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MEASURING DEPRECIATION FOR JAPAN: REJOINDER TO DEKLE AND SUMMERS

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ABSTRACT

Recently, my claim that depreciation reported in the Japanese national accounts is underestimated by a substantial margin has been challenged by Dekle and Summers (NBER Working Paper No. 3690), on the ground that the implied depreciation rate (ratio of depreciation to the capital stock) is implausibly high. I argue in this rejoinder that Japan's high depreciation rate can be attributable to two factors. First, the depreciation rate for owner-occupied housing is much higher in Japan. Second, equipment capital (a component of the denominator in the depreciation rate) in the Japanese national accounts seems underestimated. Therefore, my estimate of the level of depreciation for Japan does not seem exaggerated.

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I. Introduction

In a series of articles (Hayashi (1986, 1989a, 1989b)) I argued that Japan's net saving rate in the National Income Accounts (henceforth NIA) is substantially biased upwards due mainly to an undervaluation of depreciation. In Hayashi (1986), I calculated adjusted saving rates for 1970-1984 in a way comparable to the U.S. saving rates. I extended the adjustment back to 1955 in Hayashi (1989a), utilizing the then newly available NIA data for 1955-1970. In Hayashi (1989b), I used the long-term statistics from Ohkawa *et.al.* (1979) to examine the prewar saving rates. My conclusion for the postwar period was, and still is, that "Japan's aggregate saving rate -- however defined -- is indeed higher than the comparable U.S. saving rate, but not by as much as is commonly thought." (Hayashi (1986, p. 163))

The paper by Dekle and Summers (1991) (hereafter DS) argues that my depreciation adjustments are probably exaggerated and presents a wealth-based measure of saving to conclude that Japan's saving rate is higher than the U.S. rate. Although I certainly agree with their conclusion, I argue in this rejoinder that almost every single building block of their argument is unwarranted. In the next section, I will examine the main point of contention between DS and myself, namely the size of Japanese depreciation, and show that my estimate of depreciation is a reasonable one. Section III is my response to other points raised by DS. A brief conclusion is in section IV.

II. Measurement of Depreciation

A. Data Sources

For Japan, the single most comprehensive source of macroeconomic data is the NIA, which has both the "flow" section (income/expenditure accounts) and the "stock" section (balance sheets). Last year the Economic Planning Agency (EPA) has published the latest benchmark revision (with the benchmark year being 1985) of the NIA (EPA (1990)). The most recent 1991 *Annual Report on National Accounts* also incorporates the 1985 benchmark revision. My calculation reported below will be based exclusively on these two sources, which cover the period 1970-1989.[1] Data for 1955-1969 are in EPA (1988) but the price indexes there do not incorporate the latest benchmark revision, and in the near future I suppose the EPA will publish the 1985 benchmark revision for this period as well.

The U.S. national accounts (often referred to as the NIPA) compiled by the Bureau of Economic Analysis (BEA) do not have the stock section. Its handy source is the annual *Economic Report of the President*. Since 1986 the BEA has published its estimate of the capital stock annually in the August issue of the *Survey of Current Business*. The estimates for 1925-85, which are collected in BEA (1987), are consistent, definitionally and numerically, with its flow counterpart, the NIPA..[2] My calculations for the U.S. to be reported below are based exclusively on the NIPA data from the 1991

[1] DS used the 1990 edition of the *Annual Report on National Accounts* which does not incorporate the latest benchmark revision. This should not make a substantial difference.

[2] The rest of the balance sheet items such as financial assets and land, along with the capital stock, are in *the Balance Sheet of the U.S. Economy* (various issues) compiled by the Board of Governors, Federal Reserve System. However, there are minor differences from the BEA estimates.

Economic Report of the President and BEA (1987).

B. Replacement Cost Depreciation for the U.S. and Japan

As I pointed out repeatedly in the series of papers of mine, there are two major differences in the NIA between the U.S. and Japan. One is that depreciation in the flow section of the Japanese NIA is at historical costs, and the other is that the U.S. NIA compiled by the BEA treats all government expenditure as consumption. *Unless otherwise noted, in this article I adhere to the BEA definition.* It is relatively straightforward to account for the second difference. Accounting for the first difference, which amounts to estimating the difference between replacement cost depreciation and historical cost depreciation, is a bit complicated. Details of my procedure for the depreciation adjustment, which can be found in Hayashi (1986) and are summarized in DS, are not repeated here.[3]

Figure 1 plots three series: the Japanese national saving rate as reported in the NIA, the Japanese national saving rate adjusted according to the BEA, and the U.S. national saving rate (which of course conforms to the BEA definition) for 1970-1989. This is an update of Figure 1 in Hayashi (1989b) which was reproduced in DS as their Figure 1. The figure confirms for the latest revised data that the adjustment makes a big difference. About a half of the adjustment comes from the depreciation adjustment. To

[3] There is a very minor error in the formula for revaluation in the Appendix of Hayashi (1986). The price change factor applicable to N(t) (net investment) in (A1) should be: $[P(t+1)-PA(t)]/PA(t)$, rather than $[PA(t)-P(t)]/P(t)$. In the calculation in Hayashi (1986, 1989a, 1989b) as well as here, this correct formula was used.

see whether my depreciation adjustment is excessive, DS examines two ratios -- the depreciation/GNP ratio and the implicit depreciation rate (ratio of depreciation to the capital stock) -- implied by my estimate of replacement cost depreciation. Calculating the U.S. ratios should be a trivial exercise because it only requires taking the ratio of published numbers. Calculating the Japanese ratio requires my depreciation adjustment. Very surprisingly, it appears that DS did not get the U.S. numbers right. It is well known that the depreciation/GNP ratio is about 10% for the U.S. The numbers reported in DS's Table 2 cannot be right. In my **Table 1**, I present what I think is the correct version of DS's Table 2.[4] There is no basis for DS's claim that implicit depreciation rates implied by my adjustment are often three times that in the U.S. But I agree that Japanese depreciation relative to GNP and the capital stock is substantially larger. As I wrote in Hayashi (1989b, p. 7), one has to subtract more than 15% of GNP from gross national saving to arrive at net saving for Japan.

C. Why is Japanese Depreciation Rate So High?

As is clear from the description of my depreciation adjustment in Hayashi (1986), my estimate of depreciation is the sum of the EPA's estimate of replacement cost depreciation (which has not been published) and the residual component of the reconciliation account in the stock section of the NIA that remains in the reconciliation account

[4] My numbers for Japan are slightly different from DS's and those in Hayashi (1986) because here I use the latest revision of the Japanese NIA.

after capital gains are accounted for.[5] It is quite possible, as DS noted, that the EPA's estimate of replacement cost depreciation is on average substantially lower than my estimate if the residual component is consistently large and positive.[6] But that does not solve the mystery of Japanese high depreciation. If the residual component is large and positive for almost every year, it *should* be included in depreciation in order for the estimate of Japanese depreciation to be comparable to that for the U.S.[7] The real issue is whether my estimate is reasonable, not whether the EPA's unpublished estimate is different from mine. Since the level of depreciation equals the implicit depreciation rate times the capital stock, any possible biases in my depreciation estimate should be reflected in either the implicit depreciation rate or the capital stock. In the rest of this section I argue that my depreciation estimate is reasonable because its substantial part comes from owner occupied housing (which is the point touched upon in Hayashi (1989b)) and because whatever remaining difference in the implicit depreciation rate between the U.S.

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[5] In Hayashi (1989b) I conjectured that the puzzlingly low adjusted saving rate in the 1950s must be due to the erratic movements in the residual component.

[6] There is one piece of information in the Japanese NIA which may allow us outside the government to directly calculate the EPA's estimate of replacement cost depreciation by asset, at least for the nation as a whole. Table 2-III-1 in the stock section of the NIA shows the end-of-year value of capital stock, net investment during the year, and the reconciliation. They sum to the next year's value of the capital stock. The value of net investment is different from that in the flow section. Thus it is possible that net investment in the table is at replacement costs. *If* that is the case, the difference between replacement cost and historical cost depreciations is zero in Table 2-III-1 and the reconciliation account should equal capital gains less residual components. Therefore the residual component can be identified. According to my calculation, it is on average more than 2% of the nation's capital stock!

[7] In fact, in the capital stock estimate in BEA (1987), there is no item corresponding to the residual component. That is, the change in the capital stock equals gross investment less depreciation (at replacement costs) plus capital gains. Depreciation is defined as "the value of past investment lost through physical deterioration, obsolescence, accidents, and aging." (BEA (1987, p. xxvi))

and Japan is attributable to a possible underestimate of the capital stock in the Japanese NIA.

Asset Composition Effect Since it is a weighted average of depreciation rates for individual assets, the (overall) implicit depreciation rate can differ between the two countries if asset composition is different. In Hayashi (1986, Table 2) I went beyond examining the overall depreciation rate and calculated the asset-specific depreciation rates. **Table 2** of the present article updates my previous calculation for three broad asset categories (residential structures, nonresidential structures, and producer durable equipments) along with the corresponding U.S. depreciation rates.[8] It shows quite clearly that the difference comes from the high Japanese depreciation rate for residential structures (housing) and for equipments. The combination of the high fraction of residential structures and the low housing depreciation rate for the U.S. explains a lot: if the U.S. depreciation rate for residential structures were 9% as in Japan, then the U.S. overall implicit depreciation rate would rise by nearly 3 percentage points. I think that the Japanese housing depreciation rate of about 9% is reasonable given that a large fraction of Japanese housing is made of paper and wood; it would be puzzling if it were as low as in the U.S. What *is* puzzling is the high Japanese depreciation rate for equipments. The Japanese equipment depreciation rate of 23% is 1.8 times as large as the U.S. rate. Equipments are internationally

[8] It is not possible to calculate from the Japanese NIA the asset-specific depreciation rates for the private sector. The depreciation rates shown in Table 2 are for the nation as a whole which includes government capital. This is the reason why the overall depreciation rate in Table 2 does not agree with that in Table 1 for Japan. The overall depreciation rate for the nation is lower because government capital is mainly in the form of structures.

tradable. Why does the same piece of equipment appear to depreciate faster in Japan?

The Capital Stock Estimate Actually, the question of high depreciation rate is an old one. Japan is unique in that we have a direct estimate of the capital stock in the *National Wealth Survey* (NWS). The two most extensive surveys are for 1955 and 1970. According to EPA (1978, p. 231), the Japanese NIA takes the 1970 NWS estimate of the net capital stock to be the capital stock for 1970 in the NIA. However, it has been recognized by practitioners of the perpetual inventory method that it requires implausibly high depreciation rates for the EPA's investment series between 1955 and 1970 to be consistent with the *NWS* net capital stock for the two years. For example, Dean, Darrough and Neef (1990) reports that the depreciation rate has to be about 10% for structures and 30-50% for equipments.[9] This has prompted some prominent students of productivity growth to take the position that the NWS *gross* capital stock should be used as the capital stock (Kuroda (1990, p. 266). The detailed examination of the Japan-U.S. productivity comparison in Jorgenson, Kuroda and Nishimizu (1987) is based on this premise. For equipments, the 1970 *NWS* gross capital stock is about twice as large as its net counterpart.[10] It is, then, not surprising at all that the Japanese implicit depreciation rate for equipments in Table 2 is almost twice as large as the U.S. rate; what is mis-measured in the Japanese NIA is the capital stock, not the level of replacement cost depreciation (recovered from

[9] This raises a question of why the depreciation rate for structures in Table 2 is substantially lower than the structure depreciation rate in Dean, Darrough, and Neef (1990). I think that the answer lies in the fact that structures in Table 2 includes government capital, while the estimate in Dean *et. al.* is for manufacturing sector only.

[10] See Tables 1-1 and 1-2 of EPA (1975).

the NIA by my procedure).

III. Miscellaneous Issues

Having disposed the main issue of contention, I now turn to other points discussed in DS.

Wealth-Based Saving Rate The second half of DS is devoted to the wealth-based measure of saving to show that the market value of Japanese assets has increased faster than the value of U.S. assets. This is not at all new; I calculated my own wealth-based saving rate with the Japanese rate higher than the U.S. rate by as much as 20 percentage points on average.[11] DS takes great pains to document that the "market value" of corporate equities in the NIA is substantially undervalued[12] and goes through a procedure to try to correct for that. But their procedure seems seriously flawed. First, DS overlooks the fact that the value of equity on the *asset* side of the balance sheets for the household sector (and other sectors) are at market prices.[13] Thus it is both unnecessary and inappropriate to blow up the value of household equity holdings which are already at market prices. Second, if, as they claim, the EPA's estimate of depreciation is biased, it means that the capital stock series in the NIA are invalid. Thus I do not see why DS's

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[11] See column 5, Table 1 of Hayashi (1986).

[12] This, however, is no longer the case in the latest benchmark revision where corporate equities are at market prices. To appreciate that, compare the value of equity for the nonfinancial corporate sector for, say, 1988, in the 1990 *Annual Report on National Accounts* with that in the 1991 *Annual Report*. The latter is more than ten times as large.

[13] See page 561 of the 1990 edition of the *Annual Report*.

measure of saving is immune from the alleged accounting biases, as DS claims it is.

Use of Secondary Data Sources DS relies on the OECD national accounts for U.S. numbers. I understand that it is motivated by their desire to include government capital, but the primary data source on government capital, BEA (1987), is readily available. Reliance on secondary data sources adds a layer of uncertainty about data reliability. This may have contributed to the apparent error in their Table 2 for U.S. depreciation rates.

Other Quibbles The rest of my comments are minor quibbles.

- On page 6 of DS, it is claimed that the same asset service lives for tax purposes are used by the EPA to calculate economic depreciation. This is not true at least for the set of assets I checked. For example, the asset life used by the EPA for engines and turbines is, as noted by DS in their footnote 11, 16 years, while the asset life for tax purposes as of 1965 is shorter and is 11 years (see 31 May 1965 special issue of the *Official Bulletin*). Moreover, strictly speaking, it is not appropriate to compare asset lives between the two countries, because the procedure used by the BEA to calculate depreciation from the asset life is different from that used by the EPA.[14]
- Since service flows from government capital are included in Japanese GNP but not in the U.S. GNP, one has to adjust for that when making international comparisons. DS's

[14] The EPA uses geometric depreciation. If T is the asset life, the geometric depreciation rate d is calculated as $(1-d)^T = 10\%$ (see EPA (1978, p. 233)). The procedure used by the BEA is more complicated and utilizes what is called the Winfrey S-3 retirement distribution. See Hulten and Wykoff (1981, section IV) for a clear exposition of the BEA methodology.

Table 2 does not seem to have done that.

- Contrary to what DS appears to claim in footnote 5, the stock and flow data necessary for carrying out the perpetual inventory method from 1970 have been available in the NIA for at least several years.

- In footnote 7, DS alleges that I failed to make a correct comparison. As far as I can tell from Hayashi (1986), I did not make such a mistake. I did not include depreciation on government capital in my estimate of U.S. depreciation because I wanted to adhere to the BEA definition. The corresponding Japanese depreciation, correctly, does not include depreciation on government capital.

- Of all the points raised in DS, the *only* one which I think has any merit is the treatment of Okinawa's capital stock. The calculation reported in this article still does not properly incorporate it. But, as far as I can tell, DS's wealth-based measure does not appear to have adjusted for Okinawa, either.

IV. Conclusion

As much as I appreciate the effort and interest paid by DS, I view their work as wholly misguided. I think that directions for future research should include a more thorough examination of equipment capital in the *National Wealth Survey* and a careful measurement of housing depreciation. The latter would require collecting data on prices of houses of different ages. Also, with all due respect, I urge the EPA to publish, first, their estimate of replacement cost depreciation, and second, an explicit account of exactly what

items are included in the reconciliation account besides capital gains and the replacement cost-historical cost gap in depreciation. This will take the detective work out of academics's dealing with the most basic economic statistics published by the Japanese government.

Appendix: Data Source

Figure 1. For Japan, the unadjusted saving rate is defined in the usual way:

$$S/(GNP - DEP)$$

where S = national saving (line 3, Table 1-[2]-I-2 of the 1991 *Annual Report on National Accounts*),
GNP = gross national product (Table 1-[2]-I-1),
DEP = depreciation (at historical costs) (line 3, Table 1-[2]-I-1).

The adjusted rate calculates depreciation at replacement costs. See the Appendix in Hayashi (1986) and footnote 3 of the text for details.

The U.S. saving rate is defined in the usual way:

$$(GS - DEP)/(GNP - DEP),$$

where GS = gross saving (Table B-28 of the 1991 *Economic Report of the President*),
GNP = gross national product (Table B-1),
DEP = capital consumption allowances with capital consumption adjustment (Table B-22).

Table 1. For the U.S.,
(1) depreciation in billions of dollars (see data source for Figure 1),
(2) capital stock at year beginning (i.e., at the end of the previous year) in billions of dollars (Table A13 of BEA (1987)),
(3) GNP in billions of dollars (see data source for Figure 1).

For Japan,
(1) depreciation at replacement costs (see above),
(2) capital stock at year beginning in trillion yen (sum of: line 2 of Table 2-II-1, line 1 of Table 2-II-2, line 1 of Table 2-II-4, and line 2 of Table 2-II-5),
(3) GNP net of service flows from government capital (see Appendix in Hayashi (1986) for derivation).

Table 2 The depreciation rate is the ratio of depreciation for the asset to the stock of the asset at the end of previous year. For U.S., depreciation and the capital stock are for the private sector and are from Table A10 of BEA (1987) for residential structures, Table A7 for nonresidential structures and for equipments. For Japan, depreciation and the capital stock are for the nation as a whole (including the government sector). The capital stocks by asset are in Table 2-III-1. Depreciations by asset are calculated as explained in the Appendix of Hayashi (1986). In particular, to calculate revaluation using formula (A1) in Hayashi (1986) (see footnote 3 of the text for a very minor modification), net capital stock in Table 2-III-1 is taken to be nominal net investment.

References

BEA (Bureau of Economic Analysis, U.S. Department of Commerce), 1987, *Fixed Reproducible Tangible Wealth in the United States, 1925-85*, Washington, DC: U.S. Government Printing Office.

Dean, Edwin, Masako Darrough, and Arthur Neef, 1990, "Alternative Measures of Capital Inputs in Japanese Manufacturing", in C. Hulten *ed.*, *Productivity Growth in Japan and the United States*, University of Chicago Press for the National Bureau of Economic Research, Chicago, pp. 229-265.

Dekle, Robert, and Lawrence Summers, 1991, "Japan's High Saving Rate Reaffirmed", National Bureau of Working Paper No. 3690.

EPA (Economic Planning Agency of the Japanese Government), 1975, *1970 National Wealth Survey of Japan* (in Japanese).

--------, 1978, *Guide to the New National Economic Accounts* (in Japanese), Government Printing Office, Ministry of Finance.

--------, 1988, *Report on National Accounts from 1955 to 1969* (in Japanese).

--------, 1990, *Report on Revised National Accounts on the Basis of 1985* (in Japanese).

Hayashi, Fumio, 1986, "Why is Japan's Saving Rate So Apparently High?", *NBER Macroeconomics Annual 1986*, Vol. 1, MIT Press, Cambridge, Mass., pp. 247-210.

--------, 1989a, "Is Japan's Saving Rate High?", *Federal Reserve Bank of Minneapolis Quarterly Review*, Spring 1989, pp. 3-9.

--------, 1989b, "Japan's Saving Rate: New Data and Reflections", NBER Working Paper No. 3205, December 1989.

Hulten, Charles, and Frank Wykoff, 1981, "The Measurement of Economic Depreciation", in C. Hulten *ed.*, *Depreciation, Inflation and the Taxation of Income from Capital*, Urban Institute, Washington, D.C., pp. 81-125.

Jorgenson, Dale, Masahiro Kuroda, and Mieko Nishimizu, 1987, "Japan-U.S. Industry-Level Productivity Comparisons, 1960-1979", *Journal of the Japanese and International Economies*, Vol 1, No. 1, pp. 1-30.

Kuroda, Masahiro, 1990, "Comment", in C. Hulten *ed.*, *Productivity Growth in Japan and the United States*.

Ohkawa, Kazushi, and Miyohei Shinohara, *eds.*, 1979, *Patterns of Japanese Economic Development:*

A Quantitative Appraisal, Yale University.

Figure 1: National Saving Rate

Percent of Net National Product

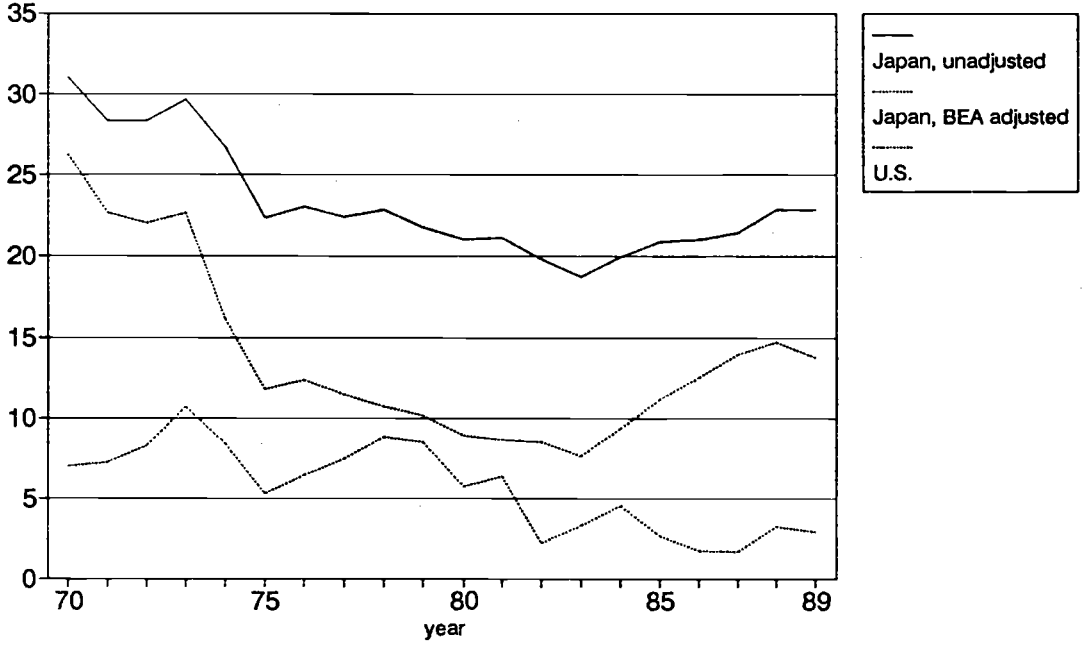

Table 1

Depreciation, Capital Stock and GNP for the U.S. and Japan

	U.S.					Japan				
year	(1) depr.	(2) cap. stock	(3) GNP	(4) (1)/(2)	(5) (1)/(3)	(1) depr.	(2) cap. stock	(3) GNP	(4) (1)/(2)	(5) (1)/(3)
1970	88.8	1516.7	1015.5	5.9	8.7	9.7	70.9	74.0	13.6	13.1
1971	97.5	1637.5	1102.7	6.0	8.8	11.1	85.8	81.5	12.9	13.6
1972	107.9	1811.0	1212.8	6.0	8.9	12.5	104.9	93.4	12.0	13.4
1973	118.1	1997.7	1359.3	5.9	8.7	16.2	146.0	114.2	11.1	14.2
1974	137.5	2267.6	1472.8	6.1	9.3	23.4	189.8	136.3	12.3	17.2
1975	161.8	2684.8	1598.4	6.0	10.1	24.7	212.9	150.4	11.6	16.4
1976	179.2	2934.5	1782.8	6.1	10.1	27.7	238.9	169.1	11.6	16.4
1977	201.5	3242.2	1990.5	6.2	10.1	30.4	266.6	188.4	11.4	16.1
1978	229.9	3681.0	2249.7	6.2	10.2	33.0	290.6	207.9	11.4	15.9
1979	265.7	4924.8	2508.2	5.4	10.6	36.6	328.0	225.9	11.2	16.2
1980	303.8	4866.5	2732.0	6.2	11.1	41.8	376.6	245.2	11.1	17.0
1981	347.8	5483.8	3052.6	6.3	11.4	43.8	407.3	262.4	10.8	16.7
1982	383.2	6103.6	3166.0	6.3	12.1	46.2	431.0	276.1	10.7	16.7
1983	396.6	6242.2	3405.7	6.4	11.6	48.2	449.5	287.6	10.7	16.8
1984	415.1	6563.2	3772.2	6.3	11.0	50.9	471.2	306.9	10.8	16.6
1985	437.2	6936.0	4014.9	6.3	10.9	53.2	494.7	327.5	10.8	16.2
1986	460.1	7206.9	4231.6	6.4	10.9	55.0	514.1	341.8	10.7	16.1
1987	487.0	n.a.	4515.6	n.a.	10.8	57.3	535.7	356.9	10.7	16.1
1988	514.3	n.a.	4873.7	n.a.	10.6	61.2	573.3	380.3	10.7	16.1
1989	554.4	n.a.	5200.8	n.a.	10.7	66.1	625.9	405.8	10.6	16.3
average				6.2	10.3				11.3	15.9

Note: See Appendix for data source.

Table 2

Depreciation Rates by Assets

year		residential structures		nonresidential structures		equipments		total	
		value share	depr. rate	value share	depr. rate	value share	depr. rate	value share	depr. rate
1970	U.S.	48.3	2.8	28.0	5.1	23.8	13.0	100.0	5.9
	Japan	20.6	9.9	54.8	7.2	24.7	28.4	100.0	13.0
1975	U.S.	47.0	2.9	29.6	5.1	23.4	13.5	100.0	6.0
	Japan	23.5	8.8	52.6	6.3	23.9	22.7	100.0	10.8
1980	U.S.	49.5	2.9	26.7	5.7	23.8	13.7	100.0	6.2
	Japan	26.1	9.0	56.5	6.5	17.4	23.9	100.0	10.2
1985	U.S.	47.7	2.9	27.3	5.6	25.0	13.5	100.0	6.3
	Japan	23.6	8.5	59.4	5.7	17.0	22.8	100.0	9.3
1989	U.S.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Japan	22.6	8.8	59.5	5.7	17.9	23.8	100.0	9.6

Note: See Appendix for data source.