OCCASIONAL MACRO NOTE

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Estimation of Productive Capital Stock for Turkey

Accumulation of capital by all means plays a fundamental role in the production process and is a significant component of wealth. Measurement of capital stock is of vital importance since it conveys significant info regarding efficacy of economic policies that aim at enhancing national income and wealth.

Productive capital stock (K^p) allows for the measurement of the real value of capital services used in production. Methodologically, past investments are cumulated after correcting for the efficiency loss that has occurred since first being put into use.

In this short note, productive capital stock for Turkey will be derived from the same underlying capital formation data used in: *Saygılı, Ş. and Cihan, C., 2008. "Growth Dynamics of Turkish Economy (in Turkish)", Co-published by TÜSİAD and CBRT*. All the concepts and methodology used in this study are borrowed from *Measuring Capital, 2009. Second Edition, OECD Manual*. The model is as follows:

$$K_t^p = \sum_{k=0}^{T_{max}} I_{t-k} * g_k * F_k$$

here, I_t represents fixed investments in 1998 prices. g_k and F_k are age-efficiency and survival functions, respectively. And finally, T_{max} denotes the maximum service life, which corresponds to twice the average service life (i.e. $T_{max} = 2*T_{avg}$).

AVERAGE SERVICE LIVES (years)

Country	Machinery &Equipment	Building &Structures	Gross Fixed Capital
Canada	20	45	28
USA	17	40	24
Belgium	19	48	28
Finland	17	45	25
France	17	35	22
Germany	17	50	27
Italy	17	45	25
Norway	19	48	28
Sweden	20	65	34
England	30	75	44

Source: ISDB User's Guide 1998, OECD

Service life is the length of time for which assets are retained in the capital stock. We assume that the average service life (T_{avg}) of total fixed investments is **25** years for Turkey (*roughly the mean of the corresponding set comprising US, Germany, France, and Italy given in the table above*). In that case, maximum service life will be equal to **50** years.

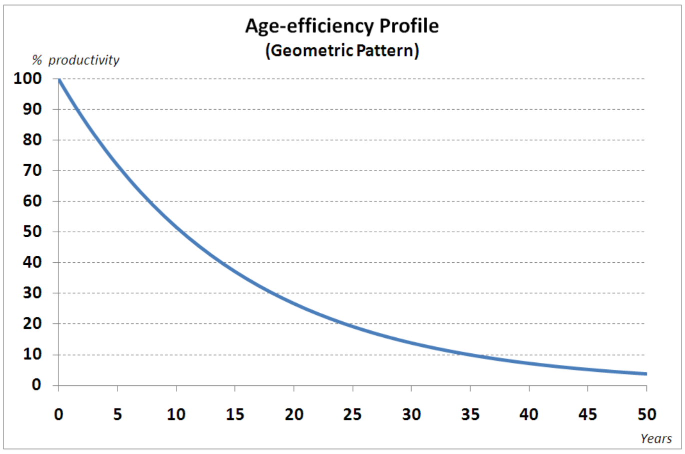
Age-efficiency describes the time pattern of productive efficiency of the asset as it ages. It reflects losses in efficiency due to wear and tear in addition to certain other effects during service life. Since there is not enough solid empirical evidence on the specific form of the age-efficiency profile, the following geometric pattern is frequently used in empirical applications:

$$g_n = (1-\delta)^n \quad n = 0,1,2,.....,T_{max}$$

where δ term refers to the depreciation rate. In the absence of reliable econometric estimates, depreciation rates are estimated with declining balance method (R) and on the basis of information about average service lives (T_{avg}):

$$\delta = \frac{R}{T_{avg}}$$

Although R is usually chosen to equal **2**, EUROSTAT recommends the value of **1.6** based on the results of an extensive simulation study. Below is the plot of age-efficiency profile with respect to these parameters:



When an asset is exported, sold for scrap, dismantled, pulled down, or simply abandoned, it is discarded/retired and removed from the capital stock as a result. Therefore, an assumption has to be made about the distribution of retirements around the average service life in order to reflect this behavior as accurately as possible. The Weibull distribution is a flexible function that can adopt most shapes and therefore has been widely used in such studies:

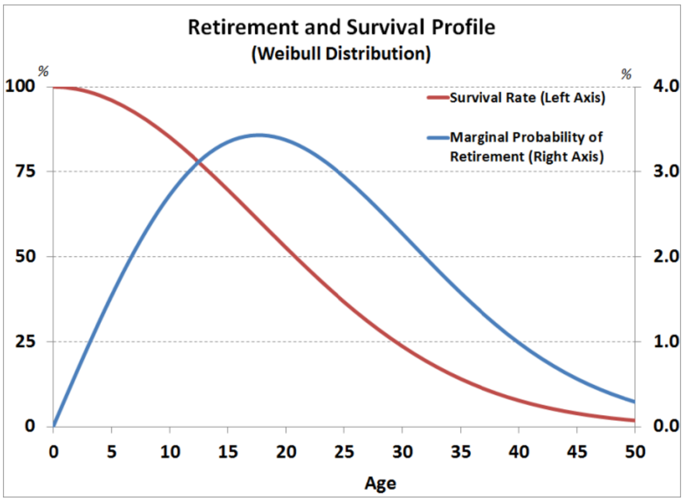
$$W_T = \frac{\alpha}{m^{\alpha}} * T^{\alpha-1} * e^{-(T/m)^{\alpha}}$$

The shape parameter, *α*, can be interpreted as a measure of changes in the risk of an asset being discarded:

- $0 < \alpha < 1$ indicates that the risk of discard decreases over time,
- $\alpha = 1$ indicates that the risk of discard remains constant through the lifetime of the asset,
- $1 < \alpha < 2$ indicates that the risk of discard increases with age but at a decreasing rate,
- $\alpha = 2$ indicates a linearly increasing risk of discard,
- $\alpha > 2$ indicates a progressively increasing risk of discard.

Since we do not have any relevant data for this purpose, we choose $m = T_{avg} =$ **25** *(or **100** for quarterly)* and $\alpha =$ **2** based on comprehensive studies carried out for the Netherlands. For a detailed estimation of Weibull parameters in the Netherlands case, please see: *Van Rooijen-Horsten, M. and others, 2008. "Service lives and discard patterns of capital goods in the manufacturing industry, based on direct capital stock observations, the Netherlands", Discussion paper 08011, Statistics Netherlands.*

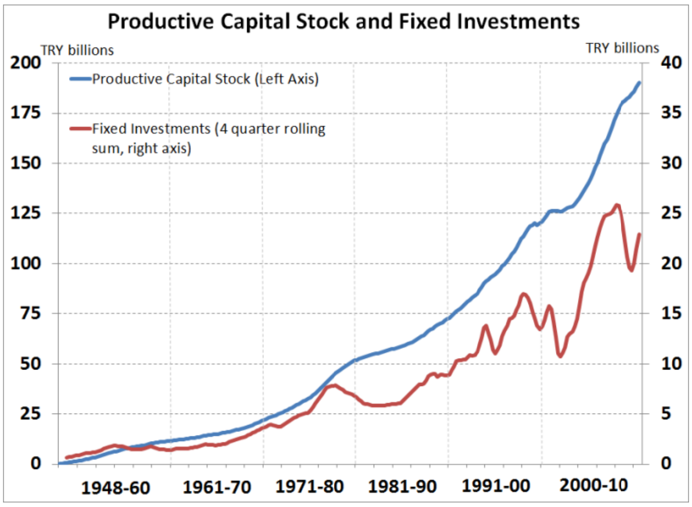
Marginal probabilities of retirement and the survival rates over the service life then assume the curvatures depicted in the picture below:



Before moving on to the estimation of productive capital stock series, we have to make some adjustments in the investment series. We want to estimate productive capital stock on a quarterly basis, but investment series are not available in that frequency during 1948-1986 period.

To circumvent the problem, we extract the seasonal factors for 1987Q1-2010Q3 period and simply decompose the annual figures for the 1948-1986 period with respect to this seasonal pattern. The estimation results turn out to be quite robust to different assumptions for the period since the impact of an investment reduces by half after 9 years.

Below is the graph of estimated productive capital stock (including the impact of earthquake) and four quarter moving sum of investments during 1948Q1-2010Q3 period:



Capital stock series are not directly measured and heavy data requirements make the estimation very challenging. Minimum requirements to serve that end could be stated as follows:

- a benchmark level of capital stock by asset type for at least one year,
- long-time-series of investment volumes and price deflators by asset type,
- as much asset type detail as possible,
- average services lives by asset and/or depreciation rates for each asset,
- industry by asset-type investment matrices for capital stock by industry.

Although it is virtually impossible to meet these requirements for Turkey (at the moment), we can still make reasonable and valid assumptions based on best practices in order to generate a feasible capital stock series. This is especially important since the availability of a reliable or consistent series of any kind would provide an invaluable contribution. We believe the series estimated in this study has such properties and can be used effectively in most applications.

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