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Service Lives of Fixed Assets

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NO. 4: SERVICE LIVES OF FIXED ASSETS

by

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SECTION 1

INTRODUCTION

A. BACKGROUND

1. Participants in the Special Meeting on National Accounts held in February 1980 requested the Secretariat to prepare a report on service lives of capital assets. Estimating service lives is one of the more difficult problems in using the perpetual inventory method to calculate capital stocks. While an earlier OECD report, The Measurement of Capital (40), had touched on the problem, participants agreed that this was an area where a more detailed study of country practices would be useful. A consultant, M. Pierre Teillet, was asked to conduct a survey of country practices and to prepare an initial report, which was briefly discussed at the Special Meeting on National Accounts held in June 1981. The present study, which has been prepared by the Economic Statistics and National Accounts Division of the ESD, draws both on the earlier work by M. Teillet and on the substantial quantity of reports, working papers and other documentation on capital stock estimates supplied by statistical offices of Member countries. The Secretariat is grateful for the generous co-operation of Member countries, without which it would clearly have been impossible to prepare this report.

B. COVERAGE

2. This report deals with capital stock statistics for 13 OECD countries, although not all 13 are covered in the same detail in all sections. The data are all published by national statistical agencies with the following exceptions: for New Zealand, the only estimates presently available have been compiled by researchers at the Victoria University of Wellington; in Germany the Deutsches Institut für Wirtschaftsforschung (DIW) publishes capital stock statistics, which are based on the official Statistisches Bundesamt series, but which provide a more detailed breakdown of assets according to kind of activity; in Austria capital stock statistics are compiled by the Osterreichisches Institut für Wirtschaftsforschung (WIFO). The countries covered and compiling agency are as follows:

Canada	Statistics Canada, Ottawa
United States	Bureau of Economic Analysis, Washington
Japan	Economic Planning Agency, Tokyo
Australia	Australian Bureau of Statistics, Belconnen
New Zealand	Victoria University, Wellington
Austria	Osterreichisches Institut für Wirtschaftsforschung, (WIFO), Vienna.
Finland	Central Statistical Office of Finland, Helsinki

France	Institut National de la Statistique et des Etudes Economiques, (INSEE), Paris
Germany (a)	Statistisches Bundesamt, Wiesbaden
(b)	Deutsches Institut für Wirtschaftsforschung (DIW), Berlin
Italy	Istituto Centrale di Statistica, Rome
Norway	Central Bureau of Statistics, Oslo
Sweden	Statistics Sweden, Stockholm
United Kingdom	Central Statistical Office, London

C. LAYOUT

3. Section II deals with the sources used for estimating average service lives of capital assets, the service lives actually used by Member countries in their perpetual inventory models, and the extent to which these lives are allowed to vary over time. Section III summarises the various mortality functions used, i.e. the pattern of retirements around the average service life of a particular asset. Section IV examines the sensitivity of capital stock estimates to errors in average service lives, to changes in service lives over time, and to the use of inappropriate mortality functions. There are two appendices. The first describes how average service lives and average ages of groups of assets can be deduced from the kind of statistics that are commonly published on capital stocks and flows. The second consists of a bibliography of publications dealing with sources and methods of capital stock statistics, identifying separately those that give information about asset lives.

SECTION II

AVERAGE SERVICE LIVES OF FIXED ASSETS

4. This section deals with three aspects of service life estimates - the main sources used, the service lives currently applied, and the extent to which service lives change over time.

A. SOURCES USED

5. The main sources used by the OECD countries are asset lives prescribed by tax authorities, company accounts, surveys, expert advice, and other countries' estimates.

(a) Tax-lives

6. In most OECD countries the tax authorities specify the number of years over which the depreciation of various types of assets may, under normal circumstances, be deducted from profits before charging taxes. The United States relies heavily on tax-lives, but most other countries also make some use of them - either to estimate the service lives of assets for which no other source is available, or to provide a general credibility check on service life estimates obtained by other methods.

7. The interesting question, of course, is what sources are used to estimate tax-lives in the first place. Hibbert et al(24) note that the United Kingdom tax lives are based on "custom and practice rather than any scientific study of longevity of assets", and for this reason, the United Kingdom is one of the few OECD countries that makes no use of tax lives. In general, it appears that tax-lives are based on a variety of sources of differing reliability including expert opinion, ad hoc surveys of particular assets in particular industries, and advice from trade organisations. Presumably, the accuracy of tax-lives will depend on the extent to which they are actually applied in tax calculations. In the United Kingdom, for example, various systems of accelerated depreciation have been used to encourage investment; the tax lives published by the Inland Revenue are therefore irrelevant to the calculation of tax liabilities, and neither tax collectors nor tax payers have any incentive to see that they are accurate and kept up-to-date.

8. As noted above, the United States estimates of service lives rely heavily on tax data. However, the Bureau of Economic Analysis believes that the Inland Revenue tax-lives, as published in the 1942 edition of Bulletin F(6) are somewhat longer than actual service lives, and the Bulletin F lives are marked down to between 0.85 and 0.68. In Germany, on the other hand, tax lives are thought to be too short, because firms keep assets in service for some years after they have been fully depreciated for tax purposes, and tax lives are therefore marked up to obtain estimates of actual service lives.

(b) Company accounts

9. Company accounts almost always record stocks and flows of assets at historic (or "acquisition") values, and while this is a disadvantage for many purposes, it does not necessarily prevent them from being used to estimate asset lives. There are at least two ways of using company accounts for this purpose.

10. In France, Atkinson and Mairesse (1) have used company accounts to construct time series of fixed investment and gross capital stocks for manufacturing assets. Since the two sets of data are consistently valued - i.e. both at historic costs - the gross capital stock in any year can be obtained by adding up some of the investment that took place in previous years. Precisely which assets from previous investments are still in the capital stock in any given year depends on the average service life of assets, and on the way that retirements are distributed around the average, i.e. on the mortality function. Atkinson and Mairesse experimented with four different mortality functions - simultaneous exit, exponential, Weibull, and log-normal - and with a large number of average life assumptions, in order to find combinations of mortality functions and service lives that best fitted the time series on investments and gross stocks.

11. In the case of the simplest mortality function - "simultaneous exit" (which assumes that all assets are retired together on reaching the average service life) - all that was involved was to compare the gross stock in each year with the sum of investments during a varying number of previous years until finding how many years' cumulated investments most nearly equalled each year's capital stock. Fitting the other mortality functions involved the same basic approach, though with some extra complications because the other functions imply a distribution of retirements around the mean.

12. Atkinson and Mairesse found that, for plant and machinery, the simultaneous exit and (sharply-peaked) log-normal mortality functions fitted the data about equally well, with average service lives ranging from 16 to 21 years for the three manufacturing sectors covered in their study. They also divided the period into a number of sub-periods and found evidence of a slow decline in average service lives over the period 1966 to 1975.

13. Because of its originality and potential application in other countries, it seems worthwhile enumerating the pros and cons of the Atkinson-Mairesse methodology. The advantages are that:

(a) Mortality functions can be estimated as well as average service lives.

(b) Inspection of the data for sub-periods may indicate whether service lives are changing.

(c) Atkinson and Mairesse showed that estimates of service lives and mortality functions are not much influenced by aggregation of the data. It may, therefore, be unnecessary to examine individual company accounts, as was done by Atkinson and Mairesse, and to work instead with highly aggregated data such as those available in annual publications on "enterprise statistics".

14. There are, of course, drawbacks to their method:

(a) The stock and investment data must be valued on the same basis over the entire period considered. While historic cost is the standard method of valuation, the assets of individual companies are often revalued at current replacement cost when companies merge, are taken over, or undergo financial restructuring. While such events are not common, there is, nevertheless, quite a high chance of them happening to any given firm at least once over the 25 years or so for which consistently-valued data are needed. In the French case, Atkinson and Mairesse found only about 150 manufacturing firms whose data were judged sufficiently consistent for use in their study.

(b) Their method provides little detail on either types of asset or kinds of economic activity. Companies cannot easily be fitted into an activity classification designed for establishments, and company accounts do not usually give much detail about the types of assets held. Atkinson and Mairesse could distinguish only a single asset type - machinery and equipment - for only three sub-sectors within manufacturing.

15. In Canada, company accounts have been used in a different, and much simpler way, to estimate average service lives. In their report to the Economic Council of Canada, Tarasofsky et al(38) estimated average service lives by dividing the gross capital stock at the end of a given year by estimated depreciation during that year. It is shown in Appendix 1 below that, so long as depreciation is calculated by the straight-line method, this ratio is the harmonic mean of asset service lives. Apart from its simplicity, this method has the enormous advantage that no time series are necessary. One year's data on depreciation and capital stocks are enough to provide a service life estimate for that year; if more than one year's data are available, changes in asset lives can be monitored.

16. By contrast with the Atkinson-Mairesse approach, this method provides no information about mortality functions. In addition, for the reasons noted above in connection with the Atkinson-Mairesse study, it cannot be used to generate a detailed breakdown of service lives by asset type and industry.

(c) Surveys

17. Japan is the only OECD country to have used a large-scale asset survey to estimate service lives, although such surveys are regularly used in Eastern Europe*. The last such survey carried out by Japan, the 1970 National Wealth Survey, (32) covered about 1.0% of government establishments and 0.5% of private enterprises. However, because the sample was selected with probability proportional to size, the survey covered a relatively high proportion of total assets. The main purpose of the survey was to establish a benchmark figure for the capital stock, which has subsequently been updated by the perpetual inventory method. However, respondents were also required to give the dates of acquisition and expected life-times for a very detailed list of fixed assets. These have been published in "Order No. 15" of the Ministry of Finance and are now used both for tax purposes and for the capital stock estimates.

18. A small-scale enquiry was carried out by Barna(2) in 1960 for the United Kingdom. Questionnaires were sent to 90 firms in the manufacturing sector, of which 57 supplied information on dates of installation of assets and expected or "normal" life-times. Barna noted that factory managers normally keep updated "plant registers" which contain the detailed basic data needed for estimating asset lives.

19. In Italy, the Istituto Centrale di Statistica (ISTAT) includes questions on the average service lives of machinery in its annual survey of industrial production. In the 1981 enquiry respondents were asked to give a percentage distribution of equipment and machinery according to their expected service lives. ISTAT plans to use this information in compiling a new series of capital stock statistics.

20. In some countries trade organisations and technical publications may also conduct surveys on the age composition of particular types of assets. For example, in the United States the trade journal "American Machinist" publishes the results of a 5-yearly survey of the age distribution of metal working machines in each of the principal user industries, and the journal "Metalworking Production" publishes the results of a similar survey for the United Kingdom. Bacon and Eltis (43) converted the age data from these publications into estimates of average service lives - 23½ and 25 years for the United States (in 1971) and the United Kingdom (in 1968) respectively. They note that these two journals provide a "hitherto untapped source of information about the relative lives of industrial plant in the U.S. and the U.K.". It seems probable that similar information on particular kinds of assets is provided by trade and technical publishers in other countries.

* The survey approach may be better suited to centrally-planned than to market economies because the (administered) asset price in the former are more stable than the (market) asset prices in OECD countries. Nevertheless, the surveys carried out in some East European countries have been of enormous complexity and scale. In Organisation of Statistics in the USSR (Progress Publishers, Moscow, 1967), A. Yezhov notes that "as regards its scale, economic significance and number of participants, the (1960 USSR asset survey) probably surpassed .... even the national population census".

(d) Expert advice

21. Most countries appear to base at least some of their asset lives on "expert advice", and Sweden and Italy rely almost exclusively on this source. The term is obviously somewhat imprecise. At its best, the use of "expert advice" may involve seeking advice from a panel of production engineers familiar with conditions in a representative cross-section of industries, or asking firms that produce capital assets for the expected or normal service lives of different sorts of equipment. At the other extreme, expert advice may be no more than a euphemism for pure guesswork by the statisticians responsible for the capital stock series.

(e) Other countries' estimates

22. Although relatively few countries specifically mentioned "other countries" as a source for estimating asset lives, it is probable that most countries periodically review estimates used by other countries to ensure that their own estimates are not too far out of line with those of neighbouring or similar countries. Certainly, when countries first estimate capital stocks, they invariably search the literature or contact other statistical offices directly to find out the service lives used elsewhere.

23. Table 1 summarizes the information available for 13 OECD countries on the main sources used for asset service lives.

B. ESTIMATED SERVICE LIVES

24. Tables 2 to 4 below show, for up to 10 countries, estimated service lives for, respectively, machinery and equipment in manufacturing, machinery and equipment in other industries, and building and construction: Table 5 gives some estimates for transport equipment, computers and dwellings. In several cases figures are given in brackets indicating that they are averages calculated by the Secretariat. For the United Kingdom these are weighted by the estimated stock of assets corresponding to each service life. For other countries they are mid-points of a range of service lives; these mid-points, however, have only been calculated when the range of service-lives is relatively narrow.

25. The last line of Table 2 shows the simple averages of the service lives of assets in the various kinds of manufacturing activities listed in the table. Although these averages are not very meaningful in themselves, they serve to rank the countries according to length of assumed service lives and these rankings generally apply also to the asset lives shown in Tables 3 to 5. First, there are two extremes - Japan with an average of only 10 years, and the United Kingdom with an average of 33. In between is a short-life group consisting of Australia, the United States, Finland, France, and Italy, where service lives are estimated at between 15 and 17 years, and two countries - Austria and Sweden - with service lives of 19 and 23 years respectively.

Table 1. Main sources used for estimating service lives of assets in OECD countries

Country	Main sources used
Canada	Company accounts and lives used for tax purposes.
United States	For agricultural equipment and agricultural structures average lives are based on unpublished studies by the Department of Agriculture and the Treasury Department respectively. For all other assets, service lives are based on the tax-lives specified in the Treasury Department's Bulletin F (6). However, the F-lives are believed to be too high and the following "F-percentages" are used: non-agricultural equipment, 85%F; manufacturing structures, 68% F; structures other than in agriculture and manufacturing, 79% F. See Fixed Non-residential Business and Residential Capital in the United States, 1925-75 (16).
Japan	The 1970 National Wealth Survey provided estimates of average lifetimes of all types of capital assets. These were subsequently codified in Order No.15 of the Ministry of Finance, and this latter document is currently used as the source of average service lives for the capital stock estimates.
Australia	Lives used for tax purposes and estimates used in other countries. See Current-cost and Constant-cost Depreciation and Net Capital Stock (11).
New Zealand	Lives used for tax purposes. See Campbell (7).
Austria	Service lives of motor vehicles are estimated from registration statistics. For all other assets service lives are based on information supplied by enterprises, estimates reported by comparable countries, and expert advice.
Finland	Surveys, expert advice, and recommendations by the Ministries of Finance and Communications.
France	For equipment in "industry" (ISIC 2-5) the estimates were derived from a study of the relationship between capital formation and asset stocks as reported in company accounts. See Atkinson and Mairesse (1). For all other assets service life estimates are based on expert advice.

Table 1 (continued)

Country	Main sources used
Germany (Statisches Bundesamt)	For motor vehicles, survey data are available on service lives; for dwellings census data are used; for other assets estimates of service lives are based on tax data and expert advice. See Lutzel (29).
Italy	Lives used for tax purposes and expert advice. (see also paragraph 21 above).
Norway	Expert advice for assets in agriculture, forestry, fishing, offshore oil and gas, rail and air transport. Survey data are available for all road vehicles. For all other assets, estimates reported by other countries are used.
Sweden	Expert advice. See Tengbland and Westerlund (39).
United Kingdom	The estimates are based on data from Feinstein (13) and Barna (2). Feinstein used company accounts to estimate capital stocks and capital formation for 1950 and earlier. Although Feinstein himself did not publish average asset lives, these can be calculated from his stock and flow estimates. Barna collected information from about 60 firms (mainly in manufacturing) on the ages and normal service lives of fixed assets in use in 1960. Dean (12) used his own judgement to average the estimates from these sources, and Dean's estimates have been used ever since. See also Hibbert et al(24).

Table 2. **Average service lives of machinery and equipment (excluding vehicles) in manufacturing activities**
(years)

ISIC Division		Canada	United States	Japan	Australia	Austria	Finland	France	Italy	Sweden	United Kingdom
31	**Food, beverages and tobacco**										
	Food and beverages	29	16	(11)	15	22	20	16	18	20	(33)
	Tobacco	15	16	(11)	15	22	20	16	18	20	(33)
32	**Textiles, clothing and leather**										
	Textiles	26	16	(10)	15	18	19	20	18	20	(35)
	Clothing	21	16	(11)	15	15	19	20	18	20	(31)
	Leather	15	16	(10)	15	(17)	19	20	18	20	(31)
33	**Wood and wood products**	26	16	(10)	15	15	18	20	18	15	(30)
34	**Paper, paper products, printing etc.**										
	Paper and paper products	22	16	(12)	15	20	17	20	16	(30)	(40)
	Printing and publishing	30	16	(12)	15	15	17	20	16	30	(40)
35	**Chemicals, petroleum products, etc.**										
	Chemicals	22	16	(8)	15	18	18	16	16	15	(37)
	Petroleum and coal products	26	16	(13)	15	18	18	16	18	30	(37)
	Rubber	15	16	(9)	15	18	18	16	15	15	(31)
	Plastic products	15	16	(9)	15	18	18	16	15	20	(37)
36	**Non-metallic mineral products**										
	Clay and stone products	26	16	(9)	15	18	15	16	16	35	(31)
	Glass	26	16	(9)	15	15	15	16	16	35	(31)
	Other	26	16	(9)	15	18	15	16	16	30	(31)
37	**Basic metals**	22	16	(13)	15	24	15	20	15	35	(32)
38	**Fabricated metal products and machinery**										
	Metal products	21	16	(11)	15	20	15	16	20	25	(32)
	Non-electrical machinery	21	16	(12)	15	20	15	16	16	25	(32)
	Electrical machinery	22	16	(10)	15	20	15	16	16	25	(32)
	Transport equipment	30	16	(11)	15	18	15	16	16	15	(35)
39	**Other manufacturing**	13	16	(11)	15	..	20	20	18	20	(31)
	Arithmetic average of above figures	23	16	10	15	19	17	17	17	23	33

( ) Average calculated by the Secretariat.

Table 3. Average service lives of machinery and equipment in non-manufacturing activities

	Canada	United States	Japan	Australia	Finland	France	Germany	Italy	Sweden	United Kingdom
Agriculture, etc.										
Agriculture	15	17	(6)	13	..	10	15	18	15	(13)
Forestry	10	..	(5)	13	5	10	15	18	20	50
Fishing	3	..	..	13	..	16	15	18	..	25
Mining and quarrying										
Petroleum and gas	20	10	(7)	11	20	16	..	18	30	5
Coal Mining	20	10	7	11	20	16	17	18	30	(12)
Iron-ore mining	20	10	9	11	20	20	17	15	30	30
Other mining and quarrying	20	10	(8)	11	20	16	17	15	30	30
Electricity, gas and water										
Electricity	35	21	15	20	25	16	20	18	35	(27)
Gas	35	..	15	20	25	16	20	18	35	(22)
Water	35	..	12	20	25	16	20	..	35	25
Construction	10	9	(5)	9	10	12	10	18	10	(26)
Wholesale and retail trade	20	..	(10)	10	15	16	..	..	15	(30)
Transport, storage and communications										
Railways	28	25	..	14	..	16	..	..	35	25
Road: passenger	10	..	..	14	..	16	12	..	..	25
freight	10	..	..	10	..	16	12	..	..	25
Air: aircraft	10	..	..	14	..	16	12	..	..	8
airports, etc.	10	..	..	14	..	16	12	..	..	20
Water: vessels	35	..	..	14	..	16	..	..	..	10
harbours, docks, canals	..	..	..	..	..	16	..	..	40	25
Warehousing	25	14	(10)	..	..	16	..	..	..	..
Broadcasting	15	..	6	..	..	16	20	..	..	..
Telephone and telecommunications	25	..	8	..	..	16	20	..	15	..
Other services										
Financial, etc. & business	15	10	..	9	10	16	..	..	20	(30)
Public administration	20	..	..	..	..	16	..	..	20	20
Education	20	..	..	10	..	16	..	..	20	20
Health	15	..	..	10	..	16	..	..	20	15
Personal services	..	..	..	12	..	16	..	..	20	(30)

( ) Average calculated by the Secretariat.

Notes:

1. Transport equipment is excluded except in the case of Australia, France and Germany.
2. For Canada public administration refers only to the federal government, and health covers only hospital equipment.
3. For the United States electricity equipment only refers to turbines and the figure for warehousing refers to materials-handling equipment.
4. For Japan "electricity" excludes hydro-electric equipment.
5. For Australia the figure for "road transport: freight" refers to equipment held by private transport enterprises; the figures for other transport activities refer to equipment held by public transport enterprises.
6. For Germany the average service lives are those given in Lutzel (29). The present capital stock estimates published by the Statistisches Bundesamt use slightly shorter service lives.

Table 4: Average service lives of buildings and other construction work
(years)

	Building					Engineering Construction				Building and Engineering Construction		
	Canada	United States	Finland	Italy	Sweden	Canada	United States	Finland	Sweden	Australia	France	United Kingdom
Agriculture, etc.												
Agriculture	40	38	..	..	80	..	38	60	60	40	40	30
Forestry	20	..	40	..	..	30	31	30	25	40	..	50
Fishing	25	..	..	..	..	25	31	60	..	40	..	25
Mining and quarrying												
Petroleum and gas	25	27	..	35	..	30	16	..	..	32	35	15
Coal Mining	25	27	25	35	60	30	31	30	80	32	35	40
Other mining and quarrying	25	27	25	32	60	30	31	30	80	32	40	40
Manufacturing	(40)	27	40	38	60	(48)	31	(45)	80	37	(37)	80
Electricity, gas and water												
Electricity	50	27	50	35	75	55	30	30	50	40	40	25
Gas	50	27	50	35	75	55	30	30	80	40	35	(47)
Water	50	27	50	..	75	70	26	30	80	40	40	75
Construction	25	27	40	40	75	30	31	30	..	32	30	80
Wholesale and retail trade, etc.												
Wholesale and retail trade	50	36	50	..	75	55	31	30	80	45	30	80
Hotels and restaurants	50	36	50	..	65	55	31	30	..	45	30	80
Transport, storage and communication												
Railways	50	27	..	..	80	55	51	..	75	45	40	100
Road: passenger	50	27	..	..	60	55	31	..	80	45	40	50
freight	60	27	..	..	60	65	31	..	80	45	40	50
Air	40	27	..	..	75	50	31	..	40	45	40	40
Water	50	27	..	..	..	50	31	..	80	45	40	10
Warehousing	50	..	..	..	..	..	31	..	80	45	..	50
Broadcasting	50	..	..	..	75	..	31	..	40	45	..	75
Telephone and communications	50	..	..	..	75	55	27	..	40	45	40	75
Other services												
Financial etc., and business	50	36	50	..	75	..	..	10	..	60	30	80
Public administration	50	..	50	..	75	55	..	70	80	..	..	75
Education	50	48	50	..	75	..	..	..	..	60	..	75
Health	50	48	50	..	75	..	..	..	..	60	..	75
Personal services	..	..	50	..	75	..	..	..	..	55	30	80

( ) Average calculated by the Secretariat.

Notes: 1. For Finland the figure for manufacturing buildings excludes pulp and paper manufactures. (Estimated service lives: 30).

2. For Sweden the figure for manufacturing buildings excludes pulp and paper manufacturers and petroleum refineries. (Estimated service lives: 65 and 70 respectively).

3. For the United Kingdom the figure for electricity excludes hydro-electric power stations. (Estimated service life: 95).

Table 5. Average service lines of vehicles, dwellings, computers (years)

	Canada	United States	Japan	Finland	Sweden	United Kingdom
Vehicles						
Farm tractors	10	8	..	9	15	10
Fishing boats	25	22	..	10	..	25
Other ships	35	22	..	10	..	25
Buses	10	9	..	10	6	10
Rolling stock	28	..	..	10	35	30
Road freight vehicles	10	9	5	10	3	10
Passenger cars	6	10	5	10	2	10
Aircraft	10	9	5	10	15	10
Dwellings						
1 to 4 unit structures:						
new	..	80	45(a)	55	75	100
additions and alterations	..	40	..	..	..	40
4 + unit structures:						
new	..	65	50(b)	55	75	100
additions and alterations	..	32	..	..	..	40
Computers/office machines						
Computers	..	8	6	..	15	..
Office machinery	..	8	6	..	10	..

(a) Brick, stone, and block-built dwellings.

(b) Reinforced concrete residential buildings.

C. CHANGES IN SERVICE LIVES

26. It seems generally to be accepted that average service lives change over time. Tengblad (39) notes that "most likely durability decreases /in Sweden/ in periods with rapid technological and economic development". The U.S. Bureau of Economic Analysis (16) suggests that "during wars or other periods of high capacity utilisation, equipment and structures may be used beyond their normal working lives. Unusual technological advances may also change service lives drastically, /and/ there may be trends in service lives". Lützel (29) believes that service lives in Germany have been declining in recent years and cites as evidence the successive reductions in tax lives of assets decreed by the fiscal authorities during the last two decades, the significant decline in the service lives of motor cars between 1955 and 1970, and a 1969 survey conducted by the Munich Institute of Economic Research (IFO), in which most firms interviewed reported that "normal" asset lives had declined over the last 15 years, and said they expected the trend to continue. Finally, as noted in paragraph 12 above, Atkinson and Mairesse found some evidence of declining service lives for manufacturing equipment between 1966 and 1975.

27. In compiling their capital stock estimates, however, only two countries presently assume declining service lives. In Sweden the normal life of road beds is assumed to have fallen from 40 years in the 1940s to 30 years in the late 1970s, and for cars and trucks, service lives are assumed to have fallen over the same period from 5 to 2 and 6 to 3 years respectively. In the capital stock model developed by the Statistisches Bundesamt for Germany, the average service life may be varied for any asset whenever new information becomes available, and asset lives have apparently been reduced quite substantially in recent years. The Australian capital stock model also provides for variation in asset lives, although to date no firm information has become available to warrant changes in asset life assumptions.

SECTION III

MORTALITY AND SURVIVAL FUNCTIONS

28. This section looks at the assumptions made about the distribution of retirements around the average service life. There is first a discussion of the characteristics of the various functions available for simulating retirement patterns, and this is followed by a table summarising the information available on the mortality functions used by 12 OECD countries.

29. Figure 1 shows typical mortality and survival functions underlying the various retirement patterns used by the OECD countries. The mortality functions, in the first column, show rates of retirement over the lifetimes of the longest-lived member of a group of assets of a particular type installed in a given year: they are essentially probability density functions with the area under each curve equal to unity. The survival functions, in the second column, show what proportion of the original members of the group of assets are still in services at each point during the lifetime of the longest-lived member of the group.

(a) Linear

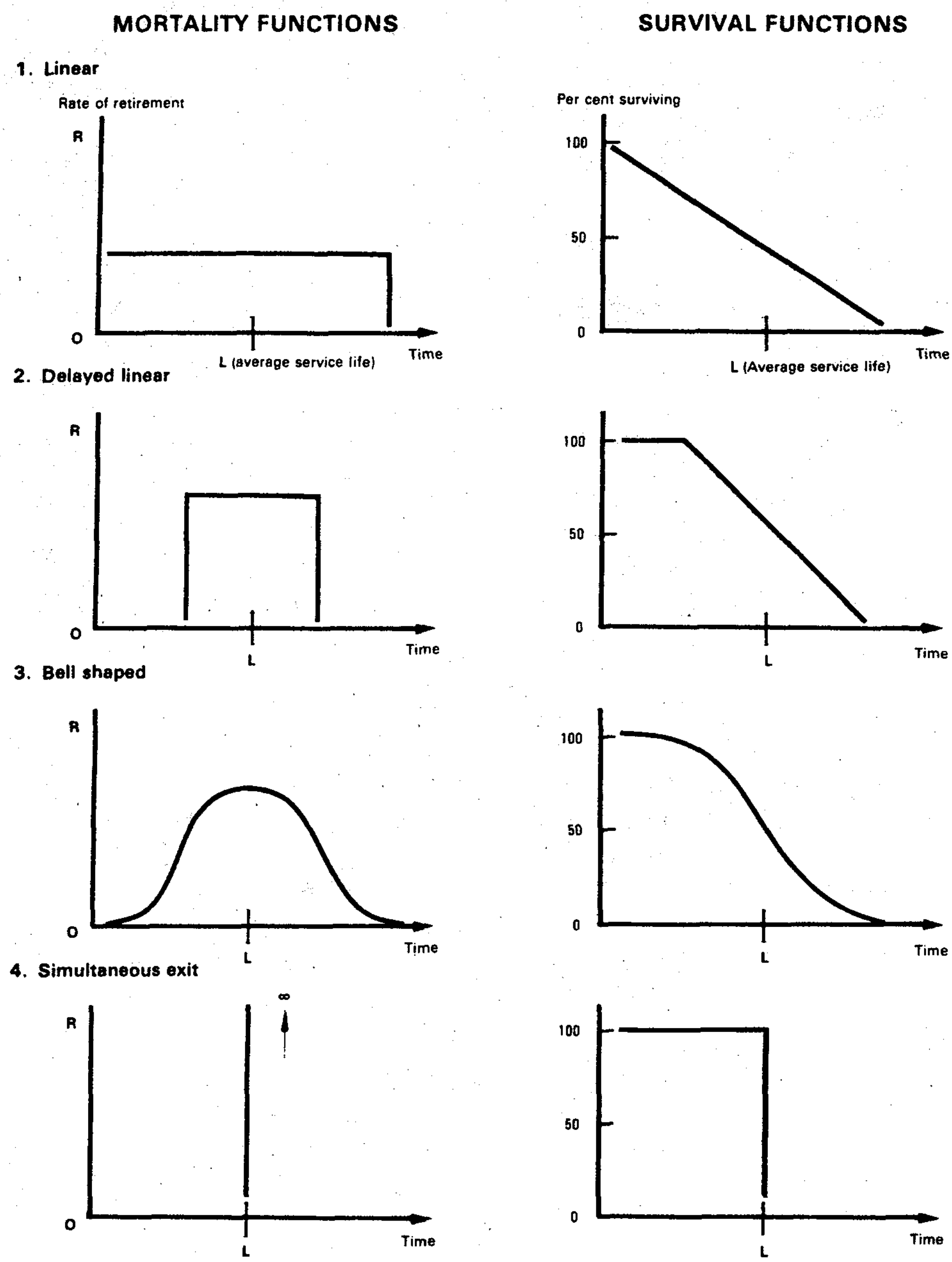
30. With a linear retirement pattern, assets are assumed to be discarded at the same rate each year from the time of installation until twice the average service life. The mortality function is a rectangle whose height - the rate of retirement - equals $\frac{1}{2L}$ where L is the average service life: the survival function shows that the surviving assets are reduced by a constant amount each year, equal to $\frac{50}{L}$ % of the original group of assets. No OECD countries presently use this retirement pattern for their regular capital stock statistics, although it is used in Canada for "alternative capital stock" estimates which are designed to show the impact on the capital stock data of using different retirement patterns. (See Koumanakos (28)).

(b) Delayed linear

31. With a delayed linear retirement pattern, discards are assumed to occur at a constant rate over some period shorter than 2L. Retirements start later and finish sooner than in the simple linear case. The United Kingdom and New Zealand use this retirement pattern for their capital stock estimates. In the case of the United Kingdom, it is assumed that all assets are retired over the period from 80% to 120% of their average service life. The rate of retirement in the mortality function is therefore equal to $\frac{1}{L(1.2-0.8)}$ or $\frac{250}{L}$ % per year during the period when the retirements are assumed to occur. For the New Zealand estimates four different types of delayed linear functions are used with retirements ranging from ±25% of the average to ±82%.

Figure 1

TYPICAL MORTALITY AND SURVIVAL FUNCTIONS



32. Until 1975 the United Kingdom estimates were based on the assumption that all assets of a given type were retired simultaneously when they reach the average service life for that group. This was found to produce a marked uneveness in the stock data for the early 1970s when the large amounts of plant and equipment installed in the 1940s for war-time production reached their average service lives. In the absence of any firm information about the actual retirement patterns, the delayed linear function was adopted because of its computational simplicity. It is interesting to note, however, that in his 1960 study, Barna (2) concluded that a delayed linear function, with discards starting 3 to 5 years after installation, best fitted the mortality pattern of manufacturing equipment.

(c) Bell-shaped

33. Most countries use some kind of bell-shaped mortality function. The actual functions in use are log-normal (France), gamma (Germany: Statistisches Bundesamt), logistic (Austria and Germany: DIW), Weibull (Finland) and Winfrey (United States and Sweden, and Australia for capital consumption estimates). In addition Canada uses a quadratic approximation to the normal distribution, and a truncated bell-shaped function (also based on the quadratic) for its "alternative capital stock" estimates. In most cases symmetrical functions are used but the German Statistisches Bundesamt uses left-skewed gamma functions, and Sweden and Australia use right-skewed as well as symmetrical Winfrey functions.

34. These various functions have presumably been selected because they appear to fit whatever information is available in the countries concerned on actual retirements of various kinds of assets. In practice, however, empirical evidence is scarce and it seems likely that in most countries the selection of a particular function is based on the retirement patterns of only a few types of assets - notably transport equipment. The main exceptions are the so-called Winfrey functions* which were developed at the Engineering School of the Iowa State College during the 1930s. Data were assembled on the mortality patterns of 176 types of assets, from which 18 standard mortality functions were derived - six being left-skewed, seven symmetrical, and five right-skewed. These are denoted by L, S and R respectively, with a subscript 0 through 6 moving from flatter to more peaked curves. The Winfrey S_1 function, for example, gives a flattish symmetrical curve with retirements spread over the period ± 95% of the average service life; the Winfrey S_4 function is again symmetrical, but it is more peaked with retirements occurring around ± 70% of the average service life.

35. While Winfrey curves are empirically well-based, it is not obvious that functions found to fit the mortality patterns of fixed assets in use in the United States during the 1920s

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* Winfrey (41) explains that the 18 functions that bear his name are derived from a study by Professor Edwin Kurtz, see Life Expectancy of Physical Property, The Ronald Press Company, New York 1930.

are still appropriate for the 1980s. Nearly a third of the 176 asset groups analysed by Winfrey consisted of railway equipment and structures, and the list covered relatively few manufacturing assets.

(d) Simultaneous exit

36. The simultaneous exit mortality function is used for capital stock estimates in Australia, Canada, Japan and Norway. As already noted it was also used in the United Kingdom until 1975.

37. This function assumes that all assets are retired from the capital stock at the moment when they reach the average service life for the type of asset concerned. The survival function therefore shows that all assets of a given type and vintage remain in the stock until time L, at which point they are all retired together. This retirement pattern is sometimes referred to as "sudden exit" but this term is somewhat ambiguous. Whatever mortality pattern is used, individual assets are always retired suddenly: the distinguishing feature of this function is that all assets of a given type and vintage are retired simultaneously.

38 Simultaneous exit may be regarded as a limiting case of a bell-shaped function where the peak approaches infinity and the variance approaches zero. The infinitely thin space inside the infinitely high vertical line sums to unity, as do the areas under the other mortality functions in Figure 1.

39 The assumption that all assets of a given vintage disappear simultaneously from the capital stock is clearly unrealistic. While it may be that the large majority of retirements occur around the average service life, it is clear that some assets are used with different intensities by different producers. It may therefore be assumed that simultaneous exit is used for much the same kind of reasons as the delayed linear function - computational simplicity and lack of data on actual retirement patterns.

40. It was noted in paragraph 32 above that the United Kingdom's capital stock estimates were based on the simultaneous exit function until implausible irregularities appeared in the series due to the (simultaneous) retirement of large quantities of war-time assets. The risk of this happening depends to a large extent on the degree of detail in the breakdown of capital assets. For example, if it is assumed that all machinery in a particular industry has the same average service life, it is much more likely that the assumption of simultaneous exit will cause irregularities in the stock series, than if 10 different types of machinery are distinguished for the industry group, each type having its own average service life.

41. Table 6 summarises the information available at the OECD about the kinds of mortality functions used in twelve Member countries.

Table 6. Mortality functions used by OECD countries for capital stock estimates

Country	Type of mortality function used
Canada	Simultaneous exit. Alternative estimates have also been made using linear, exponential, and bell-shaped mortality functions. See Koumanakos (28).
United States	Bell-shaped Symmetrical Winfrey functions are used. For residential buildings, discards are spread over the period ±95% of average service life : for all other assets discards are spread over the period ±45% of the average service life. See Fixed Nonresidential Business and Residential Capital in the United States 1925-75 (16).
Japan	Simultaneous exit.
Australia	Simultaneous exit and bell-shaped. Simultaneous exit is used for estimates of the net capital stock and consumption of fixed capital. Alternative estimates, for capital consumption only, have been made using bell-shaped Winfrey functions. For machinery and equipment in mining, manufacturing, construction, electricity, gas and water, symmetrical S2 functions were used. For all other assets, right skewed functions of type R2, R3 and R4 were used. See Current-cost and Constant-cost Depreciation and Net Capital Stock (11).
New Zealand	Delayed linear. Four different retirement patterns are used. For buildings with average service lives of 32 years retirements are spread evenly over the period ±25% of the average: for buildings with average lives of 55 years, ±28%; for equipment with average lives of 17 years, ±76%; for equipment with average lives of 27 years, ±82%. See Campbell (7).
Austria	Bell-shaped. Symmetrical quasi-logistic functions are used. See Kirner (27).
Finland	Bell-shaped. Symmetrical Weibull functions are used. See Kansantalouden tilinpito (26).
France	Bell-shaped. Symmetrical log-normal functions are used. See Mairesse (30).
Germany (a) Statistisches Bundesamt	Bell-shaped. The official capital stock series compiled by the Statistiches Bundesamt use left-skewed gamma functions. See Lützel (29).
(b) D.I.W.	The Deutsches Institut für Wirtschaftsforschung (DIW) uses a symmetrical quasi-logistic function for estimates of capital stock by industry sector. See Kirner (27).
Norway	Simultaneous exit.

Table 6 (continued)

Country	Type of mortality function used
Sweden	Bell-shaped. Winfrey functions are used. For most types of buildings and for transport equipment, right-skewed distributions are used of types R2, R3 and R4. For engineering construction and most other types of machinery and equipment symmetrical distributions of types S1, S2 and S3. See Tengblad (39).
United Kingdom	Delayed linear. Retirements are spread evenly over the period ± 20% of the average service lives. See Griffin (22).

IV. SENSITIVITY OF CAPITAL STOCK ESTIMATES TO SERVICE LIFE ASSUMPTIONS

42. This section deals with the effect on estimates of capital stocks and capital consumption of possible errors in service life assumptions. Three aspects of the problem are considered: the length of service lives, variations over time in average lives, and the choice of mortality functions.

A. LENGTH OF SERVICE LIVES

43. For the United States, capital stock and consumption estimates have been published in Fixed Non-residential Business and Residential Capital (16) using both a longer and a shorter set of average service lives. The standard estimates are referred to as "0.85F" because most assets are assumed to have service lives equal to 85% of those specified in the 1942 edition of Bulletin F (6). The longer estimates use the F lives as they stand, while the shorter estimates are based on 75% of the F lives. The longer and shorter lives are, respectively, about 18% more and 12% less than the lives used for the standard estimates. Table 7 shows the effect of using these alternative lives on gross and net stocks and capital consumption. The data refer to all assets other than dwellings for the whole private business sector and are at current replacement cost, but the general pattern shown in Table 7 applies equally to estimates at constant prices, and for the various subsectors.

Table 7. Effect on capital stock and capital consumption estimates of using different service life estimates; total non-residential capital assets in the United States, 1970

($ billion)

	Gross Capital Stock	Net Capital Stock	Consumption of fixed capital
Long lives (% of long)	1485 (100)	875 (100)	68 (100)
Standard lives (% of long)	1339 (90)	785 (90)	71 (105)
Short lives (% of long)	1235 (83)	719 (82)	74 (109)

Source: Fixed Non-residential Business and Residential Capital in the United States, 1925-75(16). See text for explanation of "long", "standard" and "short" lives.

44. The results given in Table 7 - lower stock figures and higher capital consumption as service lives are reduced - are supported by Table 8 which shows how shorter service life assumptions would change the United Kingdom's estimates of capital stock and capital consumption for plant and machinery in manufacturing.

Table 8. Effect on capital stock and capital consumption estimates of using different service life estimates: plant and machinery in manufacturing in the United Kingdom

Change in assumed service life	Gross capital stock	Net capital stock	Consumption of fixed capital
-20%	-13%	-15%	+10%
-40%	-25 to 30%	-30 to 35%	+20 to 25%

45. Hibbert et al (24), from which Table 8 is taken, note that "the relationship between the change in assumed lengths of life and the changes in estimated stock and capital consumption is... partly dependent upon the rate at which new capital formation is taking place (i.e. the rate at which the capital stock itself is changing)". If capital formation were constant so that the capital stock is static, a change of y% in assumed service life would reduce both gross and net capital stocks by y% but would result in no change in capital consumption. This last result is true only for estimates based on straight line depreciation, but in practice this is by far the commonest method used. Using straight line depreciation, capital consumption in a given year (Dt), for an asset with an average service life of (L), depends on capital formation (C) during the period (t-L) to (t),

$$\text{i.e.} \quad D_t = \sum_{i=t-L+1}^{t} \frac{C_i}{L}$$

Clearly, when (C) is a constant, the value of (L) is irrelevant since $D_t = C$. Hibbert et al go on to explain that "with increasing capital stock over time, a given percentage reduction in assumed life lengths leads to a relatively smaller percentage change in estimated stock and some increase in capital consumption...because capital consumption now represents a greater using up of more recently acquired assets."

B. CHANGES IN SERVICE LIVES OVER TIME

46. The United Kingdom Central Statistical Office has made some sensitivity studies to gauge the effect on their capital stock and consumption statistics of assuming that service lives have been falling. The results - for the industry group chemical and allied products - are given in Table 9 below.

Table 9. Effect on capital stock and capital consumption estimates of assuming declining average service life: plant and machinery in chemical and allied products industries in the United Kingdom

(Per cent reduction (-) or increase (+) in the estimates for 1973)

Assumption	Gross capital stock	Net capital stock	Consumption of fixed capital
Service lives fall from 37 to 30 years between 1947 and 1973	-2.7	-8.9	+19.5
Service lives fall from 37 to 22 years between 1947 and 1973	-6.5	-19.2	+43.7

Source: Hibbert et al (24).

47. Table 9 suggests that, if service lives really are falling, the failure to reduce assumed service lives will introduce substantial errors into the estimates of consumption of fixed capital and net capital stock, and smaller - though not insignificant - errors into the gross stock calculations.

C. CHOICE OF MORTALITY FUNCTION

48. Table 10 shows the effect of using different mortality functions on the estimates of gross and net capital stocks and consumption of fixed capital. The data for Canada are taken from Koumanakos (28), and the data for Australia from Current Cost and Constant Cost Depreciation and Net Capital Stock (11). The bell-shaped function used in Canada is a quadratic approximation to the normal distribution with retirements distributed over the period from installation to twice the average service life: the truncated bell-shaped function is again based on a (quadratic) normal distribution but with the tails cut off at 50% and 150% of the average life.

49. Although the table is confined to current cost data for a single year (1976) and a single industry (manufacturing) the main conclusions that emerge from the table generally apply to the whole period for which data are available, to other industry groups, and to data compiled at constant prices. These conclusions may be summarized as follows:

(a) For gross capital stock, simultaneous exit gives the highest estimate, but one that is only about 5% higher than that obtained using bell-shaped mortality functions. The linear function produces an estimate that is lower again by about a further 5%.

(b) For <u>net capital stock</u>, bell-shaped mortality functions produce the highest estimates, while estimates based on simultaneous exit are substantially (20-25%) lower.

(c) For <u>consumption of fixed capital</u> simultaneous exit again produces a higher figure while the bell-shaped functions give estimates around 20-25% lower.

50. In summary, it appears that gross capital stock estimates are relatively insensitive to the mortality function used, but that for both the net stock and capital consumption rather different results can be expected depending on whether simultaneous exit or bell-shaped functions are selected. It should be noted that these results are due to the fact that the capital stocks of Canada and Australia are growing. While this is true at an <u>aggregative level</u> for almost all OECD countries, in some countries there may be certain industries where capital stocks are declining. For these industries one would, <u>a priori</u>, expect the converse of the findings (a) to (c) above.

<u>Table 10.</u> <u>Effect on capital stock and capital consumption estimates of using alternative mortality functions: manufacturing in Canada and Australia, 1976</u>
(Current replacement cost: $ million)

Country	Type of distribution	Gross capital stock	Net capital stock	Consumption of fixed capital
	A. <u>All assets</u>			
Canada	Linear	83531	66377	3267
	Bell-shaped	88493	71628	3029
	Truncated bell-shaped	89784	67555	3221
	Simultaneous exit	92620	56572	3712
Australia	Bell-shaped (Winfrey)	..	..	1762
	Simultaneous exit	..	..	1774
	B. <u>Machinery and Equipment</u>			
Canada	Linear	48631	38375	2002
	Bell-shaped	51783	41514	1866
	Truncated bell-shaped	52733	39077	1997
	Simultaneous exit	54835	32279	2337
Australia	Bell-shaped (Winfrey)	..	..	1438
	Simultaneous exit	..	..	1463

APPENDIX 1. ESTIMATING THE AVERAGE SERVICE LIFE AND AGE OF A GROUP OF ASSETS

1. For several kinds of economic analysis - cross-country comparisons of productivity or potential output, for example - it is important to have some idea of the relative efficiency of a stock of assets in different countries. An obvious indicator to use for this purpose is the average age of each country's capital stock. This appendix shows how the kind of statistics commonly published on capital stocks and flows can be used first to estimate the average service life of a group of assets, and then to convert this into an estimate of the average age. Of course, both the service lives and ages so obtained merely reflect the service life assumptions underlying the capital stock estimates; the advantage of the procedures described here is that they provide simple means of averaging assumed service lives and ages over a group of assets.

A. AVERAGE SERVICE LIFE OF A GROUP OF ASSETS

2. For a group of assets - e.g. "machinery and equipment in manufacturing", or "all assets in industry" - the ratio of the gross capital stock in a given year to the consumption of fixed capital in the same year gives an average of the service lives of the assets in that group. This can be demonstrated as follows:

3. Assume that:
   (i) all gross fixed capital formation takes place on the first day of each year;
   (ii) consumption of fixed capital is estimated by the straight-line method;
   (iii) service lives do not change from year to year;
   and (iv) all assets of a given type are retired on reaching their average service life (i.e. simultaneous exit).

4. Let: G_t = gross capital stock at the end of year t
   D_t = consumption of fixed capital during year t
   C^i_y = gross capital formation in asset type i in year y
   and L^i = service life of asset type i.

5. If there is only one type of asset in the stock:

$$G_t = C_{t-L+1} + C_{t-L+2} + \ldots + C_t = \sum_{y=t-L+1}^{t} C_y \quad \ldots\ldots\ldots\ldots (1)$$

$$D_t = \frac{C_{t-L+1}}{L} + \frac{C_{t-L+2}}{L} + \ldots + \frac{C_t}{L} = \frac{1}{L}\sum_{y=t-L+1}^{t} C_y \quad \ldots\ldots. (2)$$

If there are k types of assets in the group:

$$G_t = \sum_{i}^{k} \sum_{y=t-L^i+1}^{t} C_y^i \qquad (4)$$

$$D_t^m = \sum_{i}^{k} \frac{1}{L^i} \sum_{y=t-L^i+1}^{t} C_y^i \qquad (5)$$

and the ratio G_t/D_t is seen to be a harmonic mean of L^i - the service lives of the k asset types - weighted by the stock of each type of asset.

6. Four assumptions were made in paragraph 3. The first is merely for presentational convenience. If it is assumed that capital formation takes place evenly over the year, awkward adjustment terms are introduced into the equations but the final result does not change. The second assumption - straight-line depreciation - is true for all countries except Japan, Sweden, and Italy. The third assumption - constant service lives - was shown in Section II above to be valid for all countries except Germany. The fourth assumption - simultaneous exit - appears more troublesome since it was noted in Section III that most countries do, in fact, use other mortality functions. It can, however, be shown that the Gt/Dt ratio is a weighted harmonic mean for a group of asset lives <u>regardless</u> of the kind of mortality function used.(*)

(*) The author is indebted to the Australian Bureau of Statistics for noting this point in their comments on an earlier draft of this paper. A formal proof of this proposition may be obtained on request to the author.

B. AVERAGE AGE OF A GROUP OF ASSETS

8. The relationship between average service lives and average ages is relatively straightforward. If a population is stable because additions (births or gross capital formation) equal losses (deaths or scrappings), the average age of the population is the mid-point of the average service life (L), i.e. average age = $\frac{L + 1}{2}$.

9. In general, of course, stocks of assets are not static; usually they are growing, although certain types of assets in certain industries may be declining. In principle, changes in an asset stock may occur either because capital formation changes from year to year, or because of changes in average service lives. However, it was noted earlier that, in practice, asset lives are almost always assumed to be constant, so that here we need only consider the effect of changes in capital formation. To simplify matters, it is assumed that gross fixed capital formation grows at the same rate each year, and that all capital formation takes place on the first day of the year.

10. Let A = average age of a group of assets at the end of a given year,

C = gross fixed capital formation in that year,

r = annual rate of increase (+ or -) in gross fixed capital formation over the previous L years,

L = average service life of the group of assets, calculated by the G_t/D_t ratio discussed above.

11. An arithmetic average of the ages 1 to L weighted by the assets in each age group can then be written as:

$$A_t = \frac{\sum_{t=1}^{L} tC(1+r)^{-(t-1)}}{\sum_{t=1}^{L} C\ (1+r)^{-(t-1)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

12. Since C is a constant, it disappears from (1) and A_t needs to be solved only for different average service lives L, and for rates of growth in capital formation, r. Table B gives the average ages implied by various plausible service lives and annual rates of growth (+ or -) in capital formation.

13. Table B can be used to identify the circumstances in which average ages differ significantly from the mid-points of average service lives, given by the "no growth" line in the table. The differences are negligible for value of L up to 10 years, even when capital formation is growing or declining by 5% per year, but they are quite large when L exceeds 40 years, even when gross capital formation is growing at an average of only 2% per year. Often it will only be worth using equation (1) to calculate the average age of an asset group for values of L and r represented by the shaded area in Table B. In other cases the mid-point of the average service life may provide an adequate approximation to the average age.

Table A. Average ages of asset groups corresponding to average service lives and annual growth rates of gross fixed capital formation

Annual Rate of growth of gfcf during the last L years	Average service life (L) of stock of assets in years							
	5	10	15	20	25	30	40	50
+ 5%	2.9	5.1	7.1	8.9	10.5	12.0	14.4	16.2
+ 4%	2.9	5.2	7.3	9.2	11.0	12.6	15.5	17.8
+ 3%	2.9	5.3	7.5	9.5	11.5	13.3	16.7	19.6
+ 2%	3.0	5.3	7.6	9.8	12.0	14.0	17.9	21.4
+ 1%	3.0	5.4	7.8	10.2	12.5	14.8	19.2	23.4
no growth	3.0	5.5	8.0	10.5	13.0	15.5	20.5	25.5
- 1%	3.0	5.6	8.2	10.8	13.5	16.3	21.8	27.6
- 2%	3.0	5.7	8.4	11.2	14.1	17.0	23.2	29.6
- 3%	3.1	5.7	8.6	11.5	14.6	17.7	24.5	31.6
- 4%	3.1	5.8	8.8	11.8	15.1	18.5	25.7	33.5
- 5%	3.1	5.9	8.9	12.2	15.6	19.2	26.9	35.2

APPENDIX 2. LIST OF PUBLICATIONS DEALING WITH METHODS OF ESTIMATING CAPITAL STOCKS

(* Indicates that information is given on service lives of assets)

*1. Atkinson, Margaret and Mairesse, Jacques: "Length of life of equipment in French manufacturing industries", in Annales de l'INSEE, No.30-31/1978, INSEE, Paris, 1978.

*2. Barna, Tibor, "On Measuring Capital", in The Theory of Capital by F.A. Lutz and D.C. Hague, MacMillan and Co. Ltd., New York, 1961.

3. Baumgart, E.R. and Krengel, R.:"Die industrielle Vermörgensrechnung des DIW", in Beitrage zur Strukturforschung, Heft 10, DIW, Berlin, 1970.

*4. "Das Brutto-Sachanlagevermögen der Osterreichischen Industrie 1955 bis 1973", in Monatsberichte 10, Vienna, 1975.

*5. "Das Brutto-Sachanlagevermögen der Osterreichischen Industrie - Einige Kennzahlen zur Entwicklung und Struktur seit 1955", in Monatsberichte 2, Vienna, 1978.

*6. Bulletin F (Revised January 1942). Income Tax, Depreciation and Obsolescence, Estimated Useful Lives and Depreciation Rates, U.S. Treasury Department, Bureau of Internal Revenue, Washington, 1942.

7. Campbell, Colin: Capacity Capital Formation in New Zealand Manufacturing Industries, 1952-1973, Occasional Paper No.31, Victoria University of Wellington, Wellington, 1977.

8. Campbell, Colin: The Stock of Fixed Capital in New Zealand Manufacturing Industries, 1950-51/1972-73, Occasional Paper No.32, Victoria University of Wellington, Wellington, 1977.

*9. "Capitale Fisso Riproducible delle Attivita Industriali, Anni 1951-1972", Note e Relazioni, Marzo 1975, Istituto Centrale di Statistica, Rome.

*10. Cederblad, C.O.: Realkapital och anskrivning, National Central Bureau of Statistics, Stockholm.

*11. Current Cost and Constant-Cost Depreciation and Net Capital Stock, Occasional Paper, Studies in National Accounting, Australian Bureau of Statistics, Canberra, 1981.

*12. Dean, Geoffrey: "The Stock of Fixed Capital in the United Kingdom in 1961", in Journal of the Royal Statistical Society, Series A (General), Volume 127, Part 3, 1964.

13. Feinstein, C.H.: Domestic Capital Formation in the United Kingdom, 1920-38, Cambridge University Press, 1965.

*14. Fixed capital flows and stocks, 1926-1978, Catalogue 13-568 Occasional, Statistics Canada, Ottawa, 1978.

*15. Fixed capital flows and stocks, 1972-79, Catalogue 13-211, Annual, Statistics Canada, Ottawa, 1979 (annually thereafter).

*16. Fixed Non-residential Business and Residential Capital in the United States, 1925-75, Bureau of Economic Analysis, U.S. Department of Commerce (National Technical Information Service), Reference PB-253-725, Washington D.C., 1976.

17. Goldsmith, Raymond W.: "A Perpetual Inventory of National Wealth", in Studies in Income and Wealth, Volume 14, Conference of Income and Wealth, National Bureau of Economic Research, New York, 1951.

18. Goldsmith, Raymond and Saunders, Christopher (Editors): "The Measurement of National Wealth", Income and Wealth Series VIII, Bowes and Bowes, London, 1959.

19. Görzig, B.: "Results of a Vintage-Capital Model for the Federal Republic of Germany", in Empirical Economics, Vol. I, Issue 3, Physica-Verlag, Vienna, 1974.

20. Görzig, B. and Kirner, W.: "Anlagein vestitionen und Anlagevermörgen in den Wirtschaftsbereichen der Bundesrepublik Deutschland", in Beiträge zur Strukturforschung, Heft 41, DIW, Berlin, 1976.

21. Görzig, B., Kirner, W., Kohues, M., Noack, G., Schmidt, M.: Daten zur Entwicklung des Produktionspotentials, des Einsatzes von Arbeitskräften und Anlagevermögen sowie der Einkommen-sverteilung in den Wirtschaftsbereichen der Bundesrepublik Deutschland, 1950-1975, DIW, Berlin, 1977.

22. Griffin, Tom: "Revised estimates of the consumption and stock of fixed capital", in Economic Trends, Central Statistical Office, London, October 1975.

*23. Griffin, Tom: "The stock of fixed assets in the United Kingdom: How to make best use of the statistics", in Economic Trends, Central Statistical Office, London, October 1976.

*24. Hibbert, J., Griffin, T.J. and Walker, R.L.: "Development of Estimates of the Stock of Fixed Capital in the United Kingdom", in The Review of Income and Wealth, June, 1977.

*25. Hourigan, Margaret A.: Estimation of an Australian Capital Stock Matrix for the Impact Projects, Working Paper No. I-11, Impact Project Research Centre, Melbourne, 1980.

*26. Kansantalouden tilinpito, Tutkimuksia N:058 Studies, Central Statistical Office of Finland, Helsinki, 1980.

*27. Kirner, Wolfgang: "Zeitreihen für das Anlagevermögen der Wirtschaftsbereiche in der Bundesrepublik Deutschland", in Beiträge zur Strukturforschung, Heft 5, DIW, Berlin, 1968.

*28. Koumanakos, P.: Alternative Estimates of Non-residential Capital in Canada, 1926-1980, Statistics Canada, Ottawa, 1980.

*29. Lützel, Heinrich, "Estimates of Capital Stocks by Industries in the Federal Republic of Germany", in The Review of Income and Wealth, March 1977.

*30. Mairesse, Jacques: L'évaluation du capital fixe productif: Méthodes et résultats, Les collections de L'INSEE, C18-19, Institut National de la Statistique et des Etudes Economiques, Paris, 1972.

31. Musgrave, John C.: "Fixed Non-residential Business and Residential Capital in the United States, 1925-1975", in Survey of Current Business, April 1976, Department of Commerce, Washington.

*32. 1970 National Wealth Survey of Japan, Vol. I, Summary Report, Economic Planning Agency, Tokyo.

33. Non-residential Business Capital Stock in Japan, 1965-1978, Economic Planning Agency, Tokyo, 1979. (Only available in Japanese.)

34. Non-residential Business Capital Stock in Japan: Concepts and Methodology, Economic Research Institute, Economic Planning Agency, Tokyo, 1980.

35. Philpott, Bryan: Provisional Estimates of Sectoral Real Gross Investment and Capital Stock in New Zealand, 1950-77, Internal Paper No.69, Victoria University of Wellington, Wellington, 1979.

36. Sectoral Real Gross Investment and Capital Stock in 1971/72 Prices, Internal Paper No.72, Victoria University of Wellington, Wellington, 1979.

37. A System of National Accounts in Japan (Definitions - Concepts - Sources - Methods), Economic Planning Agency, Tokyo, 1980.

38. Tarasofsky, A., Roseman, T.G. and Waslander, H.E.: Ex Post Aggregate Real Rates of Return in Canada, 1947-76. A study prepared for the Economic Council of Canada, Ottawa, 1982.

*39. Tengblad, Ake and Westerlund, Nana: "Capital Stock and Capital Consumption Estimates by Industries in the Swedish National Accounts", in The Review of Income and Wealth, December 1976.

*40. Ward, Michael, The Measurement of Capital, OECD, Paris 1976.

*41. Winfrey, Robley: Statistical Analyses of Industrial Property Retirements, Bulletin 125, Iowa Engineering Experiment Station, Iowa State College, 1935.

42. Wirtschaft und Statistik, Issues Nos. 10/1971, 11/1972 4/1976, 6/1979, Statistisches Bundesamt, Wiesbaden.

43. Bacon, R.W. and W.A. Eltis, The Age of U.S. and U.K. Machinery, NEDO Monograph 3, London, 1974.