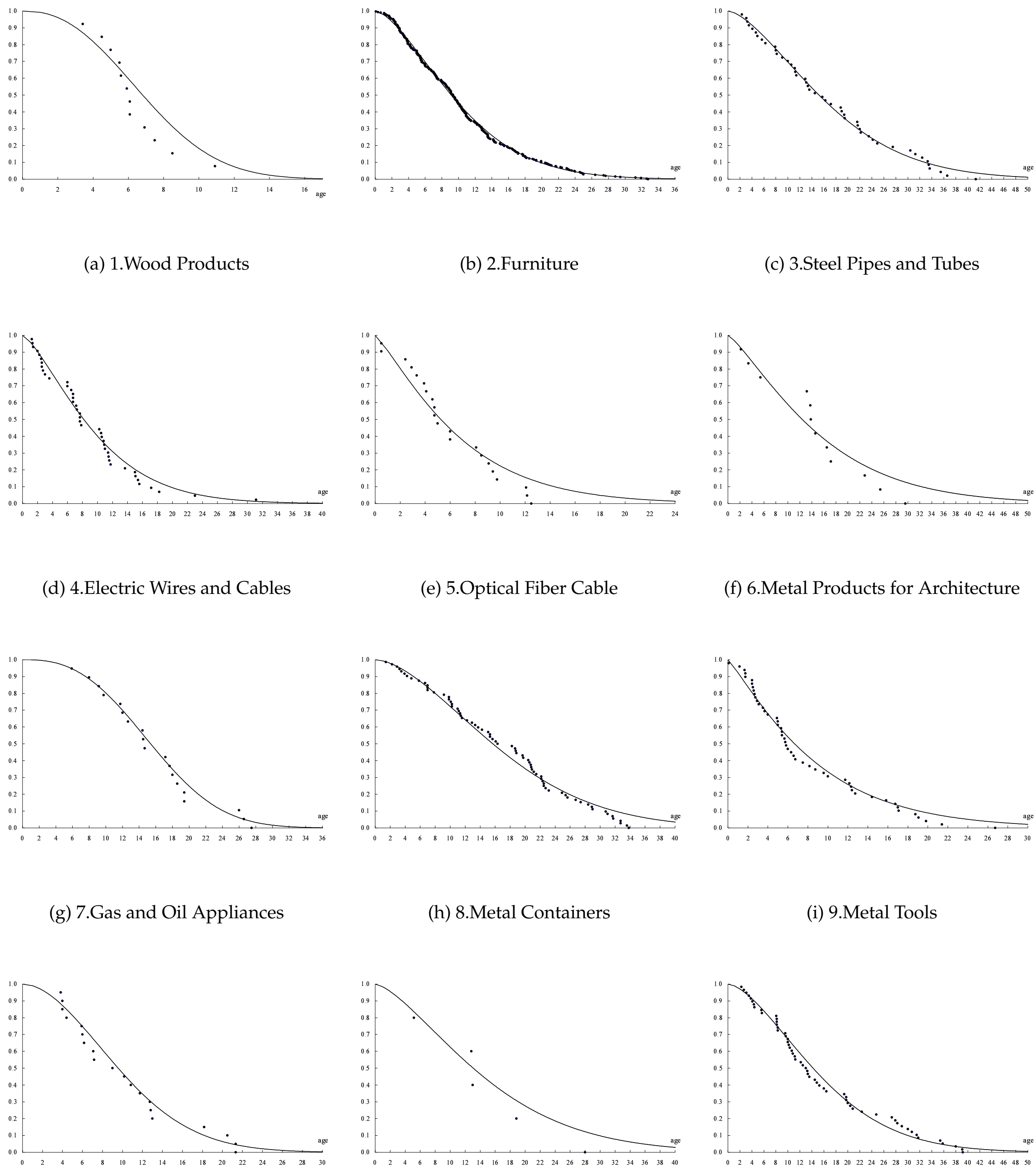
		0	5	10	15	20	30	40	50	60
1	Wood Products	100	79.8	20.3	0.7	0.0	0.0	0.0	0.0	0.0
2	Furniture	100	75.7	42.6	19.4	7.3	0.6	0.0	0.0	0.0
3	Steel Pipes and Tubes	100	96.2	82.5	61.3	38.7	8.9	0.9	0.0	0.0
4	Electric Wires and Cables	100	97.6	83.2	54.7	24.7	1.0	0.0	0.0	0.0
5	Optical Fiber Cable	100	84.0	61.0	40.4	24.7	7.7	1.9	0.4	0.1
6	Metal Products for Architecture	100	75.8	49.6	29.9	17.0	4.7	1.1	0.2	0.0
7	Gas and Oil Appliances	100	98.8	90.6	71.7	45.5	7.0	0.2	0.0	0.0
8	Metal Containers	100	97.5	87.2	69.4	48.2	14.3	2.0	0.1	0.0
9	Metal Tools	100	75.9	21.5	1.5	0.0	0.0	0.0	0.0	0.0
10	Plumber Supplies	100	94.6	71.2	37.3	12.2	0.2	0.0	0.0	0.0
11	Metal Strongboxes	100	77.1	50.5	30.1	16.6	4.3	0.9	0.2	0.0
12	Boiler and Engines	100	93.6	76.3	54.2	33.4	8.3	1.2	0.1	0.0
13	Pumps and Compressors	100	82.9	57.4	35.1	19.4	4.5	0.8	0.1	0.0
14	Metal Machine Tools	100	94.0	75.9	51.8	29.6	5.5	0.5	0.0	0.0
15	Metal Processing Machinery	100	94.3	83.2	69.8	56.1	32.3	16.2	7.2	2.9
16	Machinists' Precision Tools	100	93.6	73.5	46.9	23.9	3.0	0.1	0.0	0.0
17	Industrial Robots	100	68.4	45.4	29.7	19.3	8.0	3.3	1.3	0.5
18	Construction Machinery	100	87.7	61.5	35.2	16.5	2.1	0.1	0.0	0.0
19	Food Processing Machinery	100	97.3	89.3	77.4	63.1	35.1	15.3	5.2	1.4
20	Printing and Bookbinding Machinery	100	98.0	81.4	45.2	12.6	0.0	0.0	0.0	0.0
21	Chemical Machinery	100	96.7	87.9	75.6	61.4	34.6	15.8	5.9	1.8
22	Semiconductor Making Equipment	100	81.4	32.0	4.5	0.2	0.0	0.0	0.0	0.0
23	Other Office Machinery	100	95.9	67.3	22.6	2.3	0.0	0.0	0.0	0.0
24	Machinery for Service Industry	100	93.1	62.2	23.8	4.3	0.0	0.0	0.0	0.0
25	Conveyors	100	87.8	54.3	22.0	5.6	0.1	0.0	0.0	0.0
26	Wrapping and Packing Machinery	100	97.8	89.8	76.3	59.4	27.1	8.1	1.5	0.2
27	Casting Equipment	100	95.3	79.4	56.1	33.1	6.3	0.5	0.0	0.0
28	Plastic Processing Machinery	100	93.6	69.7	37.6	13.8	0.5	0.0	0.0	0.0
29	Industrial Furnaces	100	96.0	88.2	78.5	68.1	47.7	30.9	18.5	10.4
30	Combustion Furnaces	100	93.8	73.2	45.5	21.9	2.2	0.1	0.0	0.0
31	Copy Machines	100	69.1	27.6	6.9	1.1	0.0	0.0	0.0	0.0
32	Refrigerators and Air Conditioning Apparatus	100	90.4	63.4	33.2	12.7	0.7	0.0	0.0	0.0
33	Other Industrial Heavy Electrical Equipment	100	90.0	72.7	54.3	37.9	15.6	5.3	1.5	0.4
34	Television and Video Equipment	100	75.2	55.6	40.8	29.8	15.7	8.2	4.3	2.2
35	Air Conditioners	100	89.7	66.9	42.1	22.6	4.1	0.4	0.0	0.0
36	Electric Appliances for Kitchen	100	89.6	72.8	55.4	40.0	18.3	7.1	2.4	0.7
37	Electric Ligthting Fixtures and Apparatus	100	57.8	36.6	23.8	15.8	7.2	3.4	1.6	0.8
38	Personal Computers	100	61.1	4.6	0.0	0.0	0.0	0.0	0.0	0.0
39	Mainframes and Servers	100	62.4	18.7	2.9	0.3	0.0	0.0	0.0	0.0
40	Wired Communication Equipment	100	86.7	41.7	8.0	0.5	0.0	0.0	0.0	0.0
41	Wireless Communication Equipment	100	76.3	42.8	19.2	7.0	0.6	0.0	0.0	0.0
42	Applied Electronic Equipment	100	79.0	44.7	19.1	6.3	0.3	0.0	0.0	0.0
43	Electric Measuring Instruments	100	99.3	90.0	61.0	22.7	0.1	0.0	0.0	0.0
44	Generators and Motors	100	99.8	98.1	93.5	84.7	55.0	22.7	5.0	0.5
45	Relay Switches and Switchboards	100	84.0	62.5	43.1	28.0	10.2	3.2	0.9	0.2
46	Transformers and Reactors	100	89.5	71.5	52.7	36.2	14.3	4.6	1.2	0.3
47	Batteries	100	84.9	51.3	21.9	6.6	0.2	0.0	0.0	0.0
48	Passenger Cars	100	81.8	36.7	7.6	0.7	0.0	0.0	0.0	0.0
49	Trucks	100	88.9	53.9	19.4	3.8	0.0	0.0	0.0	0.0
50	Buses	100	97.0	85.1	65.4	43.0	10.9	1.2	0.1	0.0
51	Ships	100	99.1	92.1	73.4	45.3	5.1	0.0	0.0	0.0
52	Transport Equipment for Industry Use	100	91.7	72.1	49.0	29.0	6.8	0.9	0.1	0.0
53	Photographic and Optical Instruments	100	68.7	49.1	35.6	26.1	14.2	7.8	4.4	2.5
54	Professional and Scientific Instruments	100	92.7	68.0	36.7	14.0	0.6	0.0	0.0	0.0
55	Analytical Instruments	100	91.5	64.4	32.7	11.4	0.4	0.0	0.0	0.0
56	Measuring Instruments	100	86.6	58.2	30.9	13.0	1.2	0.0	0.0	0.0
57	Testing Instruments	100	97.0	84.8	64.0	40.5	8.6	0.7	0.0	0.0
58	Information Recording Media	100	73.8	40.0	17.5	6.4	0.5	0.0	0.0	0.0
59	Miscellaneous Products	100	78.3	44.8	19.9	7.1	0.5	0.0	0.0	0.0
60	Residential Buildings	100	99.3	95.5	87.4	75.0	43.3	16.7	4.0	0.5
61	Storehouses	100	97.3	91.4	83.6	74.7	55.9	38.7	25.0	15.1
62	Office Buildings	100	95.2	84.1	69.8	54.7	28.5	12.2	4.3	1.3
63	Stores	100	92.5	78.1	61.7	45.9	21.8	8.6	2.9	0.8
64	Factories	100	95.1	85.1	72.5	59.2	35.3	18.3	8.4	3.4
65	Road and Parking Areas	100	85.0	67.0	50.7	37.3	18.8	8.8	3.9	1.6
66	Other Construction	100	94.6	72.7	41.5	16.4	0.7	0.0	0.0	0.0

Table. 7 Estimates of the Weibull Distribution: Case-3 ($S_{\widehat{v}}(\tau)$)

		α	(t-value)	β	(t-value)	λ	$\bar{T}$	adj R^2	smpl
1	Wood Products	2.76	4.3	-5.87	-4.7	8.4	7.5	0.592	13
2	Furniture	1.43	70.5	-3.46	-76.4	11.2	10.2	0.942	309
3	Steel Pipes and Tubes	1.92	27.2	-5.83	-30.4	21.0	18.6	0.941	47
4	Electric Wires and Cables	2.67	12.3	-7.63	-16.3	17.4	15.5	0.781	43
5	Optical Fiber Cable	1.70	7.8	-4.75	-12.2	16.4	14.6	0.749	21
6	Metal Products for Architecture	1.19	11.3	-2.97	-10.9	12.1	11.4	0.920	12
7	Gas and Oil Appliances	3.24	18.4	-9.95	-20.7	21.6	19.3	0.949	19
8	Metal Containers	2.12	61.6	-6.78	-71.9	24.6	21.8	0.982	72
9	Metal Tools	2.46	10.3	-5.17	-10.7	8.2	7.3	0.687	49
10	Plumber Supplies	2.46	12.6	-6.46	-14.6	13.8	12.2	0.893	20
11	Metal Strongboxes	1.21	6.9	-3.00	-6.5	11.9	11.2	0.922	5
12	Boiler and Engines	2.14	35.9	-6.86	-43.5	24.8	22.0	0.958	58
13	Pumps and Compressors	1.48	24.5	-4.23	-29.5	17.6	15.9	0.923	51
14	Metal Machine Tools	2.12	40.0	-6.41	-44.1	20.7	18.4	0.961	66
15	Metal Processing Machinery	1.61	36.6	-4.99	-45.7	22.2	19.9	0.925	109
16	Machinists' Precision Tools	2.55	6.5	-7.69	-7.1	20.4	18.1	0.820	10
17	Industrial Robots	1.08	7.3	-3.11	-9.1	17.8	17.3	0.828	12
18	Construction Machinery	1.82	47.9	-5.15	-59.1	16.9	15.0	0.965	83
19	Food Processing Machinery	1.72	27.4	-5.72	-37.0	27.9	24.9	0.907	78
20	Printing and Bookbinding Machinery	3.24	14.7	-9.26	-17.1	17.4	15.6	0.866	34
21	Chemical Machinery	1.91	76.3	-6.70	-107.5	33.1	29.4	0.974	155
22	Semiconductor Making Equipment	2.50	32.3	-5.90	-35.8	10.6	9.4	0.965	39
23	Other Office Machinery	3.06	20.1	-8.47	-22.3	15.9	14.2	0.946	24
24	Machinery for Service Industry	2.74	33.8	-8.07	-43.7	19.1	17.0	0.933	83
25	Conveyors	2.11	18.7	-5.42	-21.4	13.0	11.5	0.883	47
26	Wrapping and Packing Machinery	2.37	19.2	-8.22	-26.2	32.3	28.6	0.885	49
27	Casting Equipment	1.96	4.0	-5.72	-4.4	18.4	16.3	0.625	10
28	Plastic Processing Machinery	2.40	10.8	-6.82	-11.9	17.1	15.1	0.872	18
29	Industrial Furnaces	1.81	12.9	-6.65	-18.0	39.1	34.8	0.851	30
30	Combustion Furnaces	2.40	27.3	-7.49	-36.4	22.5	20.0	0.867	115
31	Copy Machines	1.82	14.9	-4.05	-16.3	9.2	8.2	0.853	39
32	Refrigerators and Air Conditioning Apparatus	2.29	13.9	-6.28	-15.1	15.4	13.7	0.730	72
33	Other Industrial Heavy Electrical Equipment	1.66	42.4	-5.30	-58.9	24.6	22.0	0.944	107
34	Television and Video Equipment	1.28	15.9	-3.79	-21.3	19.2	17.8	0.815	58
35	Air Conditioners	1.87	106.6	-5.33	-120.2	17.2	15.3	0.973	315
36	Electric Appliances for Kitchen	1.53	43.1	-5.32	-61.4	32.6	29.3	0.950	98
37	Electric Ligthting Fixtures and Apparatus	0.88	10.0	-2.17	-14.7	11.8	12.5	0.833	21
38	Personal Computers	2.76	28.4	-5.49	-29.2	7.3	6.5	0.783	224
39	Mainframes and Servers	1.88	44.2	-4.04	-49.0	8.6	7.7	0.936	134
40	Wired Communication Equipment	2.82	69.0	-6.99	-80.0	11.9	10.6	0.968	159
41	Wireless Communication Equipment	2.14	12.9	-6.10	-16.7	17.2	15.3	0.879	24
42	Applied Electronic Equipment	1.74	40.1	-4.71	-46.9	15.1	13.4	0.925	132
43	Electric Measuring Instruments	3.85	9.0	-11.63	-9.9	20.5	18.5	0.785	23
44	Generators and Motors	3.44	13.0	-12.46	-17.2	37.3	33.5	0.844	32
45	Relay Switches and Switchboards	1.46	21.1	-4.70	-29.3	25.3	22.9	0.955	22
46	Transformers and Reactors	1.63	20.0	-5.27	-25.2	25.4	22.7	0.888	51
47	Batteries	2.20	9.6	-5.53	-10.3	12.3	10.9	0.867	15
48	Passenger Cars	2.32	99.2	-5.67	-116.6	11.5	10.2	0.974	261
49	Trucks	2.20	14.4	-5.54	-14.7	12.4	11.0	0.797	54
50	Buses	2.28	11.2	-7.13	-14.6	23.0	20.3	0.806	31
51	Ships	3.02	27.0	-10.29	-34.6	23.0	26.8	0.945	43
52	Transport Equipment for Industry Use	1.64	87.4	-4.98	-97.0	20.7	18.5	0.961	315
53	Photographic and Optical Instruments	0.93	9.1	-2.64	-11.8	17.1	17.7	0.764	26
54	Professional and Scientific Instruments	1.94	20.6	-5.30	-23.7	15.3	13.6	0.914	41
55	Analytical Instruments	2.29	27.0	-6.25	-30.2	15.2	13.5	0.919	65
56	Measuring Instruments	1.90	67.9	-5.20	-81.7	15.4	13.7	0.966	163
57	Testing Instruments	2.50	10.7	-7.75	-13.4	22.1	19.6	0.780	33
58	Information Recording Media	1.65	6.0	-3.93	-6.6	10.8	9.7	0.712	15
59	Miscellaneous Products	1.74	122.5	-4.41	-144.7	12.7	11.3	0.981	299
60	Residential Buildings	2.76	15.4	-9.78	-19.0	34.7	30.9	0.921	21
61	Storehouses	1.72	21.2	-6.53	-29.3	44.8	39.9	0.847	82
62	Office Buildings	1.81	49.3	-6.03	-63.2	28.0	24.9	0.903	261
63	Stores	1.61	28.1	-5.28	-37.4	26.7	23.9	0.933	58
64	Factories	1.69	29.2	-5.90	-37.3	32.9	29.4	0.907	89
65	Road and Parking Areas	1.28	40.0	-3.92	-52.9	21.3	19.8	0.893	192
66	Other Construction	2.50	23.9	-7.15	-30.1	17.5	15.5	0.846	105

Table. 8 The Weibull Survival Rates: Case-3($S_{\widehat{v}}(\tau)$)

		0	5	10	15	20	30	40	50	60
1	Wood Products	100	78.8	19.9	0.7	0.0	0.0	0.0	0.0	0.0
2	Furniture	100	73.0	42.8	22.0	10.2	1.7	0.2	0.0	0.0
3	Steel Pipes and Tubes	100	93.8	78.5	59.1	40.1	13.7	3.2	0.5	0.1
4	Electric Wires and Cables	100	96.5	79.7	51.3	23.7	1.4	0.0	0.0	0.0
5	Optical Fiber Cable	100	87.6	65.0	42.4	24.7	6.2	1.1	0.1	0.0
6	Metal Products for Architecture	100	70.5	45.1	27.5	16.2	5.3	1.6	0.4	0.1
7	Gas and Oil Appliances	100	99.1	92.0	73.5	45.7	5.4	0.1	0.0	0.0
8	Metal Containers	100	96.6	86.2	70.4	52.4	21.8	6.1	1.1	0.1
9	Metal Tools	100	74.2	19.3	1.2	0.0	0.0	0.0	0.0	0.0
10	Plumber Supplies	100	92.1	63.6	29.4	8.3	0.1	0.0	0.0	0.0
11	Metal Strongboxes	100	70.5	44.6	26.7	15.4	4.7	1.3	0.3	0.1
12	Boiler and Engines	100	96.8	86.6	71.1	53.2	22.3	6.2	1.1	0.1
13	Pumps and Compressors	100	85.6	64.8	45.5	30.0	11.2	3.5	0.9	0.2
14	Metal Machine Tools	100	95.2	80.8	60.4	39.6	11.3	1.8	0.2	0.0
15	Metal Processing Machinery	100	91.4	75.9	58.9	43.1	19.8	7.6	2.5	0.7
16	Machinists' Precision Tools	100	97.3	85.1	63.4	38.7	6.9	0.4	0.0	0.0
17	Industrial Robots	100	77.6	58.5	43.6	32.2	17.3	9.1	4.8	2.5
18	Construction Machinery	100	89.7	68.1	44.7	25.7	5.8	0.8	0.1	0.0
19	Food Processing Machinery	100	94.9	84.2	70.9	56.9	32.2	15.6	6.6	2.4
20	Printing and Bookbinding Machinery	100	98.3	84.8	54.1	21.0	0.3	0.0	0.0	0.0
21	Chemical Machinery	100	97.4	90.4	80.3	68.3	43.8	23.9	11.1	4.4
22	Semiconductor Making Equipment	100	85.8	42.1	9.2	0.8	0.0	0.0	0.0	0.0
23	Other Office Machinery	100	97.1	78.5	43.4	13.4	0.1	0.0	0.0	0.0
24	Machinery for Service Industry	100	97.5	84.3	59.6	32.1	3.2	0.1	0.0	0.0
25	Conveyors	100	87.6	56.4	26.0	8.4	0.3	0.0	0.0	0.0
26	Wrapping and Packing Machinery	100	98.8	93.9	84.9	72.4	43.1	18.9	6.0	1.3
27	Casting Equipment	100	92.5	73.9	51.2	30.8	7.3	1.0	0.1	0.0
28	Plastic Processing Machinery	100	94.9	75.8	48.0	23.1	2.0	0.0	0.0	0.0
29	Industrial Furnaces	100	97.6	91.9	83.9	74.4	53.9	35.3	21.0	11.4
30	Combustion Furnaces	100	97.4	86.8	68.7	47.3	13.7	1.9	0.1	0.0
31	Copy Machines	100	72.1	31.3	8.8	1.6	0.0	0.0	0.0	0.0
32	Refrigerators and Air Conditioning Apparatus	100	92.7	69.1	39.2	16.3	1.0	0.0	0.0	0.0
33	Other Industrial Heavy Electrical Equipment	100	93.1	79.8	64.4	49.2	25.0	10.7	4.0	1.3
34	Television and Video Equipment	100	83.7	64.9	48.3	34.9	17.0	7.7	3.3	1.3
35	Air Conditioners	100	90.6	69.7	46.3	26.7	6.0	0.8	0.1	0.0
36	Electric Appliances for Kitchen	100	94.5	84.8	73.6	62.2	41.4	25.4	14.6	7.8
37	Electric Ligthting Fixtures and Apparatus	100	62.4	42.0	29.0	20.3	10.3	5.3	2.8	1.5
38	Personal Computers	100	70.4	9.3	0.1	0.0	0.0	0.0	0.0	0.0
39	Mainframes and Servers	100	69.8	26.7	6.0	0.8	0.0	0.0	0.0	0.0
40	Wired Communication Equipment	100	91.7	54.2	14.6	1.3	0.0	0.0	0.0	0.0
41	Wireless Communication Equipment	100	93.2	73.2	47.6	25.3	3.8	0.2	0.0	0.0
42	Applied Electronic Equipment	100	86.3	61.3	37.1	19.5	3.7	0.4	0.0	0.0
43	Electric Measuring Instruments	100	99.6	93.9	73.9	40.0	1.3	0.0	0.0	0.0
44	Generators and Motors	100	99.9	98.9	95.7	89.0	62.4	28.1	6.5	0.6
45	Relay Switches and Switchboards	100	91.0	77.2	62.7	49.2	27.8	14.3	6.8	3.0
46	Transformers and Reactors	100	93.2	80.3	65.4	50.8	26.9	12.3	4.9	1.7
47	Batteries	100	87.2	53.1	21.3	5.4	0.1	0.0	0.0	0.0
48	Passenger Cars	100	86.6	48.8	15.9	2.8	0.0	0.0	0.0	0.0
49	Trucks	100	87.3	53.7	21.9	5.7	0.1	0.0	0.0	0.0
50	Buses	100	96.9	86.0	68.4	48.2	15.9	2.9	0.3	0.0
51	Ships	100	99.0	92.2	75.9	51.8	10.6	0.5	0.0	0.0
52	Transport Equipment for Industry Use	100	90.8	74.0	55.6	39.0	15.9	5.3	1.4	0.3
53	Photographic and Optical Instruments	100	72.7	54.5	41.2	31.4	18.5	11.0	6.6	4.0
54	Professional and Scientific Instruments	100	89.2	64.6	38.2	18.6	2.5	0.2	0.0	0.0
55	Analytical Instruments	100	92.5	68.3	38.0	15.4	0.9	0.0	0.0	0.0
56	Measuring Instruments	100	88.9	64.5	38.7	19.4	2.9	0.2	0.0	0.0
57	Testing Instruments	100	97.6	87.2	68.5	46.0	11.7	1.2	0.0	0.0
58	Information Recording Media	100	75.6	41.7	18.1	6.4	0.5	0.0	0.0	0.0
59	Miscellaneous Products	100	82.0	51.6	26.3	11.0	1.2	0.1	0.0	0.0
60	Residential Buildings	100	99.5	96.8	90.6	80.4	51.3	22.9	6.5	1.1
61	Storehouses	100	97.7	92.7	85.8	77.8	60.5	43.8	29.8	19.1
62	Office Buildings	100	95.7	85.6	72.4	58.1	32.3	14.9	5.8	1.9
63	Stores	100	93.5	81.4	67.3	53.3	29.9	14.7	6.4	2.5
64	Factories	100	95.9	87.5	76.7	65.0	42.6	24.9	13.2	6.4
65	Road and Parking Areas	100	85.5	68.4	52.9	39.8	21.3	10.7	5.1	2.3
66	Other Construction	100	95.7	78.1	50.7	24.8	2.1	0.0	0.0	0.0



(a) 1.Wood Products

(b) 2.Furniture

(c) 3.Steel Pipes and Tubes

(d) 4.Electric Wires and Cables

(e) 5.Optical Fiber Cable

(f) 6.Metal Products for Architecture

(g) 7.Gas and Oil Appliances

(h) 8.Metal Containers

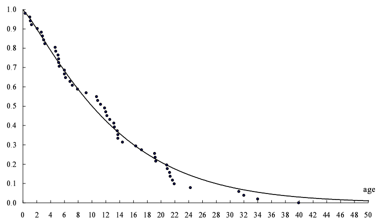
(i) 9.Metal Tools

(j) 10.Plumber Supplies

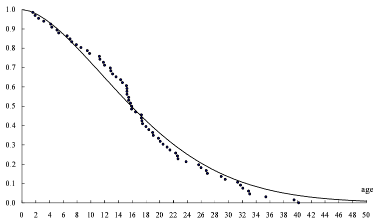
(k) 11.Metal Strongboxes

(l) 12.Boiler and Engines

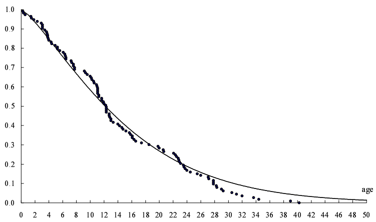
Fig. 11 $S_0(\tau)$ and the Weibull Survival Distribution: Assets 1-12



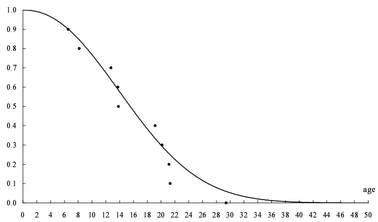
(a) 13.Pumps and Compressors



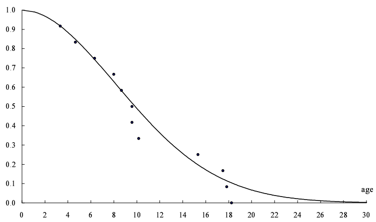
(b) 14.Metal Machine Tools



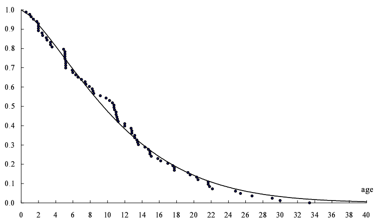
(c) 15.Metal Processing Machinery



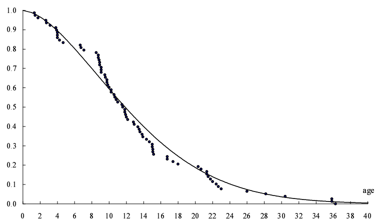
(d) 16.Machinist's Precision Tools



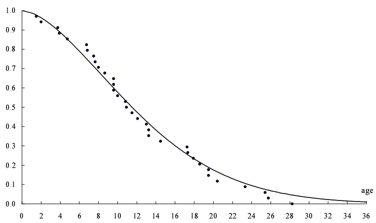
(e) 17.Industrial Robots



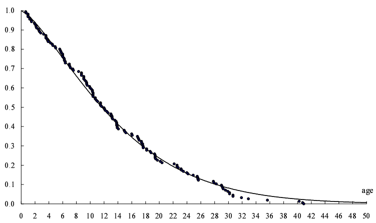
(f) 18.Construction Machinery



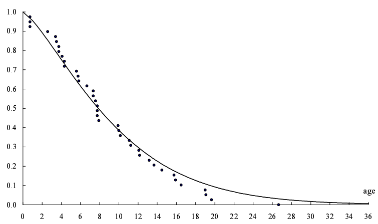
(g) 19.Food Processing Machinery



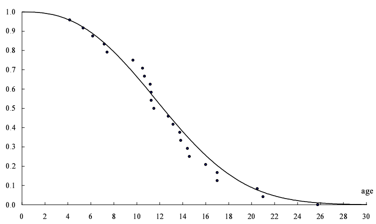
(h) 20.Printing and Bookbinding Machinery



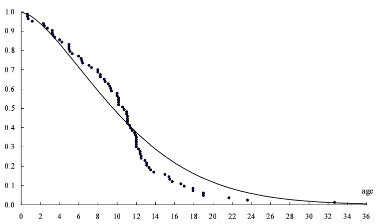
(i) 21.Chemical Machinery



(j) 22.Semiconductor Making Equipment

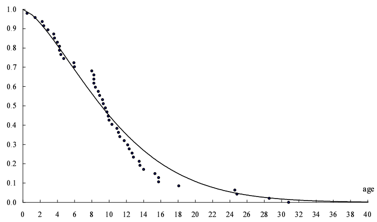


(k) 23.Other Office Machinery

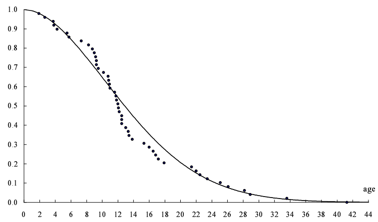


(l) 24.Machinery for Service Sector

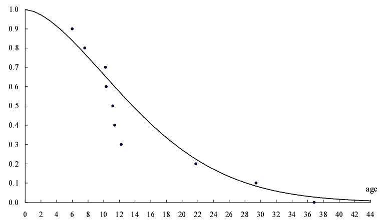
Fig. 12 $S_0(\tau)$ and the Weibull Survival Distribution: Assets 13-24



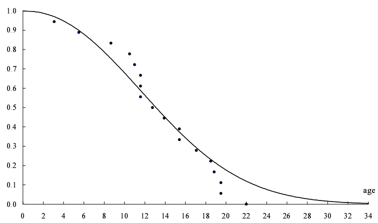
(a) 25.Conveyors



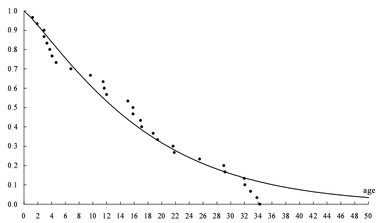
(b) 26.Wrapping and Packing Machinery



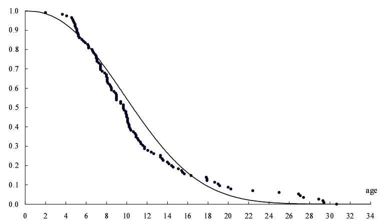
(c) 27.Casting Equipment



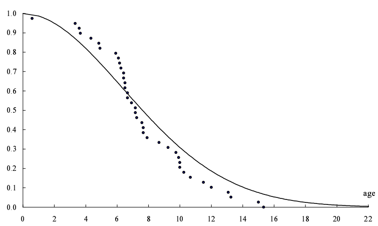
(d) 28.Plastic Processing Machinery



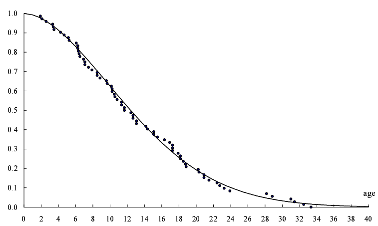
(e) 29.Industrial Furnances



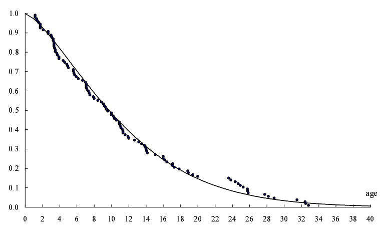
(f) 30.Combustion Furnaces



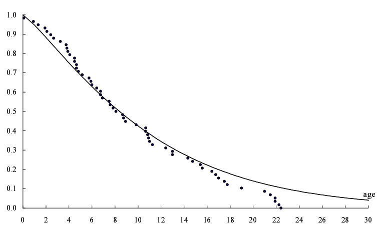
(g) 31.Copy Machines



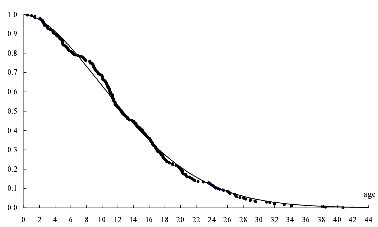
(h) 32.Refrigerators and Air Conditionaing Apparatus



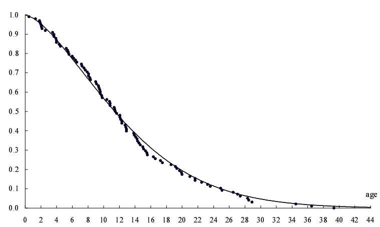
(i) 33.Other Industrial Heavy Electrical Equipment



(j) 34.Television and Video Equipment

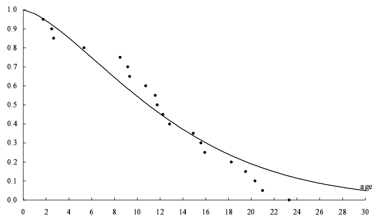


(k) 35.Air Conditioners

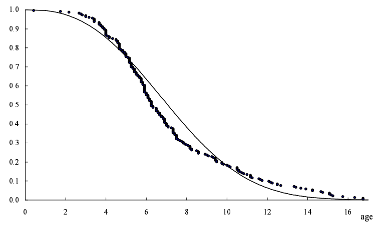


(l) 36.Electric Appliances for Kitchen

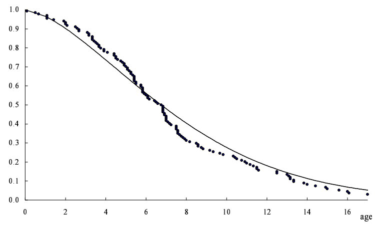
Fig. 13 $S_0(\tau)$ and the Weibull Survival Distribution: Assets 25-36



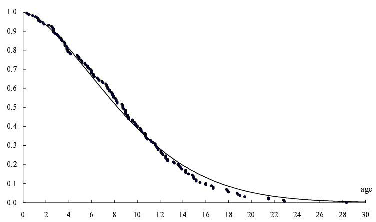
(a) 37.Electric Lighting Fixtures and Apparatus



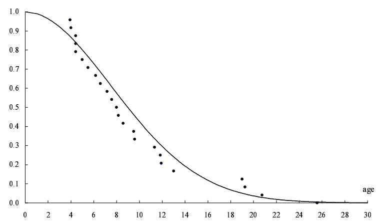
(b) 38.Personal Computers



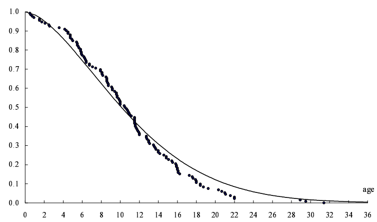
(c) 39.Mainframes and Servers



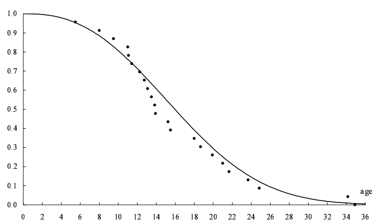
(d) 40.Wired Communication Equipment



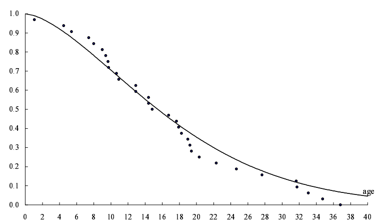
(e) 41.Wireless Communication Equipment



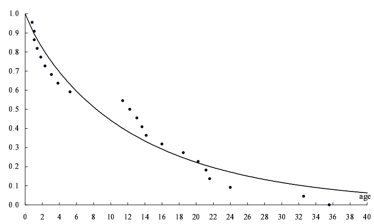
(f) 42.Applied Electronic Equipment



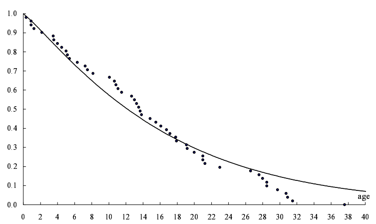
(g) 43.Electric Measuring Instruments



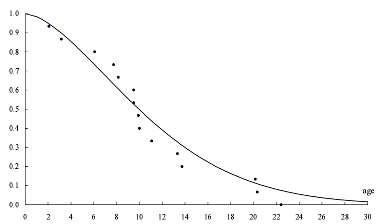
(h) 44.Generators and Motors



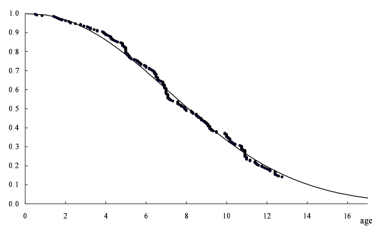
(i) 45.Relay Switches and Switchboards



(j) 46.Transformera and Reactors

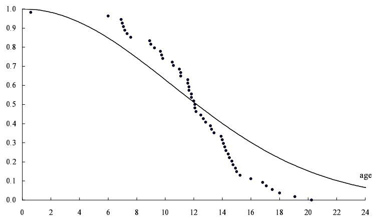


(k) 47.Batteries

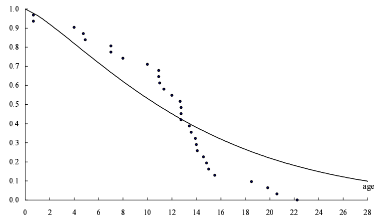


(l) 48.Passenger Cars

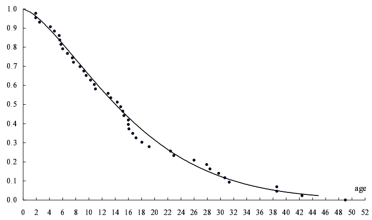
Fig. 14 $S_0(\tau)$ and the Weibull Survival Distribution: Assets 37-48



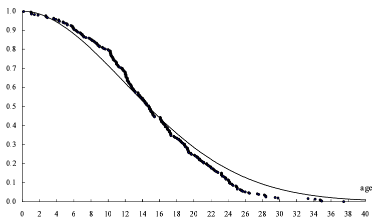
(a) 49.Trucks



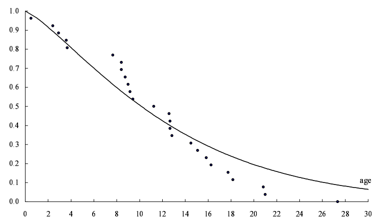
(b) 50.Buses



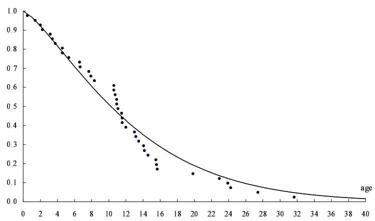
(c) 51.Ships



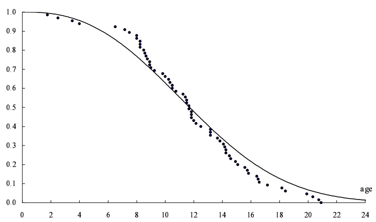
(d) 52.Transport Equipment for Industry Use



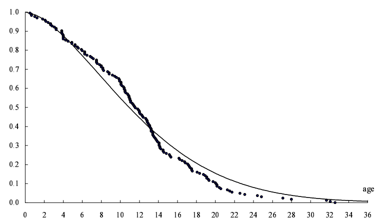
(e) 53.Photographic and Optical Instruments



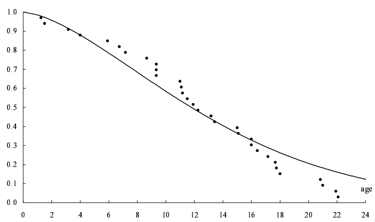
(f) 54.Professional and Scientific Instruments



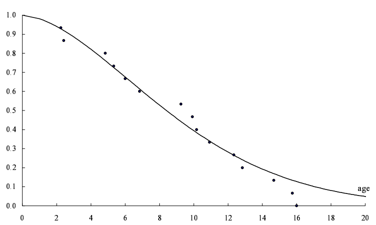
(g) 55.Analytical Instruments



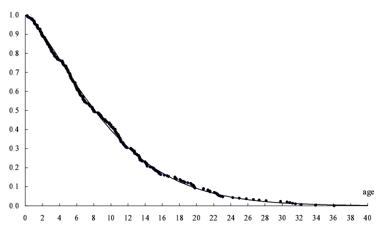
(h) 56.Measuring Instruments



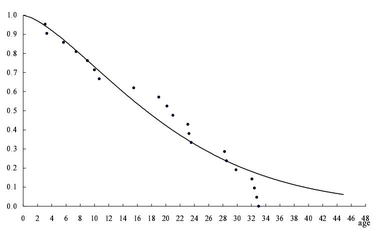
(i) 57.Testing Instruments



(j) 58.Information Recording Media

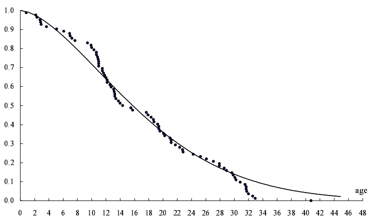


(k) 59.Miscellaneous Products

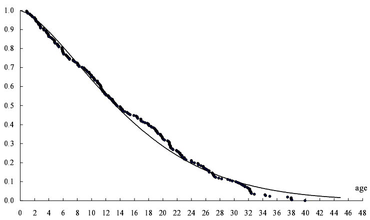


(l) 60.Residential Buildings

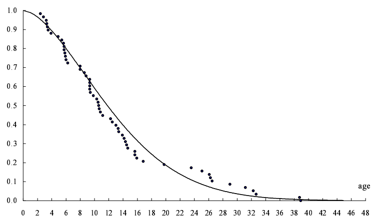
Fig. 15 $S_0(\tau)$ and the Weibull Survival Distribution: Assets 49-60



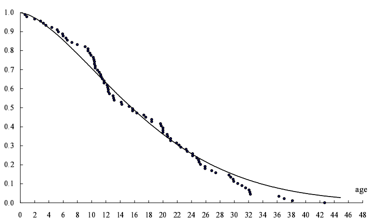
(a) 61.Storehouses



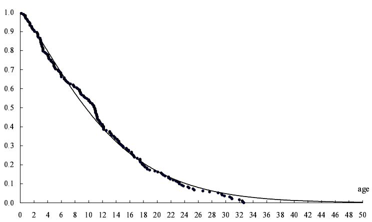
(b) 62.Office Building



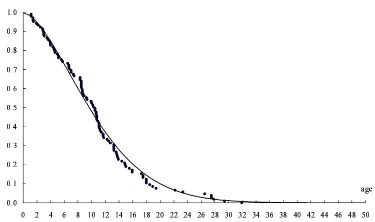
(c) 63.Stores



(d) 64.Factories



(e) 65.Road and Parking Areas



(f) 66.Other Construction

Fig. 16 $S_0(\tau)$ and the Weibull Survival Distribution: Assets 61-66

References

[1] Biørn, Erik (1989). *Taxation, Technology and the User Cost of Capital*, Amsterdam: North-Holland, 325p.

[2] 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.

[3] Blades, Derek (2001), *Measuring Capital: A Manual on the Measurement of Capital Stocks, Consumption of Fixed Capital, and Capital Services*, Paris, OECD, April.

[4] Economic Planning Agency (1976). *Japanese National Wealth Survey: Reprinted* (in Japanese).

[5] 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.

[6] Fraumeni, Barbara (1997). The Measurement of Depreciation in the U.S. National Income and Product Accounts, *Survey of Current Business*, July, 7-23.

[7] Gellatly, Guy, Marc Tanguay, and Beiling Yan. (2002). An Alternative Methodology for Estimating Economic Depreciation: New Results Using a Survival Model, in *Productivity Growth in Canada - 2002*, Statistics Canada, #15-204-XPE, 2002.

[8] Jorgenson, Dale W., and Zvi Griliches (1967). The Explanation of Productivity Change, *Review of Economic Studies*, Vol.34, 249-283.

[9] 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.

[10] Hill, Peter (1998). Gross, Productive, Net Capital Stock, Second Meeting of the Canberra Group on Capital Stock Statistics, 20p.

[11] _____(1999). The Productive Capital Stock and the Quantity Index for Flow of Capital, Third Meeting of the Canberra Group on Capital Stock Statistics, 5p.

[12] 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.

[13] _____(1981b), The Estimation of Economic Depreciation Using Vintage Asset Prices: An Application of the Box-Cox Power Transformation, Journal of Econometrics, April, 367-396.

[14] _____(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.

[15] Katz, Arnold J. and Shelby Herman (1997). Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-95, *Survey of Current Business*, May, 69-89.

[16] Kiefer, Nicholas M. (1988). Economic Duration Data and Hazard Functions, *Journal of Economic Literature*, Vol.26, No.2, pp.646-79.

[17] Nomura, Koji (2004). *Measurement of Capital and Productivity in Japan*, Tokyo: Keio University Press. (in Japanese) , 633p.

[18] Nomura, Koji and Tadao Futakami (2005). Measuring Capital in Japan - Challenges and Future Directions, OECD Working Party on National Accounts, October 11-14, 2005.

[19] 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.

[20] Mudholkar, Grovind S., Deo Kumar Srivastava, and Georgia D. Kollia (1996). A Generalization of the Weibull Distribution with Application to the Analysis of Survival Data, *Journal of the American Statistical Association*, Vol.91, No.436, pp.1575-83.

[21] Smeets, Eric and Nobert van den Hove (1997). Desinvestments, First Meeting of the Canberra Group on Capital Stock Statistics, March, 8p.

[22] Triplett, Jack E. (1996a). Depreciation in Production Analysis and in Income and Wealth Accounts: Resolution of an OLD Debate, *Economic Inquiry*, 34(1), 93-115.

[23] _____(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.

[24] United Nations (1993). *System of National Accounts 1993*, New York, United Nations, November.

[25] Winfrey, Robley (1935). *Statistical Analyses of Industrial Property Retirements*, Bulletin 125, Iowa Engineering Experiment Station, 177p.

[26] Ward, Michael (1976). *The Measurement of Capital: The Methodology of Capital Stock Estimate in OECD Countries*, Paris, OECD, July.