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Measuring Capital
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Chapter 4

Asset Retirement and the Gross Capital Stock

To this point, only a single asset has been considered. This is unrealistic because in practice, data exists only on classes and cohorts of assets. A *class* of assets brings together similar assets, for example in line with a product classification. A *cohort* of assets exists when many units of the same asset are invested during a particular accounting period. Even when identical assets are purchased at the same point in time, it is unlikely that they are all retired at the same moment.

4.1. Gross capital stock

The stock of assets surviving from past investment and re-valued at the purchasers prices of new capital goods of a reference period is called the *gross capital stock*. The gross capital stock is called gross because it has traditionally been thought of as the value of assets before deducting consumption of fixed capital. Thus, the gross capital stock ignores decay of assets and considers past investments "as new" – only retirement is taken into account.

Apart from being the conventional starting point for calculating consumption of fixed capital and the net capital stock, the gross capital stock has been regularly used in analysis. Closer inspection of its analytical application shows, however, that it has been used as a proxy for the productive capital stock (see below) rather than in its own conceptual right. For example, the gross capital stock has been widely used as a broad indicator of the *productive capacity* of a country, or it has been compared with value added to calculate *capital-output ratios*; finally, the gross capital stock has sometimes been used as a measure of *capital input* in studies of multifactor productivity. One of the first OECD publications on the matter (Ward 1976), proposes an efficiency-adjusted gross capital stock which is equivalent in concept to the productive capital stock.

Only in the special case where all assets keep their full productive efficiency until they disintegrate ("one-hoss-shay" pattern) would the gross capital stock provide an indication of the importance of capital in production. There are a number of assets that conceivably show such a pattern: certain buildings may be part of the category, and structures such as parking lots or warehouses. Even this observation must be qualified, however, in the sense that it only holds for a single type of asset. Further, when gross stocks of different types of assets are aggregated to yield an industry-wide or economy-wide gross stock, aggregation proceeds with weights that reflect "as new" market prices. This constitutes a fundamental difference to the aggregation procedure employed for the productive stock and for capital services which is based on a different set of weights, reflecting the user costs of capital.

4.2. Retirement profile and asset lives

The gross capital stock can be estimated in several ways. By far the commonest is the perpetual inventory method which involves accumulating past capital formation and deducting the value of assets that have reached the end of their service lives. To this end, a retirement or mortality profile is required to model the retirement process of a cohort

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Box 4.1. **Valuing capital stocks**

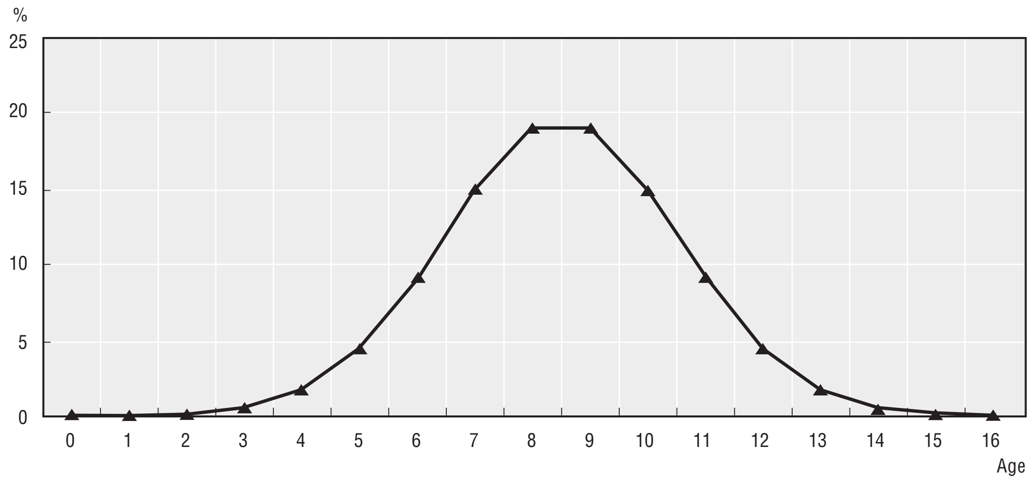
Assets can be valued at two kinds of prices:

- **Historic prices**, which means that the assets are valued at the prices at which the assets were originally acquired. Historic valuation implies that different vintages cannot be aggregated because each is on a different price basis. Valuation at historic prices is the usual procedure in company accounts. This is done because historic prices can be objectively verified by examining the invoices relating to asset purchases. Commercial accountants may also prefer historic prices because they tend to give a conservative valuation of assets. These advantages, however, are offset by the fact that assets which have been acquired at different dates are being valued at different prices so that when prices are rising/falling assets acquired more recently are implicitly given a higher/lower weight than those acquired in earlier periods. Capital stocks valued at historic prices cannot be compared with national accounting or other economic statistics that are expressed at prices of a single period.
- **Prices of a reference period**, which means that the assets are valued at the prices of a particular period. Meaningful aggregation of assets of different age to a stock requires that a vector of prices be applied which distinguishes between assets of different age and of different types but which refers to the same period or to the same point in time. The reference period can be any period, either the present accounting period or a past period. Note that the distinction between "current" and "constant" prices is not helpful in the case of stock measures: measures of flows can usefully be expressed at current prices (no deflators required) or at constant prices (deflator required). Stock measures, on the other hand, can never be constructed without price indices. Even when stocks are valued with prices of the current period, it is necessary to re-value to the present period all assets of an earlier vintage. This *Manual* avoids therefore the distinction between "current" and "constant" prices in relation to stocks and will refer to stocks valued at prices of a particular reference period, be it the most recent one or a period in the past. Valuation at prices of the current period is sometimes referred to as valuation at current "replacement" cost, but the qualifier "replacement" raises questions about what exactly is being replaced. For this reason the word "replacement" is not used in this *Manual*.

of assets over time. A key parameter in the retirement profile is the average service life of the cohort. Part II of this *Manual* lists alternative mortality profiles and describes ways how to estimate service lives. For the present purpose of demonstrating the concepts, we shall simply use a normal retirement distribution as shown in Figure 4.1. It depicts the marginal probability of retirement of a cohort of assets, with the highest probability of retirement around eight years of age, the average service life for the example at hand. The area under the retirement distribution sums to 100%, *i.e.* after around 16 years it is almost certain that all assets of the cohort will have retired. Retirement distributions can be truncated to fix a maximum service life, and in the present example this could be set at 16 years.

The retirement function can be expressed in a cumulative way, *i.e.* by adding up the successive retirement probabilities over the service life of the cohort. The result is best explained by looking at Table. It shows a sequence of investment in the same asset class over a period of 16 years. The fifth column represents the probability of survival of assets that were purchased during these 16 years. Note that the probability of survival is just

Figure 4.1. **Example of retirement distribution**



one minus the probability of retirement. Suppose that the current (latest) year is year 16. Then, the survival probability for investment goods purchased in year 16 is one, *i.e.* there is certainty of survival of the first period. There is a probability of approximately 84% that assets which were bought 8 years are still in service. But there is only a 0.6% probability for the 16 year old cohort to be still around. With this survival pattern at hand, the gross capital stock can be computed, based on the perpetual inventory method. The first column in Table shows investment expenditure over the past 16 years, at historical prices. With the capital goods price index (third column), these data are converted into comparable units, valued at prices of year 16 (fourth column). Next, the survival pattern is used to weight past cohorts by their survival probability with the result shown in column six. Upon adding up this last column, one obtains the gross capital stock valued at prices of period 16.

Table 4.1. **Retirement profile and gross capital stock**

Year (t)	Investment at historical prices	Price index (new) capital goods	Investment in prices of year 16	Survival pattern	Investment in prices of year 16, weighted with retirement pattern
1	500	1.000	672.9	0.0060	4.0
2	800	1.020	1055.6	0.0225	23.8
3	1000	1.040	1293.6	0.0666	861
4	600	1.061	760.9	0.1584	120,6
5	500	1.082	621.7	0.3083	191.7
6	700	1.104	853.3	0.4998	426.4
7	750	1.126	896.3	0.6912	619.6
8	900	1.149	1054.5	0.8411	886.9
9	1200	1.172	1378.4	0.9330	1286.0
10	1000	1.195	1126.2	0.9770	1100.3
11	1100	1.219	1214.5	0.9936	1206.7
12	1200	1.243	1298.9	0.9984	1296.9
13	1100	1.268	1167.3	0.9995	1166.8
14	1000	1.294	1040.4	0.9997	1040.1
15	900	1.319	918.0	0.9998	917.8
16	800	1.346	800.0	1.0000	800.0
Gross stock 31/Dec/year 16 at average prices of year 16					11173.6

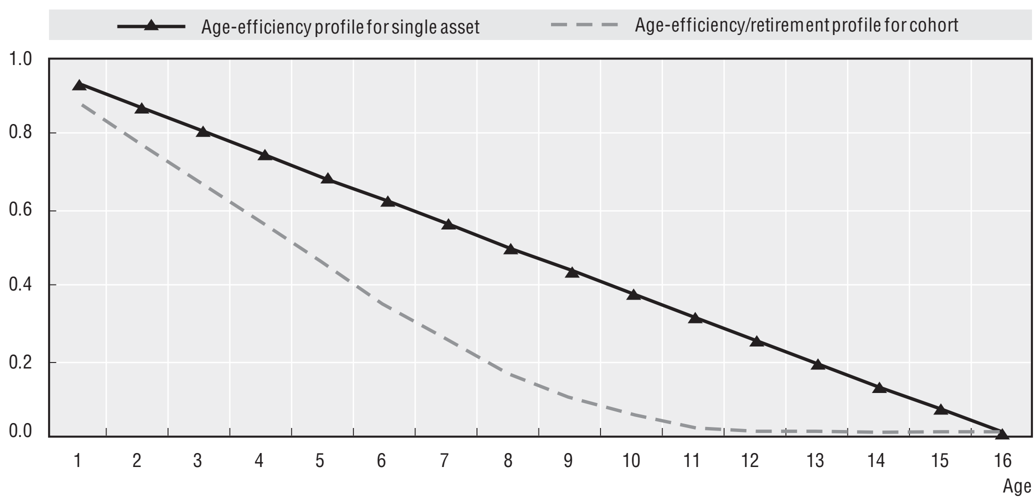
4.3. Combined age-efficiency/retirement profiles

Retirement distributions also have to be taken into account when age-price functions are derived from age-efficiency functions as was shown in section 3.2. It means that the age-price profiles derived there are age-price profiles *conditional on the survival of the asset*. If an age-efficiency profile is constructed for an entire cohort, the retirement distribution has to be taken into account which amounts to constructing a combined age-efficiency/ retirement profile. From this cohort age-efficiency profile a cohort age-price profile can be derived, in line with the methods above. The resulting age-price profile then takes survival probabilities of assets into account. The price of an asset adjusted for the probability of survival will be lower than the price of an asset without such an adjustment, *i.e.* conditional on survival. Alternatively, a retirement profile can be combined with an age-price profile to yield an age-price function for a cohort. From this combined age-price/ retirement profile, the corresponding age-efficiency profile can be derived. Note that in general the two avenues do not yield the same results. This is shown more formally in Annex 4.

If one starts on the age-efficiency side, an age-efficiency/retirement profile for a cohort of assets is computed by attaching a probability weight to different age-efficiency indices. For example, at the end of the first year of service there is a certain probability that some assets will retire. Thus, their age-efficiency profile has been falling extremely rapidly and become zero. There is a second set of assets whose age-efficiency has been falling slightly less rapidly than the first group because they are likely to retire at the end of the second period. Then there is a third group with an expected retirement at the end of the third period and with a corresponding age-efficiency profile and so on. For every point in the maximum service life of the cohort, a combined age-efficiency/retirement profile is computed by weighting each age-efficiency profile by its retirement probability as given by the retirement distribution. For a full exposition see Sections 13.2, 13.3 and Annex 4 of this *Manual*.

Even when depreciation profiles for a single asset are linear, depreciation profiles for an entire cohort turn out to be of convex shape. Reasoning in terms of a single asset is thus not a good guide to the depreciation profile of a whole cohort.

Figure 4.2. **Age-efficiency profile for single asset and for cohort of assets**



A central point is that this procedure implies that the age-efficiency profile for the cohort *as a whole* is different from the age-efficiency profile of an individual asset. Figure shows this difference for the linear age-efficiency function used in the numerical example in this chapter and for a lognormal retirement function. Despite the fact that the profile for an individual asset is linear, the age-efficiency/retirement profile for the cohort as a whole is convex. The conclusion is that a geometric age-efficiency/retirement profile may be a good approximation for a family of age-efficiency/retirement profiles for entire cohorts. As geometric efficiency and depreciation patterns immensely facilitate computational procedures for capital stocks and capital services, this is an important practical consideration.

For the remaining discussion in Part I of this *Manual*, the distinction between age-efficiency profiles for a single asset and for an entire cohort of assets will be maintained, in particular for the discussion of depreciation and the net stock.

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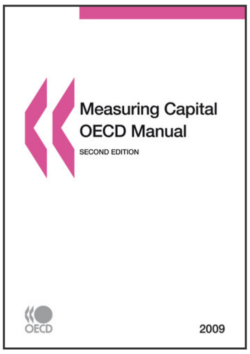

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