

Methodology – Estimates of the Capital Stock of Fixed Assets

The Estimates of the Capital Stock of Fixed Assets are the estimates produced by the Central Statistics Office (CSO) of the stock of fixed assets in Ireland. Estimates are provided of the stock of assets in existence at the end of each year from 1985. The estimates are prepared in compliance with ESA regulation 549/2013 on National Accounts.

Fixed Assets

The assets covered in these tables relate to *Produced Fixed Assets* as defined in the European System of Accounts (ESA 2010). Produced fixed assets are assets which result from human effort. They exclude natural assets such as land, mineral deposits etc. Produced fixed assets comprise

- Dwellings and other buildings and structures (excluding the land on which they are built)
- Machinery and equipment (including transport equipment)
- Cultivated assets (e.g. Livestock for breeding such as dairy cattle etc.)
- Intangible fixed assets (Research and development, Computer software, Original works of art including musical and literary works, Mineral exploration).

Gross / Net

The two most common valuation methods for fixed capital assets are *Gross* and *Net*. The gross capital stock represents the value of the stock still in use (i.e. not retired or scrapped) and valued at the price of new capital goods. The term *Gross* means gross of consumption of fixed capital (the national accounts term for *depreciation*). Thus the gross stock of assets ignores decay of assets and considers past investments as new – only retirement is taken into account. In practice fixed assets normally decline in value over time due to factors such as wear and tear and obsolescence. Taking this declining value into account together with retirements give rise to the *Net* value of the stock of assets. Estimates are provided in this report using both valuation concepts.

Current and Constant prices

The stock of assets is generally valued in current and constant prices. Valuation in current prices implies that all the assets accumulated over the years are valued at the prices obtaining in the year for which the estimates are given. In the case of the *gross* stock this is the price of new assets. In the case of the *net* stock it is the written down price of assets. Valuation at constant prices represents the stock of capital assets in the price of the stated reference year.

Methodology

There is no readily available source for the value of the stock of assets as defined above for statistical purposes. In company accounts assets are generally priced at historical prices i.e. at the prices obtaining in the years in which they were purchased. Thus the resulting accumulated stock is a sum of values in prices obtaining in different years. This situation has led to countries developing their statistical estimates of the stock of assets by a modelling exercise, referred to as the **Perpetual Inventory Method (PIM)**. Around the time the CSO embarked on this exercise the OECD had recently examined the best methodologies in its member countries and with the expertise and research of its statistical directorate had compiled a manual on the compilation of capital stock and related productivity measurement viz. *Measuring Capital, October 2007, OECD*. The guidelines in this manual were followed in compiling the estimates in this report and the manual proved invaluable as a guide in producing the CSO's first estimates of capital stocks.

Perpetual inventory method (PIM)

The perpetual inventory method accumulates past investments to form the stock of assets. Estimates of capital stocks are made within the national accounts framework. Consequently the estimates of gross fixed capital formation which were used in the compilation of GDP form the historical series of investments.

The **Gross** stock of assets can be expressed as follows

$$\text{Gross stock at time } t = \sum_{j=0}^L GFCF_{t-j} g_j$$

Where

$GFCF_{t-j}$ = the gross fixed capital formation in year $t-j$

g_j = the proportion of the gross fixed capital formation still in use after j years

L = twice the average lifetime of the fixed asset

The part of gross fixed capital formation which is still in use after j years (g_j) is calculated using mortality/survival functions. Various density functions are used to estimate mortality functions. Bell shaped distributions are recommended. In Ireland the log normal density function was chosen. It is highly recommended in the OECD manual (chapters 249 and 250) and is used in capital stock measurement in other member states of the EU. It is a left skewed distribution and the right hand tail of the distribution approaches but never reaches zero and must be arbitrarily set to zero when the probabilities become small. Some further details on the log normal distribution follow.

The log normal distribution is the distribution of a random variable whose logarithm is normal. If X is a variable with a normal distribution then $Y = \exp(X)$ has a lognormal distribution. Likewise if Y is log normally distributed then $\log(Y)$ is normally distributed. The probability distribution of the log normal function is expressed as follows.

$$f_X(x; \mu, \sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln x - \mu)^2}{2\sigma^2}}, \quad x > 0$$

where μ and σ are the mean and standard deviation of the variable's natural logarithm.

The relationship between μ and σ and the mean and standard deviation of the lognormal distribution is given below

$$\sigma = \sqrt{\ln\left(1 + \frac{1}{\left(\frac{m}{s}\right)^2}\right)}$$
$$\mu = \ln(m) - \frac{1}{2}\sigma^2$$

m is the estimated average lifetime of the fixed asset and the mean of the lognormal distribution.

s (where s^2 is the variance of the lognormal distribution) controls the flatness of the distribution curve and is generally a value between $m/2$ and $m/4$ in the context of mortality functions. The value $m/3$ was used for all types of fixed assets in Ireland with the exception of dwellings and public administration offices. In those cases a value of $m/1.5$ was assigned to s which maintained consistency with the series of net capital assets described below.

The **Net** stock of assets is calculated using geometric depreciation as highly recommended in the OECD manual (e.g. paragraphs 7, 181 etc.). Accordingly if I^t is the investment in year t in a particular asset group then the net stock of assets at the end of period t (W^{tE}) can be expressed as follows

$$W^{tE} = \left(1 - \frac{\delta}{2}\right) [I^t + (1 - \delta)I^{t-1} + (1 - \delta)^2 I^{t-2} \dots \dots \dots]$$

where δ is the annual rate of depreciation (or consumption of fixed capital) for the category of investment good in question. It is assumed that investment takes place throughout the year and that by the end of the year depreciation for a half of a year is appropriate for the year in which the investment was made. Hence the term $(1 - \delta/2)$ is the first term in the formula. The rate of depreciation has generally been assumed to be $2/m$ where m is the average life of the asset (in years). In other words double declining geometric depreciation has been used. An exception to this general rule has been made in the case of dwellings and public administration office buildings due to the extended life of some dwellings, a minority of which can be in existence for over two hundred years. In the cases of dwellings and public administration office buildings a declining geometric depreciation at a rate of 1.3 divided by the average lifetime of these assets was used.

Re pricing of investments

It can be seen from the above that the PIM involves accumulating assets acquired over a number of years. For the resultant total to be meaningful all of the assets have to be valued in the prices of a common year. The stock of assets is generally presented for a number of years as a series. They are shown in current or constant prices. The series in current prices shows for each year the value of the stocks at the end of each year priced in the average prices of the year in question. The series in constant prices shows for each year the stock at the end of each year valued at the prices of the reference year. In this latter case any change in the level of the series from year to year is not affected by changes in the prices of the assets.

Availability of investment series

In general investment series were available for a long enough period to enable the stock of assets in each category to be built up from the series of investments in the preceding years. The main exceptions to this where the historical series were not available for a sufficiently long period were

- Dwellings
- Roads
- Buildings
- Rail transport equipment
- Aircraft

These assets have particularly long lives which make consequential demands for correspondingly long historical series of investments. A solution was found for each of the above categories of assets. In the case of dwellings the stock in the year 1949 was taken from the ESRI's estimate for the years 1950 to 1984 as published in 1989. This stock of dwellings (i.e. the stock in existence up and including 1949) was then updated in value allowing for depreciation, retirements and change in value. The standard methods of using the log normal function for retirements and geometric depreciation were used for this purpose. Alongside this exercise dwellings built since 1950 were dealt with similarly to other assets in the new series (i.e. GFCF in dwellings was taken from the national accounts, depreciated using geometric depreciation and retired using log normal retirement functions). Results of the exercise show that in 2008, the earlier stock dating back to 1950 and former years only represents about 6% of the total stock of dwellings so that its importance in the overall estimate is fairly limited. [It should of course be understood here that the stock of dwellings being measured only

includes the buildings themselves and takes no account of the site or property on which they are built.]

A similar approach was adopted in the case of roads. Roads built prior to 1950 or previous years were valued from the ESRI survey. They were updated for depreciation and change in values in the usual way. The stock of roads which were built post 1949 were evaluated using annual data on GFCF in roads, the perpetual inventory method, geometric depreciation etc. Here again the pace of road building in the last fifty years, similar to construction of houses, has been so rapid that the stock of roads built prior to 1950 only accounts in 2008 for about 11% of the total road stock in the country.

This general approach of using data in the ESRI report for stocks in existence prior to 1950 while accumulating the stock of assets built since 1950 using GFCF data was adopted for building and construction work in the following sectors:

- Offices
- Commercial buildings
- Hospitals and buildings for special care
- Communications
- Religion
- Education
- Amusement and recreational activities

In other sectors which were controlled by monopolies at the time it was possible to obtain historical data from the enterprises involved. An example of this is CIE who provided data on investment in rolling stock. We take this opportunity to express our thanks to these organisations for the help they gave us in providing historical data to make the estimation procedure possible.

Availability of price indices

Reference was made in an earlier paragraph to the need to reprice the assets in order that assets accumulated over a number of years can be summed in value in a meaningful way. The repricing is done by means of suitable price indices. For some of the asset categories (e.g. cars, machinery and equipment) distinguished in this report price indices are readily available in the CSO's wholesale price index series. However for others it is not so straightforward and substitutes had to be used where exact indices were not available. For example, the WPI for transportable capital had to be used in years prior to 1975 for commercial vehicles as a specific price index for commercial vehicles was not available in the early years.

In the case of housing and building, official price indices do not exist. However deflators have been available for national accounts purposes from the Department of Environment for the purposes of bringing the GFCF to constant prices and these have been used in this exercise on the stock of assets.

NACE Sectors

Results are provided in this report by NACE Rev 2 sector. These are effectively the sectors of use in the sense that machinery hired out to a particular sector is assigned to the company which uses the machines rather than to the company which hires them out (e.g. machinery hired from a finance company to the construction industry will be assigned to the construction sector).

The allocation of stocks to NACE sector is achieved through the allocation of GFCF each year in the PIM model. The CSO has used the information available to it to achieve a reasonable allocation between sectors. However sufficient data does not exist to determine an absolutely precise allocation.

In the case of building and construction items a sectoral breakdown is provided for GFCF in the Department of Environment's "Review and Outlook in the Construction Sector". The sectoral breakdown reflects sector of use rather than sector of ownership. A consequence of this is that these tables do not accurately reflect ownership by property developers (for example) of buildings which are let to businesses in other sectors. Machinery and Equipment items are largely allocated to sectors based on the detailed description of the items in the trade and prodcom statistics. Data on capital investment in the CSO structural business surveys (e.g. the Census of Industrial Production and the Annual Services inquiries) have also been used in determining the allocation of investment items. Company reports and accounts have been used in other cases. However the final allocations to the various sectors must be looked on as the best possible in the circumstances and do not necessarily result in definitive and absolutely precise series.

Consumption of Fixed capital

Consumption of fixed capital (also known as depreciation of fixed assets) automatically becomes available as a by-product of the calculation of the stock of fixed assets in net and gross terms. This enables the transformation to be made for the main national accounts aggregates from gross to net terms e.g. Gross Domestic Product to Net Domestic Product, Gross National Income to Net National Income. Estimates of the consumption of fixed capital are provided in this report in current and constant terms.