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## **Fixed Capital Flows and Stocks, Historical**

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# Fixed Capital Flows and Stocks, Historical

## METHODOLOGY

### New Estimates of Service Lives

Starting with the 1985 Actual Survey of Capital and Repair Expenditures, questions were asked about the expected service life of assets acquired during the year. In most cases, the new estimates of service lives were shorter than the old ones and much closer to the average service lives used in other OECD countries. The assumption made in introducing the new lives was that service lives have been gradually declining as of some date in the past when the old lives were applicable, to their present new values. Thus a major change has been the abandonment of the assumption of constant service lives.

A 1987 benchmark total of the value of fixed assets was arrived at by supplementing values of stocks of fixed assets reported on the survey with those appearing on administrative records (tax data) in order to complete the survey coverage. This benchmark was used to infer lives in order to assess the overall reliability of the new life patterns selected. On average, the assumed service lives resembled the actual lives of company assets.

The new capital stock series were calculated using the new estimates of service lives just described. It was decided to introduce the new service life estimates in the following way: new surveyed lives starting in 1987; geometric interpolation over the years prior to 1987. This pattern of introduction of the new lives was adopted because it gave results which most closely approximated reported benchmark values of fixed assets and it appeared to be the most neutral assumption, given the limited amount of related information.

### Discard Pattern

To take into account that similar assets are discarded at different ages, a bell-shaped distribution of discards was adopted instead of the simultaneous exit method used previously.

The main difference between the two methods is that the bell-shaped function produces a smoother growth pattern. With the simultaneous exit discard function, all assets of a given vintage are retained in the capital stock for their full service life ( $L$  years), and then discarded. This characteristic, known as the "echo effect", is reduced by the bell-shaped discard function, since assets are discarded at various ages. Some assets are discarded soon after their addition to the capital stock and well before  $L$  years have elapsed. This means that, in general, when real capital formation is growing, the bell-shaped function will produce lower estimates of capital stock than the simultaneous exit function. Conversely, when real capital formation is falling, the bell-shaped function will produce higher estimates because some older assets will be retained in the capital stock for more than  $L$  years.

Beginning with the new measures introduced in 1990, a bell-shaped discard function was assumed. More precisely, the distribution adopted is a truncated bell-shaped (normal) distribution with discards distributed between 50% and 150% of the average service life. This change in discard patterns gave levels and annual growth rates in the new capital stock estimates similar to those in the old estimates. Annual growth rates are less volatile

using a normal distribution.

## **Depreciation**

The pattern of depreciation of fixed assets has constantly been a research topic for economists and decision makers since Jorgenson and his collaborators made extensive use of the single geometric rate economic depreciation hypothesis. Whereas discard functions assume that the efficiency of the capital assets remains the same over its entire service life, depreciation functions are formulated to take into account that efficiency declines over the service life of an asset.

There are two types of depreciation, namely physical and economic depreciation. Physical depreciation refers to the loss in total life-time productive capacity of a physical asset due to two causes, the passage of time, and falling efficiency, that is, falling productive capacity per unit of time. Economic depreciation is a measure of the asset's loss in monetary value due to age at a particular date, that is, economic depreciation is the price concept corresponding to the quantity concept of physical depreciation. In one special case - geometric depreciation - physical and economic depreciation are congruent. This means that if economic depreciation is known to be geometric, then it can be inferred that physical depreciation is geometric as well (and vice versa). This unique feature of geometric depreciation lends it additional importance. If both the physical and economic depreciation patterns and the service life of an asset could be determined, the gross and net capital stocks could be estimated by the well known perpetual inventory method.

The economic depreciation pattern has been considered one of the most important factors in modern macroeconomic and tax policy models, while physical depreciation directly involves the estimate of the rental price of capital which is normally used to calculate the capital share of output.

Economic depreciation has been estimated by some researchers by examining the relationships between the ages and prices of certain types of new and used assets. For example, Ackerman studies used cars as a depreciating asset and found that the prices of used cars decline with age at a constant exponential rate. Hulten and Wykoff applies the Box-Cox power transformation to a sample of used building prices to estimate the rate and form of economic depreciation and found that the appropriate depreciation pattern is approximately geometric.

The following example, often quoted in the literature, is used to illustrate many of these different concepts.

Suppose we consider a single asset, a light bulb, whose cost when new is \$1 and which is expected to burn for 1,000 hours. Normally, a light bulb may be expected to produce the same amount of light per hour until the last hour of its useful life, and hence, after 100 hours of use, no physical depreciation will have taken place. However, only nine tenths of the expected useful life remains and therefore, assuming a discount rate of zero, the bulb's value will be 90 cents -- it has undergone economic depreciation. As the bulb approaches the end of its useful life, this economic depreciation will continue but physical depreciation, defined as the decline in an asset's productive capacity per unit of time, will not occur until that hour when the bulb's productive capacity falls by an amount equal to the quantity of light per hour it has been producing -- i.e. it burns out.

Many types of assets do not maintain their initial productive capacity over the course of

their useful life. Let us suppose, for example, that after 300 hours of use, our light bulb's efficiency in producing light has declined, and the bulb is still burning, but not as brightly as when new. In other words, the amount of light produced per hour has decreased -- physical depreciation has occurred. The value of the bulb is, in this case, less than 70 cents because the economic depreciation reflects not only the decreased useful life (there are 700 hours remaining, or seven tenths), but also the bulb's decreased efficiency.

In order to know the rate of decline in the value of the existing capital goods as they age, not only are good data on average service lives and realistic discard functions required, it is also necessary to derive estimates of depreciation (capital consumption). When calculating net fixed capital formation and net fixed capital stocks, an important decision to be made is the form of depreciation to be used. As explained in the following section, our research in the area of depreciation supports the geometric form. However, it is important to recognize that measures of capital stock are needed for a variety of applications in economic and business analysis and that no single measure is appropriate for all purposes. For this reason, the new measures include estimates of net capital stocks calculated using each of the following three assumptions:

### **Geometric Depreciation**

Using a geometric form of depreciation assumes that productive efficiency declines at a rate which accelerates with time. The geometric form reflects this by attaching a non-zero discount rate to straight-line depreciation. When the future capital services are discounted to the present year, the present value of future capital services in the early years is greater than in the later years. The present value of the capital services declines at a geometric rate since the discount factor is operating exponentially (geometrically) on the future capital services.

The price and age characteristics of used assets that were reported on the revised Capital and Repair Expenditures Survey were used to estimate the form of economic depreciation. It was found that the pattern of depreciation is close to geometric in form for both the manufacturing and non-manufacturing sectors, although the degree of convexity is more pronounced in manufacturing.

### **Straight-line Depreciation**

Straight-line depreciation assumes that an asset's value declines in a linear fashion over its life. Under straight-line depreciation, the asset is depreciated by equal amounts each year over the life of the asset until the net value is zero.

### **Delayed Depreciation**

This form of depreciation assumes that the decline in value occurs more in the later than in the early years. Efficiency decline as reflected in delayed depreciation is the complement of increasing repair and maintenance costs. In the case of automobiles, for example, repair and maintenance expenses reflect this form; early in the asset's life the expenses are low, but over time they increase until they reach such a level that the revenues generated by the asset do not justify them. Delayed depreciation is patterned using a beta-decay function (see the appendix for a mathematical statement).

## **Price Indexes**

In order to be consistent with the National Income and Expenditure Accounts, the price indexes used to deflate capital stocks and flows were revised. Where before the price indexes were of a Laspeyres type, a Paasche type index is now used. The following text summarizes the changes made to these deflators.

## **Machinery and Equipment**

Prior to the changes, the price indexes used to deflate machinery and equipment were provided by the Prices Division of Statistics Canada. These indexes measure price movements on new fixed assets, both domestically produced and imported. Used asset price changes are not entered into the calculations so that the indexes are consistent with the capital formation measures. In many cases, purchasers are in the market too infrequently to permit the continuous collection of the prices paid for comparable assets under comparable conditions of sale. For this reason, as well as reasons of cost and response burden, extensive use is made of existing sources of producers' price information. Consequently, some elements of capitalized expense, such as freight, insurance, and installation charges may not be fully taken into account in the index calculations.

Commodity and industry weights were taken from Statistics Canada's input-output model. These weights were revised periodically with the latest base year for the commodity and industry weights being 1981.

To calculate the Paasche type price indexes now in use, the industry and commodity weights are taken from the input-output model for the years 1961 through the most current year for which the weights data are available. For the period covered by the input-output model, the industry gross fixed capital formation deflators are still based on Prices Division's machinery and equipment by commodity price indexes. However, they are adjusted by the Income and Expenditure Accounts Division to measure the full purchase price of capital by including margins, taxes, etc.

Since the input-output model data begins in 1961, the current period weighting could not be used for the prior years. The indexes for the years 1871 to 1960 were chained with those after 1960 using the average of the ratios of the fixed to current price indexes for the years 1961 and 1963.

The reason for using three years rather than one was to ensure that all types of machinery and equipment were covered in the ratio; there may not be complete coverage of all types of machinery and equipment in any one year.

With the time frame covered by the input-output model lagging four years behind the most current year for capital formation, the price indexes for these years use the weights from the input-output model's latest year. Some annual adjustments are made to these weights to capture weight shifts reflected by the Income and Expenditure Accounts. These estimated weights are replaced with weights from the input-output model as data for additional years becomes available.

### **Building Construction**

Prices Division provides price indexes based on the selling prices of buildings but this data only goes back to 1971. Prior to 1971, the structure type deflators are weighted averages of the price indexes for construction inputs such as labour, concrete, steel, architectural services, and contractor's profits. The Weights are calculated from the average quantities of each input used in the various types of structures.

In the old system, the industry indexes were weighted averages of the above-mentioned structure type price indexes using fixed weights. The weights were derived from the 1981-1984 average capital expenditure on the different types of buildings by industry.

Now, current period weights are applied to the structure type price indexes but only for the years 1981 to the present. As before, the weights are calculated using the data published in "Construction in Canada". For all earlier years, the fixed weighted price indexes are used.

### **Engineering Construction**

The current engineering construction price indexes by industry are calculated in the same way as those for building construction, i.e. fixed weights by structure for the years 1971 to 1980 and current weights after that. Prior to the new price system, the engineering construction price indexes used fixed weights over the entire time span and these weights were calculated in the same manner as the building construction weights. The commodity price indexes up to 1971 were weighted averages of the construction input price indexes calculated in the same way as those for the building construction price indexes. In 1971, price indexes based on selling prices were introduced for some types of engineering construction, highways being the major example, otherwise they continue to be calculated using input prices. Information on the output based price indexes can be found in the Statistics Canada publication *Construction Price Statistics*, Catalogue No. 62-007. The input based price indexes are calculated in the Income and Expenditure Accounts Division.