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8 Alternative Measures of Capital Inputs in Japanese Manufacturing

Edwin Dean, Masako Darrough, and Arthur Neef

Students of the Japanese economy who use capital investment and stock statistics are blessed with riches that might arouse the envy of students of other countries. For manufacturing in particular, there are four plausible sources of gross investment data and at least two means of distributing total gross investment among asset categories. Further, to provide measures of net capital stocks, a choice can be made between the use of the perpetual inventory method or an alternative approach utilizing net capital stock statistics from national wealth surveys as benchmarks. Because these alternatives yield different results, however, the researcher may be more embarrassed than blessed by these riches.

This paper examines the various data sources and methods available for measuring net capital stocks, by asset type, in Japanese manufacturing and assesses the merits of the alternatives, particularly from the viewpoint of their ultimate use in measuring multifactor productivity (MFP) growth. In pursuit of these objectives, we examine the differences in levels and growth rates of manufacturing gross investment and net capital stocks, by asset type, that result from using different Japanese data sources.

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Measures of capital services inputs are needed for computation of multifactor productivity. Capital services input measures are computed from statistics of capital stock of various asset types. Asset detail allows the input measure to reflect changes in the composition of the capital stock, as assets with different service lives grow at different rates. Capital service inputs are computed as weighted averages of the various types of capital stock, where the weights are implicit rental prices of each type of stock.

This paper begins with a statement of the method used for developing measures of Japanese capital stocks in manufacturing. Reliance is placed on use of national wealth surveys to determine average annual rates of discards plus depreciation. The second section of the paper examines the relevance of the approach used and the results obtained to research problems found in a variety of fields of economic research. In the third section, available data sources for capital stocks and annual gross investment are described. The fourth section presents an assessment of the advantages and shortcomings of each of these data sources. In the fifth section, the methods are implemented, using a variety of data sources for gross investment, to estimate net capital stocks for 1955–81. A conclusion summarizes the main findings of the paper. Finally, an appendix presents, for 1955–81, annual data on gross investment from four data sources and the preferred measures of annual net capital stock for three asset types.

8.1 Method

For most countries, measures of capital stock have been computed by the perpetual inventory method. In the absence of reliable measures of capital stock at any point in time, this method relies on statistics of past annual gross investment, estimates of average service lives, and a discard function. For most countries that have developed capital stock measures, the average service lives and discard function used are often little more than educated guesses, resting in part on service lives embodied in tax law (Blades 1983; Ward 1976).

The perpetual inventory method can be expressed as follows:

$$K_{i,j_t} = I_{i,j_t} + (1 - u_{i,j_t})K_{i,j_{t-1}}, \quad (1)$$

where K_{i,j_t} is the current year's net capital stock for the j_{th} industry's i_{th} asset, I_{i,j_t} is the current year's gross investment, and u is a proportion that must be applied against the previous year's net capital stock to account for depreciation and discards. Capital stocks in year t-1 and earlier years are computed by accumulating and depreciating long investment series; no benchmark observation of capital stock is required or, in the typical case, utilized.

An alternative method for computing capital stocks has been utilized by students of the Japanese economy. This method, first implemented by Mieko Nishimizu (1974), takes advantage of periodic official Japanese surveys of net capital stock, the national wealth surveys (NWSs). Following Nishimizu, the method has been used by, among others, Nishimizu and Hulten (1978), Norsworthy and Malmquist (1983), and Jorgenson, Kuroda, and Nishimizu (1985).

This method will be referred to as the double benchmark method. It relies on three sets of statistics for each asset: net stocks as measured by two wealth surveys and the annual gross investment for the years between the surveys, all in constant prices. These data are used in a polynomial equation. Provided that the data fulfill certain basic conditions (Nishimizu 1974), the roots of the polynomial equation generate estimates of the average annual rate of replacement (a rate summarizing average annual discards and depreciation) that are functions of opening and closing net stocks and annual gross investment. Where r is the polynomial root and u is the rate of replacement, $u = 1 - r$.[1]

The value of u, and ultimately net stock by asset type for a given year t, can be found by solving the following equation:

$$K_{i,j_t} = \sum_{s=1}^{t}(1 - u_{i,j})^{t-s} I_{i,j_s} + (1 - u_{i,j})^t K_{i,j_0}, \tag{2}$$

where K_{i,j_0} is the benchmark capital stock for the j_{th} industry's i_{th} asset. (It is obvious that eqq. [1] and [2] are consistent, so the double benchmark method is consistent with the perpetual inventory method.)

An attractive feature of this method is that the rate of discards plus depreciation is dictated by the data.[2] An equally important attractive feature is that this method gives a fix on the size of the stock. This is an advantage over procedures that do not use benchmarks. The perpetual inventory method, for example, typically makes use of very long investment series but no benchmark.

On the other hand, the double benchmark method does suffer from limitations and shortcomings. The gross investment and capital stock data must be consistent, by asset type, in their coverage, definition, and methods, as well as accurate. A change in the procedure for estimating net stock between two wealth surveys will yield biased estimates of u, as will inaccuracy in the price deflators. Further, a u determined by using data between two benchmark years may be unsuitable for computing net capital stocks prior to the earlier year or after the later year. However, most of these limitations have their counterparts in the perpetual inventory method.

Despite the shortcomings, this method is used in this study, in part because, in the Japanese case, the requirement of the perpetual inventory method for reliable gross investment series over a lengthy period is particularly difficult to fulfill, due to widespread destruction of assets during World War II (this affected some assets much more than others). Further, net capital stocks as measured through this procedure for estimating u provide a reasonably close approximation to productive capital stocks.[3]

This method for obtaining annual capital stocks, by asset type, in manufacturing is implemented using the 1955 and 1970 Japanese national wealth surveys (NWSs) for the two capital stock benchmarks. Four different series on annual gross investment are used with these two benchmarks. The data sources used to construct these series are the Census of Manufactures (CM), the Economic Planning Agency (EPA), the Annual Report on the Corporate Sector (ARCS), and the Report on the Corporate Industry Investment Survey (RCIS). A description of these data sources is provided in section 8.3 below, following a discussion of this inquiry's relevance to several fields of economic research.

8.2 Relevance to Several Research Fields: Some Illustrations

The estimates of capital stock and u produced by this study may interest economists who specialize in a number of different research fields. Economists who specialize in measurement and analysis of productivity will find these results directly relevant to their work. The results will also interest researchers who study rates of return, for example, and who need estimates of total capital stock and depreciation rates, and those who study investment incentives, who need estimates of effective tax rates.

It is found that use of the four alternative data sources on gross investment produces considerable variation in the level and growth rates of capital stocks and in implied rates of depreciation and discarding. In a series of illustrative examples, it is also found that the variations in capital stocks and rates of depreciation ultimately produce variations in multifactor growth rates, effective tax rates, and other variables. In most cases, the variation in these variables is great enough to affect research conclusions substantially.

8.2.1 Capital Stocks, Depreciation, and Multifactor Growth

The role of capital services input in the measurement of multifactor productivity growth is best explained in the context of the standard multifactor productivity growth model given in (3).

$$(3) \qquad \frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - S_k\frac{\dot{K}}{K} - S_l\frac{\dot{L}}{L} - S_m\frac{\dot{M}}{M},$$

where

$$S_k + S_l + S_m = 1.$$

In this model, $\dot{Q}/Q$ is the growth rate of gross output, $\dot{K}/K$ the growth rate of capital services input, $\dot{L}/L$ the growth rate of labor input, $\dot{M}/M$ the growth rate of intermediate inputs, and S_k, S_l, and S_m are the shares of capital, labor, and intermediate inputs, respectively, in total expenditures on inputs. Finally, $\dot{A}/A$ is multifactor productivity as computed by performing the subtraction indicated on the right-hand side. The dot notation refers to the change in the variable over time; hence $\dot{Q}/Q$ represents the growth rate of output.[4] It is well known that this measurement model assumes that the underlying production function has constant returns to scale, that inputs are paid the value of their marginal products, and that technical change is neutral (i.e., the relative marginal products of inputs are unaffected by technical change). The $\dot{K}/K$ term is computed using rental price weights to develop a weighted average of the growth rates of individual capital stocks, as was noted earlier.

The relevance of measures of capital stocks to a variety of research fields may be examined by using an alternative productivity measurement model. Unlike equation (3), this alternative model does not develop capital services input measures by utilizing rental price weights. Instead, the alternative model, given by equation (4), uses a direct aggregate of capital asset types. The capital term, $(\dot{K}/K)'$, is simply the summation of capital stocks of all asset types; rental price weights are not used. The capital share, S_k, is the same as the capital share term in equation (3). The new multifactor productivity term, $(\dot{A}/A)'$, is computed using the alternative capital term, $(\dot{K}/K)'$.

$$(4) \qquad \left(\frac{\dot{A}}{A}\right)' = \frac{\dot{Q}}{Q} - S_k\left(\frac{\dot{K}}{K}\right)' - S_l\frac{\dot{L}}{L} - S_m\frac{\dot{M}}{M},$$

where

$$S_k + S_l + S_m = 1.$$

Use of the $(\dot{K}/K)'$ term permits the examination of the influence on calculated MFP growth of alternative capital stock measures alone, without permitting the influence of differing rental prices, resulting from differing estimates of u, to affect the computations. (Eq. [4] is inferior to eq. [3] because it abandons the use of key assumptions concerning marginal products of different capital inputs and producer equilibrium in the use of these inputs.)

To illustrate the impact of alternative estimates of capital stock on calculated MFP, we implement equation (4), using illustrative examples of statistics for the cost shares of the inputs and the growth rates of all inputs, except capital, that are roughly consistent with data for the years 1973–81 from the Japanese national accounts and other sources.[5] Substitution of these figures into a discrete approximation to equation (4),[6] and adoption of several alternative capital stock measures that are produced in later sections of this study, will then yield alternative values for the growth rate of MFP.

Table 8.1 shows the effects on calculated MFP growth, for 1973–81, of using three different alternative capital stocks—directly aggregated in each case—based on gross investment data from three different data sources: CM, EPA, and ARCS. (Data from the fourth source, RCIS, are not used in this table, because, as discussed later in this paper, the authors did not use the RCIS data for years subsequent to 1974.) The results using equation (4) are

Table 8.1 **Effects of Alternative Capital Input Series on Computed MFP Growth Based on Direct Aggregation of Capital Stocks, Average Annual Growth Rates, 1973–81**[a]

	CM	EPA	ARCS
K	3.2	2.4	3.3
MFP	.8	1.0	.8

[a]Compound rates.

shown in this table. For the period 1973–81, total capital stocks, compiled using EPA gross investment data, grew at a 2.4% average annual rate, while they grew at 3.2% and 3.3% annually using the CM and the ARCS data, respectively. MFP grew most rapidly for the computations using the EPA data. MFP grew at 1.0% for the EPA data and at 0.8% for the CM as well as the ARCS data.

Earlier it was noted that the appropriate measure of capital services input is computed as a weighted sum of different types of capital assets, using rental prices as weights. Equation (3), which uses the $\dot{K}/K$ measure of capital services inputs, provides the appropriate measure of MFP growth.

The $\dot{K}/K$ measure of capital services inputs is a weighted sum of the growth rates of all types of capital assets, as follows:

$$(5) \qquad \frac{\dot{K}}{K} = \sum S_{k_i} \frac{\dot{K}_i}{K_i}, \quad (i = 1, 2, \ldots, n).$$

The weights, S_{k_i}, are computed as:[7]

$$(6) \qquad S_{k_i} = \frac{c_i K_i}{\sum_j c_j K_j}, \quad \sum S_{k_i} = 1.$$

The implicit rental prices, the c_i, provide measures of (the usually unobservable) prices of capital services. The equations used to estimate rental prices will vary from country to country depending on the tax structure of the country. For the Japanese case, we use the following rental price equation:

$$(7) \qquad c_t = \frac{1-[h_t+v_t(1-h_t)]z_t}{(1-h_t)(1-v_t)} \; [r_t p_{t-1} + u p_t - (p_t - p_{t-1})].$$

In this equation, h_t represents the corporate income tax rate in year t, v_t is the business establishment income tax rate (a prefecture tax), z_t is the present value of ¥1 of tax depreciation allowances, r_t is the nominal rate of return on capital, p_{t-1} the price of the asset in year $t - 1$, and u is the average annual rate of discards plus depreciation. (This equation represents a simplified version of the Japanese tax structure; it includes the major tax provisions affecting rental prices of capital, while omitting such taxes as the business property tax, the real property acquisition tax, the property tax on automobiles, the inhabitants tax, and an investment tax credit first introduced in 1978.) A comprehensive discussion of measurement of capital services inputs, including the development of rental prices, is presented by the U.S. Department of Labor (1983). Rental prices for use in MFP calculations for Japan are discussed in Nishimizu (1974).

This equation can be implemented, for illustrative purposes, using parameters that are of plausible magnitudes for the period 1973–81. For all variables except u, the values used are identical for the three alternatives.[8] For u, the values for each of the alternatives are those determined using equation (2) above.

Table 8.2 presents a comparison of three measures as determined by using the gross investment series developed from the alternative data sources. The first measure is u, the average annual rate of discards plus depreciation, estimated using equation (2); the second is the rental price, developed using equation (7); and the third is the rental share weights used in aggregation of capital assets, estimated using equation (6). It is possible to develop the first two measures for all four data sources, including the RCIS, while the third variable, the share weights, can be estimated only for the CM, the EPA, and the ARCS data.

Table 8.2 **Effects of Alternative Gross Investment Series on u's, Rental Prices of Capital, and Capital Weights, 1973–81**

	CM	EPA	ARCS	RCIS	Range ÷ Mean
u:					
Buildings and structures	.062	.111	.078	.029	1.171
Machinery and equipment	.173	.288	.199	.117	.880
Other	.281	.459	.317	.206	.801
Rental prices (c):					
Buildings and structures	.116	.191	.141	.066	.973
Machinery and equipment	.278	.433	.313	.203	.750
Other	.458	.685	.504	.363	.641
Capital weights (S_{k_i}):					
Buildings and structures	.175	.221	.183	N.A.	.238
Machinery and equipment	.602	.614	.593	N.A.	.035
Other	.223	.165	.224	N.A.	.289
Total	1.000	1.000	1.000	N.A.	

Note: The u's are those that are developed later in this study, using Census of Manufactures asset proportions (see table 8.8, panel A below). The numbers given for rental prices of capital and capital weights are based on various assumed parameters, as explained in the text, and are presented only to illustrate the effects of alternative gross investment series and the related alternative u's. N.A. = not available.

The values for u vary widely depending on the data set used. The RCIS data yielded the lowest values of u, the EPA data the highest. The EPA values were more than double the RCIS values for every asset and about four times the RCIS value for buildings and structures.

Rental prices also vary widely, solely as a result of the differences in the values of u. The ratio of the range of the four values for rental prices to their mean is 0.8 or more for each asset.

The capital weights also vary substantially, except for machinery and equipment. The variation in capital weights is produced both by the different values of the rental prices and by differences in the asset-type composition of total capital and in the growth rates of the assets in each data set (see eq. [6]). (The variation in share weights might have been greater if estimates had been possible for the RCIS.)

This table provides an illustration of the wide variation in rates of depreciation and discards, capital rental prices, and capital share weights that can be produced by use of different data sets for measuring gross investment.

Table 8.3 illustrates the variation in estimated MFP growth produced by use of alternative measures of capital services inputs, $\dot{K}/K$, which are in turn computed using alternative data sources for gross investment. The use of rental price weights to develop capital service inputs in this case results in wider variation in the growth rates of capital input than does the use of directly aggregated capital stocks. In table 8.3, capital services input growth rates range from 2.3% to 4.2% per year, while in table 8.1—prepared using directly aggregated capital stocks—the growth rate of total capital stock ranges from 2.4% to 3.3%. However, these differences in capital input growth rates do not produce greatly increased differences in MFP growth rates: in table 8.1, the difference between the highest and lowest MFP growth rates is 0.2%, while in table 8.3 the difference increases only to 0.3%.[9]

8.2.2 Effective Tax Rates

Measures of u are of interest to researchers who study investment incentives, because measures of depreciation and discards are needed in the computation of effective tax rates on income from capital. Measures of u are also relevant to researchers who examine profitability or rates of return.[10]

The concept of effective tax rates may be explained by beginning with the

Table 8.3 Effects of Alternative Capital Input Series on Computed MFP Growth Based on Rental Price Share-weighted Aggregation of Capital Stocks; Average Annual Growth Rates, 1973–81[a]

	CM	EPA	ARCS
K	3.9	2.3	4.2
MFP	.7	1.0	.7

[a]Compound rates.

idea of a tax wedge. King and Fullerton (1984) define the tax wedge as the difference between the rate of return on investment and the rate of return on the savings used to finance the investment. The wedge, then, is

$$w = p - s,$$

where p is the pretax real rate of return on a marginal investment project, and s is the posttax rate of return to the saver who supplied the finance for the investment. The effective tax rate, t, is defined as the tax wedge divided by the pretax rate of return, that is,

$$t = (p - s)/p.$$

The appropriate pretax real rate of return, p, is the return net of depreciation. Hence,

$$p = \text{MRR} - d,$$

where MRR is the gross marginal rate of return to an increment to the capital stock, and d is the rate of depreciation. It is often the case, in fact, that the best measure of depreciation must be computed without detailed information on actual depreciation. In the case of Japanese manufacturing, the average annual rates of discards plus depreciation, u, that are computed in this paper may well be the best available estimates of d that can be obtained for macroeconomic studies.

Hence, the effective tax rate may best be estimated as follows:

$$t = (\text{MRR} - u - s)/(\text{MRR} - u).$$

Estimates of $p = \text{MRR} - u$ vary substantially depending on the data source used to estimate u. The alternative estimates of u produced in this paper have large effects on calculated values of p. These effects are shown in table 8.4 for one asset type, machinery and equipment. For this asset, u varies between .12 (from the RCIS) and .29 (from the EPA). Using an assumed and arbitrary value of .35 for the gross marginal rate of return (MRR)—the actual value of MRR is unknown—the resulting values of p vary from .06 (EPA) to

Table 8.4 **Effects of Alternative u's on Pretax Real Rate of Return on Investment in Machinery and Equipment**

	CM	EPA	ARCS	RCIS	Range ÷ Mean
Gross marginal rate of return (MRR)	.35	.35	.35	.35	N.A.
u	.17	.29	.20	.12	.88
Pretax real rate of return (p)	.18	.06	.15	.23	1.10

Note: The 0.35 value used for MRR is assumed and arbitrary. N.A. = not available.

.23 (RCIS). The asset type chosen, machinery and equipment, is used to illustrate the potential impact on p of variation in u because the results are intermediate between those that would be produced by examination of the two other asset types.

For studies of effective tax rates, as for studies of rental prices and MFP, variation in u may be critical. It is important, therefore, to compare values of u produced by using different data sources and to assess the merits of the various data sources.

8.3 Data Sources: Description

The Japanese national wealth surveys (NWSs) were conducted by the EPA in 1955, 1960, 1965, and 1970. The 1965 survey has been dismissed as "meager in scale and quality compared to the other years" (Nishimizu 1974, 108). The 1960 survey contains some figures that are not based on a fresh survey of assets, but rather on the 1955 asset figures adjusted for estimated increases or decreases in stocks based partly on gross investment figures (Japan, Economic Planning Agency 1964). The 1955 and 1970 NWSs are of higher quality and are used in this study.

Gross investment statistics are available or can be derived from four sources: (1) a series produced by the EPA, using the commodity flow method, but which contains no breakdown of depreciable assets, by asset type, for the manufacturing sector; (2) a series resulting from annual surveys of corporations conducted by EPA—the annual Report on the Corporate Industry Investment Survey (RCIS)—which, for the years 1956–74, obtained investment by nine asset categories; (3) a series resulting from the Census of Manufacturers (CM), conducted annually by the Japanese Ministry of International Trade and Industry (MITI), which contains three asset categories; and (4) data resulting from annual surveys of corporations conducted by the Ministry of Finance and published in the Annual Report on the Corporate Sector (ARCS), which provides no breakdown of depreciable assets by asset category. The first two of these series present private-sector investment statistics for all industries (the RCIS presents figures for the corporate private sector only), while the third presents private-sector figures only for manufacturing. The fourth source covers investment in all industries except finance and insurance.

The commodity flow method used by the EPA involves, first, the estimation of the value of production or shipments of over 2,000 goods; next, in order to prepare estimates of goods available for domestic gross fixed capital formation (GFCF) and other uses, adjustment of shipments by inventory change, exports, and imports; allocation of goods to using sectors—including intermediate demand, households, and GFCF; adjustment of values by the appropriate estimated transportation and trade margins; and, finally, allocation of total GFCF to each industry. In this process, use is made of input-output tables. The resulting statistics on GFCF form part of the national accounts (Japan, EPA 1980a, 26–37, 80–83; Japan, EPA 1980b).

Most of these data sets have been widely used by productivity researchers. The NWS capital stock data have been used by, among others, Nishimizu (1974), Nishimizu and Hulten (1978), Norsworthy and Malmquist (1983), Christensen, Cummings, and Jorgenson (1980), Uno (1984), and Jorgenson, Kuroda, and Nishimuzu (1985). Regarding the various annual gross investment series, the EPA series (in an unpublished 1973 version) was used by Denison and Chung (1976); the CM by Norsworthy and Malmquist (1983) and Uno (1984); and the RCIS by Nishimizu (1974) and Nishimizu and Hulten (1978). Jorgenson, Kuroda, and Nishimizu (1985) used all three of these series. Christensen, Cummings, and Jorgenson (1980) used gross investment series from the Japanese National Accounts, which are identical to the EPA series. To our knowledge, the ARCS data have not been used in productivity studies.

The present study examines data only on corporate private-sector manufacturing investment and on depreciable assets. Nondepreciable assets—land and inventories—generally have small (though nontrivial) weights in capital services inputs. The corporate private sector, moreover, is dominant in Japanese manufacturing: in 1970, this sector accounted for almost 97% of total manufacturing gross investment and almost 96% of net capital stock (Economic Planning Agency 1975, 1:134).

In the remainder of this section, two tasks are undertaken: first, the four sources of gross investment data are discussed in detail, and, second, information is presented on the 1955 and 1970 national wealth surveys. In the section that follows, we assess the merits and deficiencies of these various data sources in light of the purposes of this study.

Table 8.5 presents information on the four sources of gross investment data. Three of the four series result directly from surveys; the fourth, the EPA series, is based on the commodity flow method, as noted earlier. Of the three series produced by surveys, only the CM series is based on an annual census of all establishments above a certain small size. The other two, the ARCS and the RCIS, are based on probability samples. The only series that present data by asset category are the CMs (three categories for the entire period covered in this study, 1955–81) and the RCIS (nine categories, but only for the years 1956–74).[11] Therefore, the EPA and ARCS series must be supplemented by information from other sources to obtain gross investment estimates by asset type. For most of the following analysis, CM asset proportions have been applied to the EPA and ARCS totals, since RCIS asset proportions are not available after 1974.

The gross investment data used in the present study were adjusted, by the authors, in the cases of the CM, ARCS, and RCIS data sources. EPA gross investment data for private manufacturing corporations are taken directly from EPA publications.[12]

The adjustments made, for this study, to the CM data were more extensive than those made to the ARCS and RCIS data. The CM data, as published, suffer from several shortcomings: (1) they do not present separate data for

Table 8.5 Characteristics of Four Sources of Data on Gross Investment in Japanese Manufacturing by Private Corporations[a]

	CM	EPA	ARCS	RCIS
1. Producing agency	Ministry of International Trade and Industry	Economic Planning Agency	Ministry of Finance	Economic Planning Agency
2. Data source	Survey	Commodity flow for total investment; expenditure by final user for distribution by industry	Survey	Survey
3. Coverage	Total population covered[b]	Total population estimates	Sample survey: Inflated to total population	Sample survey: Inflated to total population covered[c]
4. Origin of gross investment statistics	Establishments' annual expenditures for fixed assets	Commodity flow method; several data sources	Corporations' reports of depreciation and book value of fixed assets[d]	Corporations' reports of annual expenditures for fixed assets.
5. Inclusion of unincorporated enterprises' investment?	No[e]	No[f]	No	No
6. Inclusion of acquisition of secondhand assets?	Yes[g]	Yes	Yes	Yes
7. Are figures published net of "in process" investment?	Yes[h]	Yes[h]	Yes[h]	No, for most years[i]
8. Are figures published net of investment in residences?	No	Yes	No	Yes
9. Are figures published by asset category?	Yes, 3 asset categories[j]	No	No	Yes, 9 asset categories[k]
10. Are figures in constant or current yen?	Current yen	Constant yen[l]	Current yen	Current yen
11. Are data published for fiscal or calendar year?	Calendar year	Both	Fiscal year[m]	Fiscal year[n]

12. Are data available for all years, 1956–81?	Yes	Yes	Yes	Only for 1956–74

Sources: CM: Ministry of International Trade and Industry (various years) *Census of Manufactures, Report by Industries* (Kogyo tokei hyo sangyohen). EPA: Japan, Economic Planning Agency (1977, 1984b). ARCS: Japan, Ministry of Finance (various years), *Monthly Financial and Monetary Statistics; Special Annual Report of Financial Statements of Corporations;* Ministry of Finance (1976); Office of the Prime Minister (various years), *Japan Statistical Yearbook*, RCIS: Japan, Economic Planning Agency (various years), *Report on the Corporate Industry Investment Survey;* Japan, Office of the Prime Minister (various years), *Japan Statistical Yearbook.*

[a]For the EPA series, "private" corporations; for the ARCS and RCIS, "profit" or "profit-oriented." For the CM, all establishments "excluding those belonging to the government and the public service corporations." These differences in terms probably entail little difference in the coverage of the series.

[b]For 1956–62, population of all establishments with 4 or more persons engaged; for 1963–75, 20 or more persons engaged; and for 1976–81, 30 or more persons engaged. We adjusted the 1963–81 figures to approximate all establishments with 4 or more persons engaged.

[c]Corporations with capital of 10 million yen or more from 1956–72; 100 million yen or more in 1973–74 (see text).

[d]The ARCS data are from annual financial statements of corporations. The authors computed gross investment from published ARCS statistics on end-of-year book values and depreciation as follows: gross investment in fiscal year t is the difference between fiscal year t and fiscal year $t-1$ book values (end-of-year book value of fixed assets net of end-of-year book value of "in process" fixed assets) plus regular and special depreciation in fiscal year t. Calendar year gross investment was approximated by computing $I_{ct} = 0.75\, I_{ft} + 0.25\, I_{ft-1}$, where I_c and I_f are calendar year and fiscal year investment. (Throughout the period studied in this paper, the Japanese fiscal year t began on April 1 of calendar year t.)

[e]Published data include expenditures on fixed assets of incorporated and unincorporated enterprises. Authors eliminated estimated expenditures of unincorporated enterprises.

[f]The EPA publications provide separate figures for unincorporated enterprise gross investment.

[g]Expenditures on acquisition of secondhand assets are separately published for 1957–75 and are estimated by the authors for 1956 and 1976–81.

[h]Published figures on in process investment are also available for most or all years. In process figures are not available by asset category in the CM.

[i]Published figures permit elimination of in process investment by asset category and for the total in 1956, 1957, 1973, and 1974 and elimination of total in process investment in 1958, but not for other years. Therefore, the series used for all years includes in process investment.

[j]Published figures for investment in each asset category were adjusted by the authors to achieve consistency with their estimates for 1956–81 of all gross investment by establishments of four or more persons engaged, including purchases of secondhand assets in all years, after elimination of unincorporated enterprise investment.

[k]For some years, gross investment figures are available for 11 asset categories. This study used only 6 of the 9 major categories: investment in residences is eliminated; investment in "land improvement works" is combined with "other structures;" and "other investment"—a miscellaneous category—is allocated to all other categories (including residential investment) in proportion to each category's percentage of the total.

[l]We have asked the EPA whether current yen corporate gross investment figures are available for manufacturing alone.

[m]An approximation to calendar year investment is used in this study for the ARCS (see n. 4 above). A similar approximation to calendar year investment was not attempted for the RCIS, since the RCIS was not conducted in fiscal year 1955.

corporate and noncorporate investment—and separate figures are needed for the computation of an asset's rental prices (to provide weights for computing capital services inputs); (2) they do not present data for all years on the acquisition of secondhand assets; and (3) the coverage of the census was changed from establishments with four or more persons engaged (1956–62) to 20 or more persons engaged (1963–75) to 30 or more persons engaged (1976–81). The data on total investment and investment by asset category have been adjusted by the authors (1) to eliminate estimated expenditures by unincorporated enterprises; (2) to add estimates for the acquisition of secondhand assets for the seven years for which such data are not reported; and (3) to approximate, for the years after 1962, gross investment of all establishments with four or more persons engaged. Several straightforward adjustments were also needed in the ARCS and RCIS data to provide gross investment series as closely comparable as possible to the CM and EPA series.[13]

Deflators for the three gross investment series in current yen—all of the series except for the EPA series, which is only published in constant yen—were developed from two sources, the Bank of Japan's *Price Indexes Annual* (*PIA*) (various years) and the 1970 National Wealth Survey (1970 NWS). Buildings and structures, whether treated as two separate categories, as in the RCIS, or combined, as in the CM, were deflated by the *PIA*'s construction materials index. Machinery and equipment was deflated with an index computed for this study using elements of the *PIA*'s general machinery and electrical machinery indexes.[14] More complicated procedures were used to compute deflators for the asset category labeled "other." In the CM, "other" assets is a single category, while in the RCIS there are three categories of "other" assets: water transportation equipment, other transportation equipment, and tools and instruments. For the years 1955–70, price indexes published with the 1970 NWS were used. These price indexes were combined using 1970 gross investment weights from the 1970 NWS for broad categories and 1970 net capital stock weights from the 1970 NWS for detailed categories (in the absence of gross investment weights). For 1970–81, *PIA* price indexes were used, with the 1970 gross investment weights from the 1970 NWS for the broad categories and PIA weights for detailed categories.[15]

Table 8.6 shows gross investment in Japanese manufacturing in 1970 prices, for selected years, from the four data sources. Appendix table 8A.1 shows the data for all years, 1956–81. The EPA series on total constant price investment was taken directly from published EPA statistics. For the other three series, current price total gross investment was distributed among asset categories prior to deflation and subsequently deflated and summed to obtain total investment. The three CM asset category proportions were used to distribute the ARCS as well as the CM totals by asset category; the six RCIS asset categories were used for the RCIS.

EPA total gross investment was 6,595 billion yen in 1970. The ARCS, CM, and RCIS total investment figures were 79%, 76%, and 70%, respectively, of

Table 8.6 **Real Gross Investment in Japanese Manufacturing, Selected Years, 1956–81**

Period	CM[a]	EPA[b]	ARCS[a]	RCIS[a]	
Billions of 1970 yen:					
1956	453	490	469	399	686
1970	5,015	6,595	5,200	N.A.	4,605
1973	4,892	6,120	5,418	2,816[c]	4,304[c]
1981	6,023	7,455	7,127	N.A.	N.A.
Average annual growth rates:[d]					
1956–81	10.7	11.5	11.5	N.A.	N.A.
1956–70	18.7	20.4	18.7	N.A.	14.6
1956–73	15.0	16.0	15.5	12.2[c]	11.4[c]
1970–81	1.7	1.1	2.9	N.A.	N.A.

Note: N.A. = not available. CM, EPA, and ARCS exclude in process investment. RCIS includes in process investment. For sources, see table 8.5.

[a]Total gross investment in current prices is divided into three asset categories for the CM and ARCS (for the RCIS, six asset categories) using the asset proportions from the CM (for the RCIS, the asset proportions from the RCIS). Each of the three (or six) categories is deflated by its own deflator. The deflated investment figures, by asset type, are then summed to yield total investment in 1970 prices.

[b]For 1956 and 1970, total gross investment in 1970 prices, as published. The 1973 and 1981 figures result from linking investment as published in 1975 prices to 1970 investment in 1970 prices.

[c]The RCIS statistics relate to corporations with capital of at least 10 million yen prior to 1973 and to corporations of at least 100 million yen beginning in 1973. This affects the levels of the 1973 figures, compared to those for earlier years, and the 1956–73 growth rate.

[d]Compound rates.

the EPA figure. The RCIS investment series, in contrast to the other three series, includes "in process" investment. It would be substantially less than 70% of EPA investment if it were presented excluding the "in process' investment.

The growth rates of gross investment also differ substantially among series. For 1956–70, the growth rate of EPA investment is almost 2% higher than the ARCS and CM growth rates and about 6% higher than the RCIS growth rate. Gross investment growth rates since 1970, though much lower, also differ substantially.

The differences among the four series in the levels and growth rates of individual assets are also substantial. The differences between the CM, ARCS, and RCIS figures for specific assets reflect the differences shown for total investment in table 8.6. The asset proportions used to distribute total investment among asset types would be similar (identical for the CM and ARCS data, since CM asset proportions are used for both in preparing table 8.6) and the deflators would be identical. The same cannot be said for the relation between EPA asset categories and the others. The EPA gross investment series comes already deflated. EPA investment by asset category could be computed (and,

Table 8.7 **Net Capital Stock in Japanese Manufacturing, by Asset Category, 1955 and 1970, in Billions of Yen**

Asset Category	1955 in 1955 Prices	1955 in 1970 Prices	1970 in 1970 Prices
Total	1,511.3	2,012.7	18,439.8
Nonresidential buildings and structures[a]	603.0	970.2	6,948.8
Nonresidential buildings	481.7	775.1	5,487.0
Structures[a]	121.2	195.1	1,462.8
Machinery and equipment	808.0	951.7	10,003.4
Other assets[b]	100.3	90.8	1,486.6
Water transportation equipment	4.6	4.9	38.9
Other transportation equipment[b]	41.4	47.4	499.8
Tools and instruments	54.4	38.5	947.9

Sources: Economic Planning Agency (1975), *1970 National Wealth Survey,* 1:92, 134–38. Economic Planning Agency (1957), *1955 National Wealth Survey,* 3:53.

[a]Includes a small amount for land improvement works in 1970.

[b]Includes small amounts for animals and plants.

later in this paper, is computed) using CM asset proportions or, up to 1974, RCIS proportions. Such a procedure implicitly assumes that all assets had the same rates of price change, an assumption that is contrary to the evidence on price changes. Unfortunately, we have not located figures on the EPA price deflator for gross manufacturing investment. Therefore, the effect of differences in price deflators cannot be assessed.

The 1955 and 1970 national wealth surveys, as noted earlier, can be used as two benchmarks of the value of assets. These two surveys provide estimates for the whole economy of the value of assets, by asset type, industry, and institutional sector (private corporate, private noncorporate, and government) as well as some information on the year of acquisition of assets. Both surveys relate to end-of-year stocks (31 December 1955 and 31 December 1970). Assets are valued at replacement cost as of the year of the survey, that is, 1955 and 1970. For the private corporate sector, the corporation was the unit of observation. The 1970 survey provides estimates of both gross and net stocks, the 1955 survey provides net stocks only.

Table 8.7 presents the 1955 and 1970 net capital stocks in manufacturing, with the 1955 stocks valued in both contemporary and 1970 prices, in asset categories similar to those used in the CM (three categories) and RCIS (six categories). All figures in this table exclude "in process" assets.

8.4 Data Sources: Assessment

This section assesses the adequacy of the 1955 and 1970 national wealth surveys for the specific needs of this paper as well as the relative merits of the four gross investment series.[16] It is concluded that the two national wealth surveys are adequate for their tasks. However, because somewhat different methods were used to determine net stocks in the two surveys, it cannot be claimed that they are ideal. It is also concluded that, for the purposes of this study, the CM is the best of the four sources of estimates of gross investment.

8.4.1 The Adequacy of the 1955 and 1970 National Wealth Surveys

In several critical respects, the 1955 and 1970 NWSs are appropriate for the purposes of serving as benchmarks for net capital stocks and the estimation of u. They were well designed to estimate end-of-year net capital stocks at 1955 and 1970 replacement costs. They both used private corporations as respondents for the survey of private corporate assets. They both used stratified probability sampling.

The surveys are less than ideal, for present purposes, in two respects: (1) the sample proportions were small, and (2) the methods used to determine net stocks differed in some respects between the two surveys.

The 1970 NWS surveyed all Japanese corporations with capital of 1 billion yen or more (1,293 corporations). It used stratified sampling, with the strata defined by size of corporate capital assets and geographical area, to select 10,017 of 701,859 remaining corporations. Among corporations with capital between 100 million and 1 billion yen, 100% were selected outside Tokyo and 50% within Tokyo. Smaller proportions of categories with smaller capital size were selcted for the survey (Japan, Economic Planning Agency 1975, vols. 1 and 4). A similar sampling plan was followed for the 1955 NWS.[17]

Both surveys were well designed to measure end-of-year capital stocks at current replacement costs. The methods used were similar in most, but not all, respects.[18] There are grounds to suspect, however, that the 1970 NWS might have underestimated the level of net stocks relative to the 1955 levels.[19] If this is so, the u's developed for this study are overestimates. A sensitivity test, carried out by increasing published 1970 NWS stocks by 10%, yielded substantially lower u's.[20] It appears unlikely that 1970 stock levels would have been as much as 10% higher than the published figures.

8.4.2 Relative Merits of the Four Gross Investment Series

The main characteristics of the four gross investment series are summarized in table 8.5. Analysis of the merits and shortcomings of each of the data sources indicates that, on balance, the CM is the best of the four sources for the purposes of this study. This analysis includes examination of the coverage of the universe of potential respondents; the shortcomings of the use of book value compared to data on expenditures on capital assets; and special problems of the EPA series.

Series Coverage

The CM series is based on a survey of all establishments above a certain relatively small size defined by numbers of persons engaged. The EPA series, constructed using the "commodity flow method," relates to all manufacturing corporations. The ARCS and RCIS are sample surveys inflated to a universe. The universe for the ARCS is all corporations; the universe for the RCIS is all corporations above a minimum capital size.

The ARCS sampled all firms above a minimum size of capital and proportions of firms below this size. Prior to 1959, all corporations with capital of 50 million yen and more were in the sample; between 1959 and 1979, all corporations with capital of 100 million yen and over; and as of 1981, all corporations of 1 billion yen and over.[21] Sample results were used to estimate financial magnitudes for corporations of all sizes.

The RCIS, unlike the ARCS, did not sample firms below a minimum capital size—10 million yen between 1956 and 1972 and 100 milliion yen in 1973 and 1974—and no estimates are made for firms below the minimum cutoff sizes. In 1969, the RCIS sent questionnaires to all corporations with capital above 1 billion yen, while for the same year the ARCS queried all corporations with capital above 100 million.[22] Clearly, the RCIS results are based on a smaller sample than the ARCS and relate only to corporations above the minimum capital size sampled.[23] The weakness of the RCIS from the viewpoint of providing accurate total investment statistics undoubtedly also affects the RCIS figures on investment by asset type.[24]

In sum, the CM provides the most complete coverage of the three sources that make use of surveys, while the RCIS provides the most scanty coverage. The EPA does not use a survey procedure; the method used for the EPA gross investment data are examined below.

Book Values versus Expenditure Data

The CM and RCIS series are based on establishment or corporation reports of annual expenditures for fixed assets whereas the ARCS is based on book values of fixed assets. Expenditure data rather than book values are generally preferred for deriving capital stock estimates.

The usual warnings against the use of book data on fixed assets in studies of capital stock and investment (Mairesse 1972) apply in some measure to the ARCS data. In particular, book value can change without investment or depreciation. Revaluation through interfirm sales can have the effect of changing book value. If one manufacturing corporation acquires assets from another manufacturing corporation at a higher value than shown on the books of the seling corporation, this causes an increase in book value even though no assets are added in manufacturing. Further, a firm may realize all its loss in a plant in one year.

In several respects, however, the ARCS book value data are more appropriate for use as a source of capital formation statistics than is usually the case. Gross fixed investment is the sum of depreciation plus the change in net fixed assets between two years, if there has been no revaluation of the type described above. Any inappropriate procedures for computing depreciation, due, for example, to features of tax law,[25] are effectively eliminated by this method. By adding depreciation to the change in book value, the influence of depreciation practices on original book value levels is simply cancelled. Further, the ARCS investment figures are from corporations' annual financial statements, which have a semiofficial status. Under tax law and accepted accounting principles, corporations are expected not to revalue assets remaining in their possession, even if their market values rise.[26]

Book values are net of retirements of equipment;[27] this permits the annual changes to reflect more accurately the changes in fixed assets actually employed. This feature, an advantage in some contexts (Faucett 1980), is a disadvantage for present purposes. The correct estimation of u requires gross investment figures that are not adjusted for retirements of assets. The CM, EPA, and RCIS figures are all available on this basis. These considerations imply that, ceteris paribus, the u's estimated from the ARCS will be smaller than those estimated from the other three series. However, the u's are larger for the ARCS than for the CM and RCIS (see table 8.2).

The gross investment figures in the CM and RCIS are computed as costs of acquiring assets. This method is likely to yield investment figures more appropriate for present purposes than the methods used for the ARCS.

In sum, the book value concept, which allows for the possibility of revaluation of assets and is net of retirements, is less appropriate for present purposes than the methods used by the CM and the RCIS. Of the three data sources that rely on surveys of respondents, we have so far uncovered important shortcomings in the ARCS and the RCIS but not in the CM.

Special Problems with the EPA Data

The EPA does not publish a current yen counterpart of its constant yen gross investment series.[28] It is necessary, therefore, to obtain investment by asset category by multiplying total constant gross investment by asset category proportions from the CM (or, up to 1974, from the RCIS). This implies that each asset category has had the same rate of price change as total gross investment, which, as noted earlier, is contrary to fact.

The EPA series, as described in section 8.2, is constructed using the commodity flow method. This method has certain advantages. The EPA procedures take advantage of a variety of data sources, including input-output tables, the CM, the ARCS, and other sources (Japan, EPA, 1980a, 26–37, 80–83; Japan, EPA, 1980b). This approach permits comparison of information from various data sources and identification of problems that might not be recognized if only one data source were used.

On the other hand, practitioners of the commodity flow method have noted that commodity flow calculations require a number of decisions that are largely arbitrary. For example, the addition of transportation and trading margins to the cost of producing investment goods requires judgment calls that are little short of guesswork. The EPA itself notes problems related to the trade and transportation margins and allocation of goods to final using sectors (Japan, EPA, 1980a, 26–27).

The CM does not suffer from these disadvantages. It would appear to be the preferred series for total investment. Unlike the EPA, it does not rely on the commodity flow method. Further, among the three sources that use survey procedures, it has the largest coverage and does not use book value. Also, asset proportions for the whole period, 1955–81, are available in the CM, but not after 1974 for the RCIS, and it is appropriate to use total investment information and asset category proportions from the same data set. Finally, it is found below that up to 1974 there is similarity between the CM asset proportions and the proportions that result from aggregation of the six RCIS asset types to approximate the three CM types.

8.5 Net Capital Stocks, 1955–81

8.5.1 Net Stocks and Calculation of *u*, 1955–70

Table 8.8 presents *u*, the average annual rate of discards plus depreciation, calculated according to the method described in section 8.1, using the 1955 and 1970 benchmark net capital stocks and 1956–70 gross investment, all in 1970 prices, as presented in table 8.7 and table 8A.1 in the appendix below. In table 8.8, panels A, B, and C present the *u*'s computed using the CM, EPA, ARCS, and RCIS data.[29] Panel A presents *u*'s for three asset categories. For all four data series in panel A, the gross investment figures by asset type are computed using annual proportions based on reported CM expenditures by asset type, as adjusted for this study. Panel B presents *u*'s for six asset types, using RCIS annual asset proportions. Panel C presents results using asset proportions from the RCIS, grouped for consistency with the three CM asset categories. These grouped RCIS asset proportions are quite similar to the three CM asset proportions.[30]

The *u*'s estimated from the EPA data set are the largest, for every asset and in all panels, followed by the ARCS *u*'s; the RCIS *u*'s are the lowest. Regardless of whether the RCIS or the CM asset proportions are used, the rank of the *u*'s by asset category does not vary. Buildings and structures have the lowest rate of discards plus depreciation and "other" assets the highest.

The variation among *u*'s is wide, as is indicated by the range to mean ratios presented in table 8.8. For most assets, the EPA *u*'s are more than double the RCIS *u*'s; for every asset, they exceed the CM *u*'s by over 50%. The relatively large ARCS *u*'s are surprising. The fact that the ARCS gross investment series is net of retirements while retirements are not deducted from the other series leads one to predict that, ceteris paribus, the ARCS *u*'s will be relatively low.[31]

For any asset, the four net stock series constructed for 1955–70, using the four gross investment series and the corresponding *u*'s, will yield different net

Table 8.8 Computed *u*'s, by Asset Type, Based on CM and RCIS Asset Proportions and 1955 and 1970 Benchmarks

	CM	EPA	ARCS	RCIS	Range ÷ Mean
	A. *u* Computed Using Three Asset Types from CM				
Buildings and structures	.062	.111	.078	.029	1.171
Machinery and equipment	.173	.288	.199	.117	.880
Other	.281	.459	.317	.206	.801
	B. *u* Computed Using Six Asset Types from RCIS				
Nonresidential buildings	.047	.090	.061	.016	1.383
Structures	.100	.157	.117	.063	.860
Machinery and equipment	.181	.299	.208	.123	.868
Water transportation equipment	.297	.463	.326	.236	.687
Other transportation equipment	.122	.214	.143	.078	.977
Tools and instruments	.342	.560	.384	.252	.801
	C. *u* Computed Using RCIS Asset Proportions, Aggregated to Three CM Categories				
Buildings and structures	.058	.105	.073	.026	1.206
Machinery and equipment	.181	.299	.208	.123	.868
Other	.257	.432	.291	.183	.856

stocks for the years 1956–69. The benchmark stocks for 1955 and 1970 will be identical, of course, as will the 1955–70 growth rates. This would not be so if the double-benchmark method did not constrain each series.

Table 8.9 illustrates the results of dropping this constraint. It shows the differences in 1970 net stocks and 1955–70 growth rates that are produced by using the four different gross investment series, while accepting a single benchmark (the 1955 net stocks) and a single set of *u*'s (the CM *u*'s). The first column of table 8.9, which is produced using the CM gross investment and the CM *u*'s, yields the 1970 and 1955–70 growth rates implied by the double-benchmark method, that is, using both 1955 and 1970 NWS net stocks.

The EPA 1970 net stocks, produced using EPA gross investment and CM *u*'s, are 21%–39% above the 1970 NWS levels. The ARCS net stocks are all about 7% above and the RCIS net stocks about 10% below the 1970 net stock levels.[32] The differences in average annual growth rates between the CM and the ARCS are not large, but the EPA growth rates are substantially higher than those for the other three series.[33]

8.5.2 Net Stocks, 1970–81

Table 8.10 presents net stocks, by asset type, for 1970, 1973, and 1981. This table is produced using the asset proportions from the CM series (RCIS asset proportions are not available after 1974), identical net stocks in 1970

Table 8.9 **Net Capital Stocks in 1970, Computed with CM *u*'s and Own-Series Gross Investment**[a]

	CM[b]	EPA	ARCS	RCIS[c]
1970 stocks, in billions of yen:				
Buildings and structures (u = .062)	6,949.7	8,420.8	7,447.6	6,240.1
Machinery and equipment (u = .173)	10,003.3	13,226.4	10,763.3	8,972.8
Other (u = .281)	1,486.6	2,069.1	1,598.4	1,343.0
Average annual growth rates, 1955–70[d]				
Buildings and structures	14.0	15.5	14.6	13.2
Machinery and equipment	17.0	19.2	17.6	16.1
Other	20.5	23.2	21.1	19.6

[a]Computed using CM asset proportions, 1955 net capital stocks in 1970 prices (from table 8.3), own-series gross investment in 1970 prices (from table 8.A1), and CM u's (from table 8.8).

[b]Differences in the final digit from 1970 net stock data in table 8.3 result from rounding.

[c]RCIS 1970 levels are computed using RCIS gross investment, which is gross of "in process" investment, and 1955 NWS net capital stock figures by asset type plus a proportionate amount of "in process" stock.

[d]Compound rates.

from the 1970 NWS, and the u's determined in the previous section using the double benchmark method and the CM asset proportions. The u's are those determined specifically for each gross investment series. In the absence of a national wealth survey after 1970, these provide alternative estimates of levels and average annual rates of change in net capital stocks from 1970 forward. The RCIS series is not included in this table.[34]

The differences between the CM, EPA, and ARCS 1973 or 1981 net stocks for buildings and structures are not particularly large. For the other two asset types, the differences are substantial. It was found in section 8.2 above that the differences between the EPA and the two other series in the 1973–81 growth rates are large enough to result in differences in the proportion of output growth attributed to capital inputs, and hence in the growth of multifactor productivity. These differences are nontrivial when the gross output model is used and substantially larger when the value-added model is used.

Dramatic effects on 1981 net capital stocks are produced by using u's from one series and gross investment from another series. Table 8.11 shows the 1981 net stocks, and the resulting 1970–81 growth rates, that arise from using identical 1970 net stocks, u's from the CM data, and own-series gross investment. The EPA net stock series has substantially higher levels and growth rates when computed using the CM u's rather than the EPA u's. The 1970–81 growth rate for EPA buildings and structures is 7.5% when computed with the CM u's (table 8.11) and 4.7% when computed with the EPA u's (table 8.10). Similar large effects are produced on the growth rates of the other two assets. While the 1981 level of EPA stocks for buildings and structures is only 2% higher than the CM level when both are computed with their own u's (table 8.10), it is 36% higher when both are computed using the CM u's. An oppo-

Table 8.10 Net Capital Stocks, 1970–81, Computed with Own-Series *u*'s and Own-Series Gross Investment, Selected Years, in Billions of Yen[a]

	CM[b]	EPA	ARCS	Range ÷ Mean
Buildings and structures	(u = .062)	(u = .111)	(u = .078)	
1970[c]	6,949.7	6,949.9	6,949.7	0.00
1973	9,148.2	9,040.5	9,061.0	0.01
1981	11,266.5	11,478.0	10,919.4	0.05
Growth rate, 1970–81[d]	4.5	4.7	4.2	0.11
Machinery and equipment	(u = .173)	(u = .288)	(u = .199)	
1970[c]	10,003.3	10,003.4	10,003.5	0.00
1973	13,294.5	11,793.9	13,148.8	0.12
1981	15,877.9	13,256.9	15,936.8	0.18
Growth rate, 1970–81[d]	4.3	2.6	4.3	0.46
Other	(u = .281)	(u = .459)	(u = .317)	
1970	1,486.6	1,486.6	1,486.6	0.00
1973	2,209.9	1,764.6	2,225.2	0.22
1981	4,611.4	2,544.2	4,936.2	0.59
Growth rate, 1970–81[d]	10.8	5.0	11.5	0.71

[a]Computed using CM asset proportions, 1955 net capital stocks in 1970 prices (from table 8.7), own-series gross investment in 1970 prices (from table 8A.1), and own *u*'s (from table 8.8).
[b]Annual data on CM net capital stocks, 1955–81, are presented in table 8A.2.
[c]Differences in the final digit from 1970 net stock data in table 8.7 result for rounding.
[d]Compound average annual growth rate.

Table 8.11 Net Capital Stocks in 1981, Computed with CM *u*'s and Own-Series Gross Investment[a]

	CM	EPA	ARCS
1981 stocks, in billiions of yen:			
Buildings and structures (u = .062)	11,266.5	15,349.3	12,116.6
Machinery and equipment (u = .173)	15,877.9	20,168.3	17,799.5
Other (u = .281)	4,611.4	3,728.1	5,339.9
Average annual growth rate, 1970–81:[b]			
Buildings and structures	4.5	7.5	5.2
Machinery and equipment	4.3	6.6	5.4
Other	10.8	8.7	12.3

[a]Computed using CM asset proportions, 1970 net capital stocks in 1970 prices (from table 8.7), own-series gross investment in 1970 prices (from table 8A.1), and CM *u*'s (from table 8.8).
[b]Compound rates.

site effect is produced when the EPA u's are used to compute the CM and ARCS stocks; the 1981 stock levels of these two series decrease compared with the levels computed with own-series u's. These comparisons indicate the inappropriateness of using u's from one series and gross investment from another series.

There is widespread evidence of a slowdown after 1973 in productivity growth in the manufacturing sectors, as well as for the total economies, of large industrialized countries (Neef and Dean 1984; Neef and Thomas 1987; Kendrick 1981). The slowdown in manufacturing labor productivity growth in Japan, as in several other countries, began after 1973.[35] Because of this slowdown, it is of interest to compare 1955–73 and 1973–81 growth rates of capital.

Table 8.12, computed using the CM, EPA, and ARCS own-series u's, shows remarkably high growth rates of net capital stock for the period 1955–73. The 1955–73 growth rates for the three series are, of course, fairly close since they are constrained to equality for the 1955–70 period. Dramatic declines in growth rates, reflected in all three capital stock series and affecting all three asset types, occurred in the 1973–81 period. The 1973–81 growth rates for buildings and structures and machinery and equipment were all less than one-quarter of the 1955–73 growth rates for all three series used for table 8.12. This slowdown in the growth of capital stocks almost certainly contributed in a major way to the post-1973 slowdown in labor productivity growth in Japanese manufacturing.[36]

8.5.3 EPA-based Depreciation in an International Perspective

The estimates of u based on the EPA investment data are much higher than the estimates derived from the three other data sets, as is noted above (table 8.8). The EPA-based estimates are higher for all three asset types, but they are especially high for buildings and structures. The four estimates of u for buildings and structures in Japanese manufacturing are compared in table 8.13 with estimates from five studies of depreciation rates for buildings or buildings and structures in the United States, the United Kingdom, and France. The EPA-based rate of 11.1% is more than four percentage points higher than the highest estimate listed for the other countries. Information on depreciation rates of buildings in additional countries can be computed from information on capital service lives in manfacturing presented in Blades (1983). These depreciation rates are also lower than the EPA-based estimate of u for buildings and structures. This reinforces the judgment, reached above without benefit of these statistical results, that the EPA is not the preferred source of investment data for Japanese manufacturing.

The EPA data have been used in a number of studies of Japanese productivity, including Denison and Chung (1976) and Jorgenson, Kuroda, and Nishimizu (1985).[37] The present results indicate that this choice of data sources

Table 8.12 Growth Rates of Net Capital Stocks, by Asset Type, 1955–73 and 1973–81[a]

	CM	EPA	ARCS
1955–73:			
Buildings and structures	13.3	13.2	13.2
Machinery and equipment	15.8	15.0	15.7
Other	19.4	17.9	19.4
1973–81:			
Buildings and structures	2.6	3.0	2.4
Machinery and equipment	2.2	1.5	2.4
Other	9.6	4.7	10.5
1973–81 minus 1955–73:			
Buildings and structures	−10.7	−10.2	−10.8
Machinery and equipment	−13.6	−13.5	−13.3
Other	−9.8	−13.2	−8.9

[a]Growth rates are compound average annual rates. Figures computed using CM asset proportions, own-series gross investment in 1970 prices, and own-series u's. The RCIS is omitted from this table because 1973 and 1974 gross investment figures are not fully comparable to those of earlier years, and the series is not used after 1974 in this study.

Table 8.13 Annual Percentage Depreciation of Buildings, Estimates from Several Studies

Country/Building Class	Study	Depreciation (%)
Japan: manufacturing buildings and structures[a]	CM	6.2
	EPA	11.1
	ARCS	7.8
	RCIS	2.9
United States: industrial buildings	BLS[b]	3.4
	BEA[c]	6.5
	Hulten/Wykoff study[d]	3.6
United Kingdom: buildings	King/Fullerton study[e]	2.5
France: manufacturing buildings and structures	King/Mairesse study[f]	5.7

[a]See this study, table 8.8.

[b]BLS is the Bureau of Labor Statistics. First-year decay computed using a hyperbolic decay function. For discussion of the BLS hyperbolic decay function, see U.S. Department of Labor, Bureau of Labor Statistics (1983, app. C.)

[c]BEA is the Bureau of Economic Analysis of the U.S. Department of Commerce. We computed this using the BEA estimate of asset life of industrial buildings and applying the double-declining-balance formula, $d = 2/L$, where d is the computed annual depreciation rate and L is the asset life in years. For a justification of this formula, see King and Fullerton (1984, 29).

[d]Hulten and Wykoff (1981).

[e]King and Fullerton (1984, 46). Computed by King and Fullerton using the double-declining-balance formula.

[f]King and Mairesse (1984). We made computations using the double-declining-balance formula.

may not be the best for the manufacturing sector. However, Jorgenson and his colleagues faced limited alternatives. They examined productivity trends for a number of industries outside manufacturing, and the CM data are not available for these industries. The desirability of using the same source of capital input data for all industries undoubtedly weighed against the use of the CM data for manufacturing. Further, it is noted above that the ARCS and the RCIS gross investment data have their own serious shortcomings.

8.6 Suggestions Regarding Data Collection

As a by-product of the analysis of Japanese capital and investment data for this study, several ideas have occurred to us on current and future data collection practices.

The Japanese national wealth surveys present the researcher with an opportunity without counterpart in any other major country with a large private sector—to undertake studies of capital using an official measure, based on well-designed surveys, of the level of capital stocks. Only in Japan, among the large private enterprise economies, have such surveys regularly been conducted (Ward 1976; Blades 1983).[38] Therefore, only in Japan is the double-benchmark method an attractive alternative to the perpetual inventory method. In light of this situation, the resumption of national wealth surveys—none has been conducted since 1970—would be most useful, despite the relatively small sample sizes of these surveys.[39]

Regarding gross investment series, there are presently four series on total gross investment, one of which is confined to manufacturing. By contrast, only one of the four sources currently provides manufacturing data on investment by asset category, and that is the source that relates only to manufacturing. Balance sheet information on asset distribution is available from reports on more than 1,800 firms listed on the large stock exchanges, including several hundred outside manufacturing.[40] The industrial coverage of these data, however, excludes primary industries, finance, and insurance. Further, the data relate only to large corporations.[41] We suggest that consideration be given to reducing the number of surveys of total investment and introducing data collection on investment by asset category by industry for the whole economy.

It would be most useful if the EPA were to publish a continuous series of total gross investment in current prices, compatible with the EPA constant price series. Finally, it would be interesting to know why the level of total gross investment in current prices in 1970 and 1975, as reported by the EPA, is substantially greater than the levels reported by the other data sources.

We convey these ideas with some hestitation. We are not acquainted with the costs of various types of surveys in Japan. We are, further, unacquainted with the range of client interests that inform present practices; some present data collection practices, for example, may proceed from clients' interests in forecasting.

8.7 Conclusions

The main conclusions of this study are as follows.

1. The double-benchmark method of measuring net capital stocks, an attractive method from a theoretical perspective, is the most appropriate method to use for Japanese manufacturing. As the 1970 NWS becomes more outdated, and if another NWS is not soon undertaken, it may be advisable to estimate capital stocks for recent years using the perpetual inventory method.

2. The Census of Manufactures series, as adjusted for this study, is the best series to use for annual total investment and for investment by asset category for the whole period 1955 to the present. While the RCIS offers information on six asset categories, as opposed to the three offered by the CM, the deficiencies of the RCIS as a survey are serious. The CM is the preferable series even for the years 1956–74, when asset-type data are available from the RCIS.

3. There are substantial differences among the post-1970 growth rates of net stocks computed using the CM, EPA, and ARCS data. These differences are large enough to lead to nontrivial differences in the measured growth of multifactor productivity in Japanese manufacturing.

4. The growth rates of net capital stocks for the period 1973–81 were about one-half to one-quarter of the growth rates for the period before 1973. This decline affected all three asset types and is reflected in the three alternative net stock series used for the post-1973 period. This slowdown in the growth of net capital stocks almost certainly contributed in a major way to the post-1973 slowdown in the growth of labor productivity in Japanese manufacturing.

5. Considerable variation in estimated capital stocks, rates of depreciation and discarding, multifactor growth, and effective tax rates is produced by use of the four alternative data sources on Japanese manufacturing gross investment. The variation in most cases is great enough to affect substantially the conclusions that researchers or policymakers might reach.

This study began by observing that students of the Japanese economy are blessed with statistical riches, and that this blessing might ultimately prove embarrassing. It is perhaps more important to suggest that the different results obtained with these alternative data series provide a sobering lesson to those who would use available data—for Japan as well as for other countries—and announce their conclusions without qualification. If other countries had four sets of data providing information on rates of depreciation or multifactor growth, in how many instances could we expect that the results would be substantially the same for each data set?

Appendix

Gross Investment and Net Capital Stocks in Japanese Manufacturing: Annual Data

Table 8A.1 Gross Investment in Japanese Manufacturing in 1970 Prices, 1956–81, in Billions of Yen[a]

Year	CM	EPA	ARCS	RCIS
1956	453	490	469	686
1957	702	797	735	712
1958	717	810	869	565
1959	792	974	777	854
1960	1,145	1,569	1,527	1,235
1961	1,592	2,084	1,574	1,631
1962	1,897	2,385	1,985	1,427
1963	1,873	2,430	1,981	1,417
1964	2,037	2,662	1,954	1,702
1965	2,084	2,445	2,304	1,462
1966	1,883	2,499	2,085	1,556
1967	2,488	3,326	2,723	2,469
1968	3,507	4,746	3,370	3,188
1969	4,266	5,709	4,871	3,824
1970	5,015	6,595	5,200	4,605
1971	5,245	6,077	5,174	4,415
1972	4,840	5,976	5,472	4,162
1973	4,892	6,120	5,418	4,309
1974	4,760	6,141	5,072	4,224
1975	4,160	5,542	4,835	. . .[b]
1976	4,505	5,557	4,673	. . .
1977	4,654	5,621	4,523	. . .
1978	4,389	4,982	5,111	. . .
1979	4,875	5,772	5,590	. . .
1980	5,117	6,851	6,166	. . .
1981	6,023	7,455	7,127	. . .

Note: CM, EPA, and ARCS exclude in process investment; RCIS includes in process investment.

[a]For methods of computation and sources see notes to tables 8.5 and 8.7.

[b]Ellipses indicate that, although total RCIS investment data are available after 1974, investment by asset type is not, and so the total investment data are not used in this study. See discussion in text.

Table 8A.2 Net Capital Stocks in Japanese Manufacturing in 1970 Prices, 1955–81, in Billions of Yen

Year	Buildings and Structures	Machinery and Equipment	Other	Total
1955	970.2	951.7	90.8	2,012.7
1956	1,059.5	1,052.7	103.2	2,215.3
1957	1,214.6	1,291.7	133.9	2,640.2
1958	1,353.1	1,511.7	156.1	3,020.8
1959	1,499.0	1,737.6	186.5	3,423.0
1960	1,776.8	2,101.3	243.5	4,121.6
1961	2,154.9	2,683.0	333.3	5,171.2
1962	2,627.4	3,326.9	421.8	6,376.1
1963	3,033.9	3,851.1	506.4	7,391.4
1964	3,480.3	4,369.7	580.5	8,430.5
1965	3,887.8	4,850.7	640.3	9,378.8
1966	4,145.9	5,140.1	714.6	10,000.6
1967	4,534.6	5,765.1	840.8	11,140.4
1968	5,197.2	6,916.3	1,017.8	13,131.3
1969	5,994.4	8,367.8	1,228.4	15,590.6
1970	6,949.7	10,003.3	1,486.6	18,439.6
1971	7,898.5	11,516.2	1,688.7	21,103.5
1972	8,602.3	12,534.5	1,847.5	22,984.3
1973	9,148.2	13,294.5	2,209.9	24,652.6
1974	9,766.9	13,800.6	2.354.4	25,921.8
1975	10,188.8	13,926.1	2,308.9	26,423.8
1976	10,454.6	14,351.5	2,430.4	27,236.4
1977	10,666.9	14,707.5	2,698.9	28,073.3
1978	10,768.3	14,681.3	3,045.5	28,495.1
1979	10,871.2	14,838.6	3,593.7	29,303.5
1980	11,003.6	15,146.8	4,016.4	30,166.8
1981	11,266.5	15,877.9	4,611.4	31,755.7

Note: Figures are derived from CM data. For methods of computation, see text and esp. notes to tables 8.5, 8.7, and 8.10. Excludes in process investment. Detail may not sum to total because of rounding.

Notes

1. Although u is a constant, its use does not imply acceptance of the hypothesis that the loss-of-efficiency function is geometric. Rather, u is the average rate of discards plus depreciation over the period of time between two surveys of net assets. Underlying this average rate could be any one of a number of loss-of-efficiency functions.

2. The proof that at least one real zero is contained in the set of all zeros for every real polynomial requires that the polynomial be of odd degree (Nishimizu 1974).

3. For a detailed discussion of productive capital stocks, see U.S. Department of Labor, Bureau of Labor Statistics (1983, app. C). While u does not explicitly correct stocks for loss of efficiency, it is estimated in such a way as to correct for any change in the average age of assets between the two benchmark years. Net stocks in both years are measured net of depreciation. So, if benchmark A contains gross stocks that are,

on average, older than the stocks in benchmark B, the net stock to gross stock ratio will be appropriately lower for benchmark A.

4. Eq. (1) is based on a Divisia index with changing weights, which requires continuous data. Multifactor productivity indexes are customarily based on the Törnqvist index number formula, which is a discrete approximation to the Divisia index. See U.S. Department of Labor, Bureau of Labor Statistics (1983). See also Mark and Waldorf (1983).

5. The values adopted are $\dot{Q}/Q$, 2.79% per year (compound average annual rate); $\dot{L}/L$, 0.8% per year; $\dot{M}/M$, 2.2% per year. S_k, 0.147%; s_l, 0.168%; S_m, 0.685%.

6. The discrete approximation involved the use of compound average annual rates of change for the growth rates of Q, K, L, and M.

7. For use in the Törnqvist index number formula, eq. (6) is estimated as:

$$S_{k_i} = \tfrac{1}{2}(S_{k_{i_t}} + S_{k_{i_{t-1}}}),$$

where

$$S_{k_{i_t}} = \frac{C_{i_t}K_{i_t}}{\sum_j C_{j_t}K_{j_t}},$$

and where $t = 1981$ and $t - 1 = 1973$. For this illustrative exercise, the value of c_i is the same for both years.

8. The magnitudes used are as follows. For all assets, $p = 1.0$, $r = 0.8$, and $[h_t + v_t \ (1 - h_t)] = 0.47$—and, therefore, $(1 - h_t) \ (1 - v_t) = 0.53$. For $(p_t - p_{t-1})$, the first difference in price appreciation, average annual rates were assumed to be .066 for buildings and structures, 0.047 for machinery and equipment, and 0.0 for other depreciable assets. For z, the values used were 0.4 for buildings and structures, 0.6 for machinery and equipment, and 0.7 for other assets. For purposes of the present illustration, nondepreciable assets (inventories and land) are ignored.

9. The differences in MFP are much greater when MFP is computed for a value-added growth model instead of a gross output growth model. Eqq. (3) and (4) are gross output models—the output measure is gross output and inputs are capital, labor, and materials. A value-added model uses a value-added measure for output and inputs of capital and labor only. The value-added counterpart of eq. (4)—i.e., when directly aggregated capital stocks are used for capital input—yields MFP measures of 3.3%, 3.7%, and 3.3% when capital input is measured using data from the CM, EPA, and ARCS series, respectively. If rental price–weighted capital stocks are used—i.e., the value-added counterpart of eq. (3)—the resulting MFP measures are 3.0%, 3.8%, and 2.9%, respectively, for the same three data sources. For further discussion of the distinction between value added and gross output MFP models, see Gullickson and Harper (1987).

10. Recent studies of effective tax rates include King and Fullerton (1984) and Jorgenson and Sullivan (1981). A recent study of international comparisons of rates of return is King and Mairesse (1984).

11. The absence of 1955 data from the RCIS presents only minor problems because 1955 stocks are derived from the 1955 National Wealth Survey. It is possible to estimate post-1974 asset category proportions, consistent with the RCIS asset categories, using balance sheet data from all firms whose common stocks are listed on the Tokyo, Nagoya, and Osaka stock exchanges (1,299 firms, of which 964 are in manufacturing). Jorgenson, Kuroda, and Nishimizu (1985) used these data. Gross investment by asset category is also published in the Japanese national accounts, but only for the total economy.

12. Data in 1975 prices were linked to data in 1970 prices at 1970. In 1978, the

EPA revised its estimates of nonresidential business capital investment for 1965 forward, in 1975 prices, in connection with its adoption of a new system of national accounts (Japan, Economic Planning Agency 1980b, 1). The old series is used for the years 1965–70, as well as for the earlier years. After computations used in this paper were completed (in the summer of 1985) the EPA revised its data on capital stock in 1975 prices; later, EPA published data in 1980 prices.

13. For ARCS adjustments, see table 8.5, n.4. Further, "in process" assets for 1954–59 had to be estimated. For 1956–59, the ARCS fixed assets at the end of the fiscal year were multiplied by the ratio of "in process" to fixed assets, at end of fiscal year, from the RCIS. For 1954 and 1955, the ARCS fixed assets were multiplied by a ratio that was a weighted average of the 1956 to 1958 ratios. Special depreciation for 1954–59 was estimated using ratios of special to total depreciation presented in Ratcliffe (1969, 83–91). For RCIS data adjustments, see table 8.5, n. 11.

14. Prices of exported goods and goods produced mainly for consumers were excluded.

15. These procedures were used for the "other" asset deflators because deficiencies in the *PIA* weights and price indexes affect the "other" assets more severely than they affect buildings and structures and machinery and equipment. The *PIA* weights reflect total transactions in the economy and some of the price indexes relate to commodities purchased mainly by consumers (e.g., cars, bicycles, motorcycles, and cameras). It was necessary to use *PIA* price indexes for 1970–81 because no better price indexes were available. The index numbers, for selected years, are as follows:

Year	Buildings and Structures	Machinery and Equipment	Other
1956	.638	.919	1.226
1970	1.000	1.000	1.000
1981	2.178	1.578	.908

An index was also computed for "other" assets from the *PIA*, using *PIA* weights, for 1955–70. The 1956 value for this index was 1.134. It was decided that the indexes published with the 1970 NWS were preferable.

16. The adequacy of the deflators used in this study is not examined, though it is clear that their quality could be improved (see sec. 8.2.). In particular, the index used for buildings and structures could be improved by development of a weighted index of construction materials and construction labor costs.

17. Firms were divided into five size categories. For each of these five categories, 19 subcategories were defined on the basis of geographical area and capital size. Among firms above 50 million yen, 100% were sampled. For some of the smaller size categories, 100% of the corporations in some of the 19 subcategories were sampled (Japan, Economic Planning Agency 1957, vols. 3 and 6).

18. The 1955 NWS took advantage of an extensive revaluation of assets that was carried out following passage of the Asset Revaluation Law, which permitted corporations to revalue their assets as of January 1, 1950. Assets not revalued as of this date, and assets subsequently acquired, were added to the revalued assets. Firms were asked to report time of acquisition and acquisition costs. For depreciable assets in manufacturing and most other industries, assets were depreciated by the EPA, which used asset-specific constant depreciation rates. Price deflators that were specific to type of asset and usage—one price series went back to 1874—were applied to obtain values in 1955 costs. For assets revalued in 1950, the following formula was used: 1955 replacement cost of assets $= V - S + I$, where V is the 1955 value of the assets revalued in 1950 and valued at 1955 prices by application of the appropriate constant depreciation rate and deflator, S is the scrapping of assets valued at 1955 replacement cost, and I is assets

acquired since the revaluation, minus depreciation, valued at 1955 replacement costs. For assets whose time of acquisition or acquisition cost was not known, the EPA used an "assessment value" as of 31 December 1955, based on market prices as of that time. The 1970 NWS methods differed from those of the 1955 NWS in at least one respect: gross stocks in 1970 prices were estimated first and net stocks were then computed using constant depreciation rates. Also, the description of methods used for the 1970 NWS contains no reference to the 1950 revaluation. For both surveys, assets' tax lives were explicitly used for average expected lifetimes. Given the average lifetimes, constant depreciation rates were computed.

19. Tax law changes in 1961 and 1964 reduced substantially the useful lives of assets other than buildings and structures. The lifetimes applicable to buildings and structures were reduced in 1966. (Ratcliffe 1969, 88). Since tax lives were used to depreciate assets in both wealth surveys, it would appear that these tax law changes would have reduced the level of 1970 assets relative to 1955 levels. This impression is somewhat reinforced by statements by the EPA (Economic Planning Agency 1980b, 10). When the EPA was developing its capital series, it initially computed 1956–70 stock levels on the base 1955 by adding post-1955 investment and deducting depreciation and discards. The result was a level of 1970 stocks 7% higher than that in the 1970 NWS. These observations do not conclusively show that 1970 levels were underestimates. It is possible that useful lives of assets did decline after 1955. And EPA itself might have initially overestimated investment and/or underestimated discards and depreciation over the 1956–70 period. The EPA decided to accept the 1970 NWS levels of 1970 stocks as definitive and to recompute its investment, discard, and depreciation series.

20. The *u*'s obtained by increasing published 1970 NWS stocks by 10% using the CM gross investment and asset proportions, are as follows:

	Buildings and Structures	Machinery and Equipment	Other
Item 1: published 1955 and 1970 NWS stocks	.062	.173	.281
Item 2: published 1955 NWS stocks and 1970 NWS stocks plus 10%	.043	.141	.237
Item 1 ÷ Item 2	1.44	1.23	1.19

These lower *u*'s yield higher average annual growth rates for net stocks for the 1970–81 period; these growth rates are as follows:

	Buildings and Structures	Machinery and Equipment	Other
Item 1: published 1955 and 1970 NWS stocks	4.5	4.3	10.8
Item 2: published 1955 NWS stocks and 1970 NWS stocks plus 10%	5.8	5.7	12.0
Item 2 ÷ Item 1	1.29	1.33	1.11

21. In 1981, all corporations below 1 billion yen were divided into six categories, and larger proportions of the categories with the larger firms were sampled. For example, one-fifth of the corporations between 50 and 100 million yen were sampled, but only 1/300 of the corporations below 2 million yen were sampled (Japan, Ministry of Finance 1982, *Special Annual Report of Financial Statements of Corporations*).

22. In 1969, the RCIS obtained results from 14,956 manufacturing corporations. Surveyed corporations in all industries were estimated to have been responsible for 52% of all private, nonhousehold, domestic gross fixed capital formation and 50% of nonresidential capital formation (Japan, EPA 1970, *Report on the Corporate Industry Investment Survey.*)

23. When the minimum size rose from 10 million yen to 100 million yen in 1973, there was a substantial decline in the population of firms to which the published RCIS investment figures applied. Despite this, published current value investment rose in 1973.

24. In one respect, the RCIS was superior. The RCIS questionnaire was especially well designed to elicit the actual magnitude of annual spending for new capital assets.

25. Hulten and Wykoff (1980), working with U.S. data, find that economic depreciation is less than allowed for in the tax code. They also find, however, that economic depreciation depends on the tax laws; the more rapidly a firm may depreciate a piece of equipment, the more rapidly its resale value declines, because part of the value of any piece of equipment is the present value of the remaining depreciation allowances.

26. Corporations were permitted, by law, to revalue their assets in 1950 and in 1953, before the earliest ARCS data used in this study.

27. This may not be entirely correct. It is possible, for example, that tax law might permit the pooling of assets of certain types into asset classes of a particular year of acquisition for purposes of computing depreciation. This might lead to the retention on the books of some scrapped assets until the whole asset class reaches its service life, as provided in tax law.

28. The EPA does prepare unpublished deflators. Efforts have been made to obtain such unpublished data.

29. The RCIS investment series includes "in process" investment. Therefore, *u* was computed using 1955 and 1970 net stocks that include "in process" assets, distributed proportionately across asset categories.

30. The averages of the three asset percentages over the years 1956–1974 are as follows:

	CM	RCIS
Buildings and structures	26.0	26.2
Machinery and equipment	61.7	62.0
Other	12.3	11.7

The percentages also compare closely for individual years, except for 1956, the first year of the RCIS. In 1956, buildings and structures accounted for 34.5% of total gross investment according to the RCIS and 24.8% according to the CM. During the years 1957–74, there were only five instances when the percentages for one of the assets differed between the two data sources by as much as three or four percentage points.

31. Some sensitivity to benchmarks is indicated by comparing the RCIS *u*'s in panel B of table 8.8 with *u*'s obtained by Nishimizu (1974, 113), who used benchmarks from the 1955 and 1960 NWSs. For the largest asset categories, machinery and equipment and nonresidential buildings, the *u*'s are close (for machinery and equipment, 0.123 in

the current study and 0.133 in Nishimizu) while for smaller categories they differ greatly (for tools and instruments, 0.252 and 0.127).

32. The uniformity of the RCIS and ARCS percentages by asset category reflects the fact that the same deflators are used for these series. The EPA figures were deflated by EPA. Regarding the levels of the RCIS figures, see table 8.9, n. 3.

33. Apart from the differences in deflators betwen the EPA and the other series, the differences between the series presented in table 8.9 really result indirectly from differences in the four gross investment series. It is the latter differences that produce the differences in the *u*'s.

34. The RCIS was continued after 1974, though that was the last year in which it included questions on asset acquisition by asset type. The post-1974 RCIS results are not used in this study. Analysis presented in section 8.4 indicates that it is not one of the more accurate sources of total annual gross investment.

35. For the United States, France, Germany, and the United Kingdom, see Neef and Dean (1984). In Japan, a dip in labor productivity growth occurred in 1971, followed by a strong recovery that extended through 1973, when growth was over 10%. The average annual compound growth rate for 1955–73 was 9.6%, for 1973–81, 5.5% (unpublished data series underlying Neef and Thomas 1987). The apparent persuasiveness of these figures disguises the difficulty of separating cyclical and long-term trends in productivity growth (Berndt 1984).

36. It is interesting to note that the slowdown in the growth rates of capital stock began before the slowdown in labor productivity. There is little evidence of a slowdown in labor productivity up to 1973. The growth rates of net stock, on the other hand, began to decline around 1970 and, with a few exceptions, dropped steadily during the 1971–74 period. During the 1971–74 period, there were declines in the net stock growth rate every year, or every year but one, in all three CM, all three EPA, and two of the three ARCS series. The ARCS "other" asset category showed increases in two of the four years.

37. Jorgenson, Kuroda, and Nishimizu (1985) also make use of the CM data, for distributing EPA gross investment in manufacturing by industry, and the RCIS data, for dividing gross investment into asset categories. After 1974, stock market information is used for dividing gross investment into asset categories.

38. In the United States, annual gross book value data are compiled by the Bureau of the Census using the Annual Survey of Manufactures and by the Internal Revenue Service for its Statistics of Income series. The Bureau of Labor Statistics is comparing these series, for selected industries, with series compiled using the perpetual inventory method to shed light on cyclical variations in multifactor productivity in the United States. See Powers (1985) and Powers (1988). However, these series have several shortcomings compared with the national wealth surveys: they are not based on asset data of specific vintages and they provide little information by detailed asset type. Further, they suffer from the general shortcomings of book value data discussed above.

39. The Japanese Statistics Council (a permanent advisory organ on government statistics) prepared a report to the Director General of the Management and Coordination Agency entitled "Medium- and Long-Term Plans for Government Statistical Activities," dated 25 October 1985. The council noted that "the economy of Japan has experienced oil-shocks twice since the survey of national wealth was conducted in 1970 and is assumed to have undergone some large changes in the structure of its capital accumulation." The council also stated that "the present situation where the estimation of capital accumulation in later years has to be made with the 1970 National Wealth Survey results as a benchmark creates some arduous problems." The council concluded that "the development of statistics on tangible assets is especially needed" and that "such statistics should urgently be developed." (Management and Coordination Agency 1986, 4).

40. As of the middle 1980s, balance sheet data were available on tape for 1,299 firms, including 335 outside manufacturing, whose common stocks were listed on the Tokyo, Nagoya, and Osaka stock exchanges.

41. The Ministry of Agriculture, Forestry, and Fisheries conducts an annual sample survey that yields information on capital assets in agriculture. The national accounts include tables on gross fixed capital formation for the whole economy, by six asset categories, in current and constant prices.

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Comment Masahiro Kuroda

This paper provides us with a good summary of the gross investment data for Japan. I believe that this research would be a valuable aid in revising capital stock series in Japan, and I would like to add some comments and suggestions. My comments are broadly divided into three points.

First, the evaluation of the capital input is very important, as the authors have stated, in obtaining estimates of multifactor productivity. However, when it comes to measuring multifactor productivity, not only is it important to get accurate data on one input, such as capital, it is also necessary to obtain a whole set of consistent data on labor, capital, and output. However, Dean, Darrough, and Neef do not provide any information on the consistency of the four alternative choices of gross investment with other data needed in the construction of multifactor productivity estimates.

According to my experience, when we measure multifactor productivity in Japan, we have to depend upon input-output tables or on data from the system of national accounts for obtaining data on output, labor compensation, and capital compensation. From the viewpoint of consistency with these output and input measures, I think the EPA measures are preferable, because EPA data are constructed by methods that are consistent with the input-output table and the system of national accounts (the "commodity flow" method).

The authors found the economic rate of depreciation to be much higher using EPA gross investment series than it was using alternative series. When I used EPA gross investment and net capital stock to measure the economic rate of depreciation by the double benchmark method, I also found the estimated rate of depreciation to be overvalued. But, instead of changing the gross investment series, I changed the bench values of capital stock in the benchmark process.

The "gross" value of assets in NWS was estimated by multiplying the nom-

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inal value of each asset at acquisition time by the rate of change in prices between the acquisition time and the survey year. The "net" value was estimated by multiplying the gross value by the remaining value ration in proportion to lifetime and year elapsed from acquisition time. Theoretically, the capital assets used as benchmarks should be measures in net terms since this corresponds to the real flow of capital services. It is, however, somewhat doubtful that the estimates of "net" values in NWS are consistent with the theoretical concept of net capital stock. Therefore, I believe that one should change the benchmark capital stock to a "gross" concept and adjust the overvalued estimates of the economic rate of depreciation. This allows us to use EPA investment data, which is consistent with other data for the measurement of the multifactor productivity.

As a second general point, the authors try to measure capital input in aggregate Japanese manufacturing. As part of this work, they divide capital stock into several asset categories. The change in the relative proportions of different asset types in aggregate manufacturing results in quality change in capital input during the period of rapid economic growth in Japan. However, there were also large changes in the distribution of capital stock among individual manufacturing industries during this period. Thus, when evaluating capital input in Japanese manufacturing, we have to consider not only the changes in the type of capital but also changes among the component industries within total manufacturing.

Finally, it is worth noting that when you estimate the deflators of investment goods, you can use the fixed capital formation matrix, which is consistent with the input-output tables and EPA commodity flow data. These matrices are available for 1970 and 1975 in Japan.