Appendix 1

Determining Capital Stock in the Business Sector in Japan

There are several types of reproducible fixed assets reported by the Economic and Social Research Institute of the Japanese government (ESRI) in the National Accounts. However, as several authors have pointed out, Japan's depreciation rate is very much higher than the US rate (for example Hayashi (1986)).

Depreciation rates in the Japanese National Accounts are the same as those in the tax code, so it is possible that depreciation is over-estimated. Thus, we decided to construct estimates of reproducible fixed assets (excluding housing) for the business sector (that is, excluding general government but including public enterprises) by item and sector. In this appendix we describe the procedures followed. We decided to use National Accounts estimates of dwellings and their depreciation, given that housing in Japan has some characteristics (such as a substantial portion built with wood) that makes unusually high depreciation rates not implausible.

We have constructed the stock of each type of reproducible fixed asset by first determining the benchmark stock, updating the stock each period using the perpetual inventory method, and then computing the stock and depreciation by sector.

Calculation of Benchmark Stock

The National Accounts do not report gross investment data by business sector by asset type, so we are not able to construct the capital stock of the business sector directly. Instead, we begin by constructing the aggregate capital stock. First, we calculate the benchmark stock using the National Wealth Survey of 1970, from which we get the net stock value for the business sector, defined as the sum of the whole private sector, public corporate sector, and non-profit institutions.

We include all assets with the exception of the residential stock and the stock corresponding to investment in land improvement and divide it into five types: (1) buildings,

(2) structures, (3) machines and tools, (4) transportation equipment, and (5) plants and animals.

The Survey is at 1970 prices. We convert it to 1990 prices using the stock deflator reported in National Accounts Table 6.4.1 (Closing Stocks of Net Fixed Assets).

Accumulation of Capital Stock

To accumulate capital stock using the perpetual inventory method, we need the investment series and depreciation rate by asset. Investment data by asset in the National Accounts covers all sectors including the general government sector. Using the ratio of government to aggregate investment, we can impute government investment by item, exclude it from the aggregate, and thus obtain investment by item for the business sector as a whole.

We adopt depreciation rates for fixed capital using those reported by Hayashi and Inoue (1991). Their data for machinery and transportation equipment includes information on early retirement of capital, whereas the National Accounts do not. Thus, following their suggestion, we augment their depreciation rates (based on Hulten and Wykoff (1979) rates) by 40% to take account of this omission.

For buildings we use the rate reported by Dean, Darrough and Neef (1990). For remaining structures we augment Dean, Darrough and Neef rates by 20%, as Hayashi and Inoue suggest. For plants and animals we apply the rate used in the United States by the Bureau of Economic Analysis as reported in Fraumeni (1997).

Depreciation Rates by Asset Type

0.047 Buildings
0.056 Structures
0.157 Machinery, tools, and furnishings
0.245 Transportation equipment (including ships)
0.023 Plants and animals

Using these rates and the perpetual inventory method, we calculate the capital stock from 1970 to 1998. An adjustment is made for the 1995 Hanshin-Awaji (Kobe) earthquake by subtracting the estimated losses (provided by Mr Mitsuo Hosen of the ESRI) from the capital stock at the end of 1995.

Assets Lost in the 1995 Hanshin-Awaji Earthquake (in billion yen)

3,088	Buildings
1,895	Structures
22	Machinery, tools and furnishings
88	Transportation equipment (including ships)

Calculation of Capital Stock by Sector

The National Wealth Survey of 1970 can be used to construct capital stock by type and sector. Gross investment by sector can be obtained from the National Accounts.

Because housing is excluded from our stock calculation, we have to subtract housing investment, which is recorded in the National Accounts only for the combined corporate sector and for the combined household and non-profit institutions sector. We assume only households and non-financial corporations invest in residential structures. This seems innocuous, as we combine households and non-profit institutions in any event and financial institutions hold a negligible amount of residential structures (0.49%) as reported in the National Wealth Survey.

We need the depreciation rate by sector to accumulate the stock. To obtain it, we calculate aggregate depreciation by item, sum across items, and divide by total stock. This provides an implied depreciation rate, which is used for each individual sector. This implied rate is, on average, a little above 8%, which is a considerably less than the rate obtained from the National Accounts (Table 7).

Having obtained gross investment and depreciation, we can use the perpetual inventory method to obtain capital stock by sector. We allocate the total loss of assets due to the Hanshin-Awaji earthquake reported above to each sector according to the stock held at the end of 1994.

The results of our calculations are shown in Supplemental Tables A.1 and A.2. Table A.1 shows our calculation of capital stock and depreciation by item and compares the totals to the corresponding National Account magnitudes. Our estimate of aggregate stock shown (column 11) is roughly 20% higher than the National Account's (column 13).

The difference in depreciation is considerable, especially in the early years. This is to be expected, as in those years our estimate of the stock is not that much different from theirs, whereas our depreciation rates are considerably smaller. In later years the difference in stock becomes bigger and thus the difference in depreciation becomes smaller although still sizeable. Note that column 14 reports National Accounts depreciation at original cost (at 1990 prices) and thus has to be augmented by an estimate of the capital consumption adjustment (column 15) to be comparable to our estimate of depreciation in column 12.

Table A.2 reports stocks and depreciation for non-financial corporations and financial institutions.

References

Dean, E., M. Darrough, and A. Neef (1990), “Alternative Measures of Capital Inputs in Japanese Manufacturing”, in Productivity Growth in Japan and the United States, edited by C. Hulten. University of Chicago Press, Chicago.

Fraumeni, B. M. (1997), “The Measurement of Depreciation in the US National Income and Product Accounts,” Survey of Current Business, July, pp. 7-23.

Hayashi, F. (1986), “Why Is Japan’s Saving Rate Apparently So High?”, NBER Macroeconomics Annual, MIT Press, Cambridge, MA, pp. 147-210.

Hayashi, F. and T. Inoue (1991), "The Relation between Firm Growth and Q with Multiple Goods: Theory and Evidence from Panel Data on Japanese Firms," Econometrica 59, May, pp. 731-753.

Hulten, C., and F. Wykoff (1981), "The Measurement of Economic Depreciation", in Depreciation, Inflation and the Taxation of Income from Capital, edited by C. Hulten, Urban Institute, Washington, D.C, pp. 81-125.

Appendix 2

Adjusting Depreciation and Capital Stock

In order to interpret the differences between Parts B and C of Table 3, let us consider the consequence of constructing the data for depreciation and the net capital stock assuming a depreciation rate much higher than the one that actually prevailed in the economy. We have the identity:

$$IG_t - D_t = K_t - K_{t-1}, \qquad (1)$$

where IG_t is gross investment, D_t is depreciation and K_t is the stock of capital at the end of period *t*. Dividing equation (1) by K_{t-1}, we have

$$\frac{IG_t}{Q_t} \times \frac{Q_t}{K_{t-1}} - \frac{D_t}{K_{t-1}} = \frac{K_t - K_{t-1}}{K_{t-1}},$$

where Q is the value-added measure of output. On a steady growth path, the rate of growth of Q_t should be equal to the rate of growth of K_t. Denoting this growth rate by g and defining $d_t = D_t / K_{t-1}$, $ig_t = IG_t / Q_t$, we have, on the steady state growth path,

$$ig \times \frac{Q_t}{K_{t-1}} - d = g$$

$$\frac{K_{t-1}}{Q_t} = \frac{ig}{d+g}. \qquad (2)$$

The Japanese economy has not been on a steady state growth path. Therefore, we cannot apply equation (2) to the Japanese data directly. However, we can rely on the reasoning leading up to (2) to formulate a hypothesis concerning the potential biases that are likely to be present in the Japanese data. For this purpose, let us note that the quantity ig is known, and there is no reason to suppose that information on this quantity is biased one way or another. The same is true of Q. D is generated multiplying K_{t-1} by an assumed value of d, and K_t is generated by formula (1). Therefore, for a given g, if the assumed value of d is much larger than the true value of d, the recorded values of K and K/Q must be smaller

than the true values of K and K/Q. For example, if ig is 0.2 and g is 0.02, and the true value of d is 0.08, then the true value of K/Q would be 2.0. If the value of d is incorrectly assumed to be 0.12, and the time series of K is generated by the perpetual inventory procedure, however, the resulting recorded value of K/Q approaches 1.5. That is, the estimate of capital stock under the assumption that d is 0.12 is roughly 75% of the correct value. Similarly, the estimate of depreciation, D, under with the incorrectly large depreciation rate of 12% will be roughly 112.5% of the correct value.

Returning to Table 3 and comparing the last values of columns (5) and (2) between Part B and C, we see that the estimates of the capital stock and depreciation with 12% depreciation rate are roughly 85% and 119%, respectively, of estimates with 8% depreciation rate. Given that the Japanese economy was by no means in a steady state equilibrium condition during the period leading up to l998, we believe that our empirical results are within the reasonable range of our analytical predictions.

Appendix 3

Computing "Lost" Household Wealth

To compute "lost" wealth we assume there is no market value discrepancy for corporations – that is, the market value of net equity is equal to accounting equity, which is the same as saying that Tobin's average *q* is one. We then made four additional assumptions, listed below, to create a hypothetical distribution of equities among sectors. This is used to calculate the household sector's adjusted net worth.

Assumptions Regarding Distribution

1 Government entries do not change. This is because virtually all its equity is in public corporations that are not traded and whose objectives are typically quite different from those of profit-seeking ones.

2 The ratio of equity owned to net equity for the corporate sector as a whole (column 3) remains the same. That is, row i' = j'*(i/j).

3 The ratio of non-financial equity owned to total corporate equity owned remains the same. That is, for row i', the ratio of column 1 to column 3 is the same as for row i. The same is true for the ratio of column 2 to column 3.

4 The relative distribution of equities between households and the rest of the world remains the same. That is, for row j', the ratio of column 5 to (column 3 minus column 4) is the same as for row j.

Table A.1
Capital Stock and Depreciation by Asset Type, 1970-98:Our Estimates Compared to National Accounts

(billion of 1990 yen)

Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(11)	(12)	(13)	(14)	(15)
	Buildings		Structures		Machines and tools (incl. plants and animals)		Transportation and machines[1]		Business sector				
									Our Totals		National Accounts Totals		
	Stock	Depreciation	Stock	Depreciation	Stock	Depreciation	Stock	Depreciation	Stock[2]	Depreciation[3]	Stock	Depreciation	CCA[4]
1970	50,961		50,768		31,640		6,586		139,956		126,268		
1971	57,527	2,395	59,680	2,863	36,383	4,824	8,100	1,614	161,691	11,696	145,760	24,124	-4,281
1972	64,382	2,704	68,863	3,366	40,296	5,600	9,547	1,985	183,088	13,654	165,265	24,134	-5,251
1973	71,782	3,026	78,650	3,884	45,876	6,276	10,842	2,339	207,151	15,525	186,975	26,911	-3,580
1974	77,927	3,374	87,709	4,436	50,054	7,146	11,048	2,656	226,738	17,612	204,093	29,564	417
1975	83,292	3,663	96,624	4,947	52,229	7,776	11,100	2,707	243,244	19,092	218,705	26,519	1,477
1976	88,313	3,915	104,902	5,450	54,794	8,154	11,092	2,719	259,102	20,237	232,141	23,264	2,682
1977	92,848	4,151	112,860	5,916	57,097	8,526	11,284	2,718	274,088	21,311	244,367	24,257	3,041
1978	97,529	4,364	121,048	6,365	59,700	8,825	11,843	2,765	290,120	22,319	257,429	25,022	3,294
1979	103,029	4,584	129,567	6,827	63,758	9,135	12,805	2,901	309,158	23,447	273,542	26,139	3,082
1980	109,718	4,842	137,275	7,308	68,439	9,623	13,742	3,137	329,174	24,910	290,400	28,417	3,722
1981	116,285	5,157	144,738	7,742	73,715	10,177	14,558	3,367	349,296	26,443	307,256	29,681	3,071
1982	122,295	5,465	151,491	8,163	79,392	10,822	14,883	3,567	368,062	28,017	322,451	31,119	3,545
1983	127,849	5,748	157,527	8,544	84,941	11,530	15,345	3,646	385,663	29,468	336,063	32,417	3,665
1984	133,663	6,009	163,671	8,885	93,213	12,222	15,787	3,760	406,334	30,875	351,952	33,857	4,203
1985	140,360	6,282	169,484	9,231	102,705	13,330	16,737	3,868	429,286	32,711	369,796	36,057	4,197
1986	147,540	6,597	175,495	9,559	111,212	14,612	17,740	4,101	451,988	34,868	387,562	38,304	3,743
1987	154,378	6,934	182,304	9,898	119,969	15,765	19,236	4,346	475,887	36,944	406,081	40,523	3,634
1988	162,359	7,256	190,437	10,282	132,201	16,948	20,798	4,713	505,796	39,199	429,843	43,050	3,759
1989	172,662	7,631	199,637	10,741	146,818	18,664	22,842	5,096	541,959	42,131	459,333	46,183	2,653
1990	184,509	8,115	210,208	11,260	163,228	20,744	24,999	5,596	582,944	45,715	493,368	51,413	3,511
1991	198,854	8,672	220,997	11,856	178,674	23,093	26,790	6,125	625,315	49,746	528,323	54,329	4,252
1992	212,736	9,346	230,645	12,464	189,166	25,308	27,490	6,563	660,037	53,681	555,609	57,621	5,238
1993	224,542	9,999	238,749	13,008	193,826	26,769	27,092	6,735	684,208	56,511	572,052	59,391	7,148
1994	234,409	10,553	245,905	13,465	196,356	27,349	26,457	6,638	703,127	58,005	582,980	58,795	7,328
1995	240,783	11,017	250,515	13,869	202,505	27,598	26,452	6,482	720,255	58,967	592,181	58,905	6,226
1996	248,763	11,317	257,171	14,129	217,158	28,401	26,707	6,481	749,798	60,328	608,917	60,240	7,179
1997	258,638	11,692	263,877	14,504	234,772	30,522	26,612	6,543	783,899	63,261	629,753	63,284	8,366
1998	266,726	12,156	268,879	14,883	246,108	33,063	25,473	6,520	807,186	66,621	641,504	65,776	9,285

Includes non-profit institutions. Capital stock is reported on a year-end basis.

1 Includes ships.

2 Sum of stock of the four specific categories (columns 1, 3, 5, 7).

3 Sum of depreciation of the four specific categories (columns 2, 4, 6, 8).

4 Imputed capital consumption adjustment (CCA), excluding housing, from National Accounts. Calculated using data on real capital stock and flows. Note this CCA is not the same as the capital consumption adjustment (CCAdj) used by the United States – see discussion in the text under "Depreciation".

Source: EPA, Annual Report on National Accounts, 2000, pp. 79-89, 248-249, 322-337, 390-391 and Appendix 1.

Table A.2
ESTIMATES OF CAPITAL STOCK AND DEPRECIATION OF NON-FINANCIAL AND FINANCIAL CORPORATIONS

Year	Reproducible fixed assets of nonfinancial corporations (excl. housing)	Depreciation of reproducible fixed assets of nonfinancial corporations (excl. housing)	Reproducible fixed assets of financial institutions (excl. housing)	Depreciation of reproducible fixed assets of financial institutions (excl. housing)
1970	107,433.5		3,471.2	
1971	126,086.7	8,978.4	3,815.4	290.1
1972	144,164.8	10,647.5	4,117.7	322.2
1973	163,919.0	12,224.6	4,614.4	349.2
1974	179,876.5	13,936.3	5,006.4	392.3
1975	192,334.2	15,146.5	5,344.1	421.6
1976	203,661.9	16,001.7	5,601.3	444.6
1977	214,825.1	16,751.1	5,881.3	460.7
1978	226,630.4	17,493.2	6,123.0	478.9
1979	241,265.9	18,315.9	6,452.8	494.8
1980	257,061.1	19,440.0	6,852.4	519.9
1981	273,501.5	20,650.2	7,251.0	550.5
1982	289,390.9	21,937.7	7,562.7	581.6
1983	303,833.8	23,169.4	7,911.3	605.5
1984	321,308.6	24,324.4	8,349.6	633.4
1985	340,895.5	25,866.4	8,743.7	672.2
1986	360,335.0	27,688.6	9,227.0	710.2
1987	380,552.0	29,452.7	9,962.1	754.2
1988	405,534.9	31,346.0	11,156.9	820.6
1989	436,000.6	33,779.7	12,792.5	929.3
1990	471,103.9	36,777.2	14,760.0	1,079.1
1991	507,740.1	40,201.9	16,438.4	1,259.6
1992	537,485.5	43,587.9	17,679.9	1,411.2
1993	559,048.6	46,018.1	18,460.6	1,513.7
1994	576,722.5	47,394.7	19,105.6	1,565.0
1995	593,505.1	48,365.8	19,262.8	1,602.3
1996	621,008.5	49,711.4	20,180.7	1,613.4
1997	653,546.3	52,395.0	21,423.6	1,702.7
1998	676,024.1	55,542.8	22,568.1	1,820.7

Source: See Appendix 1.