

Productive Capital Stock: Methodological Issues and Some Empirical Results

Stock di Capitale Produttivo: Aspetti Metodologici e Risultati Empirici

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Riassunto: La letteratura sullo stock di capitale ha recentemente prestato molta attenzione ai problemi legati alla determinazione del contributo dei beni capitali al processo produttivo nonché alla loro valutazione. L'OCSE ha infatti da poco pubblicato due manuali dedicati ai problemi di misurazione dello stock di capitale e della produttività totale dei fattori della produzione. In questo lavoro proponiamo una misura dello stock di capitale produttivo ottenuta secondo le direttive dell'OCSE ed illustriamo i risultati ottenuti applicando tale metodologia allo stock di macchine e attrezzature dell'economia italiana dal 1980 al 2000.

Keywords: Productive Capital Stock, Capital Services

1. Introduction

The literature on capital stock measurement addresses two main issues: the quantification of the contribution to the production process of all the assets still in use and their valuation. The OECD manuals on productivity and capital measurement (OECD 2001a, 2001b) describe a consistent and comprehensive framework to deal with these issues.

The market valuation of the stock of a capital good is given by its net capital stock (the measure of the capital stock regularly published by ISTAT and calculated as described in Lupi, Mantegazza, 1994) while a measure of the contribution of capital stock to the production process has never been produced in Italy.

In this paper we deal with the problems related to the measurement of the productive contribution of capital stock. We outline the approach described in the OECD manuals, we present a relationship that can be used to calculate the productive capital stock for a single asset type and we report the empirical results for the productive capital stock of machinery and equipment for the Italian economy.

2. Methodology

2.1 The OECD manuals approach

The calculation of the contribution of capital stock to the production process requires a two-stage process. First it is necessary to estimate the productive capacity of each type of asset and then to construct an aggregate measure of the productive contribution of the different type of assets.

In order to quantify the contribution of a specific type of asset to the production process it is essential to evaluate the flow of capital services generated by the asset during the accounting period. The flows of capital services are not (usually) observable, therefore they have to be measured by a proxy. The OECD manuals recommend to assume that the service flows are in proportion to the productive capital stock. For an asset whose service life is T years (i.e. an asset that remains in use in the productive process for T years), the productive capital stock is defined as a weighted sum of past investment of

the last T years, where the weights reflect the efficiency decay of the asset as it ages (i.e. the fact that older assets are less productive than newer ones because of wear and tear).

The pattern of the quantity of capital services produced by an asset over its service life relative to the quantity produced by a new asset (i.e. the sequence of the weights used to define the productive capital stock) is referred to as the age-efficiency profile.

Since there is no empirical evidence on the efficiency decay of an asset, the age-efficiency pattern is not often estimated but rather it is assumed that it follows a specific pattern over the service life. To choose a specific function one has to evaluate how well it reproduces the actual efficiency decay of that particular type of capital good. On the other hand to select an age-efficiency function one has to consider also the relation between the net and the productive capital stock.

The net capital stock must take into account the loss in value of the asset as it ages (the so-called economic depreciation) while the productive capital stock must take into account its efficiency decay.

Economic depreciation and efficiency decay follow two (in general) different but not independent patterns over time: actually every specific age-efficiency pattern implies a specific depreciation pattern. This fact requires that in choosing a specific age-efficiency function we have to consider also if the pattern of economic depreciation it implies is at least broadly consistent with that one implied by the depreciation method used to estimate the net capital stock (the straight-line method in the Italian case).

Till now we have assumed that the service life is known and it is the same for all the assets of a specific type. The estimation of the productive capital stock must deal with the fact that the actual service life for assets put in place in a given year won't be the same for all the assets.

In order to account for the heterogeneity in the service lives the usual approach is to assume that retirements follow a given distribution around the mean service life, so we need to make a decision about the mean service lives and the distribution functions.

Moreover if the service life is one of the parameters of the age-efficiency function, we have to choose whether to consider this parameter a constant for all the asset acquired in a given year or to make it a function of the retirement pattern.

The former option implies that we assume that the assets of a given cohort lose productive capacity at the same rate but are retired when they have different capacity of producing services. The latter option instead implies that we assume that the assets of a given cohort are affected by wear and tear with different rates and are retired when they have lost all their productive capacity.

Another point to note is that we can't estimate the capital stock for a truly homogeneous asset but for aggregates of heterogeneous assets (e.g. equipment and machinery, structures, transport equipment). It's clear that the service lives and the efficiency decay of the different components of these aggregates are likely to be different. So actually we have to select an average age-efficiency profile and an average retirement profile.

Once we have estimated the productive and the net capital stock for different types of assets, then we have to aggregate them. The aggregation procedure is different for the two measures of capital. The aggregate net capital stock is obtained simply by summing up the stocks of each asset. The aggregate measure of capital services, is given by a Tornqvist index with asset-specific user costs as weights.

2.2 The productive capital stock calculation

The productive capital stock for each of the homogenous asset types can be calculated by way of the following relationship (see OECD 2001c):

$$S_t^i = \sum_{t=0}^T \left[IN_{t-t}^i / q_{t-t,0}^i \right] h_t^i F_t^i$$

Here the productive capital stock of asset i at the beginning of period t is the sum over all past investments in this asset, where the current price investment in past periods,

IN_{t-t}^i is deflated with the purchase price index of new capital goods, q_{t-t}^i . T represents the maximum service life of asset type i .

The parameter F_t^i is the retirement function: it gives the share of assets of age τ that are still in service at time t . It is the complement to one of the cumulative value of the retirement distribution of capital goods, which describes the probability of survival over the cohort's life span. Obviously it must be that $F_0^i=1$ and $F_T^i=0$. The retirement pattern (i.e. the retirement distribution and the average service lives) we have selected is the one that is currently used to calculate the net capital stock at ISTAT and described in Lupi, Mantegazza (1994).

The parameter h_t^i represents the age-efficiency function: h_t^i is a number between zero and one that measures the proportion of the productive efficiency of a τ years old asset of type i with respect to the efficiency of a new asset of the same type. In this work we have selected an hyperbolic function of the form:

$$h_t^i = (T - t) / (T - bt)$$

where b is a parameter whose value determines the shape of the function. We have set $b = 0.5$, that is the same value chosen by the U.S. Bureau of Labor Statistics for machinery and equipment. With this value of b efficiency declines slowly in the earlier period and at an increasing rate towards the end of the asset's life. This pattern is considered a plausible description of the efficiency decay of many types of capital goods. Moreover the depreciation pattern implied by this age-efficiency function is broadly consistent with the depreciation obtained from the straight-line method (Blades, 1998, OECD 2001b). In our calculation the parameter T in the hyperbolic function is the same for all the assets, regardless of their actual length of life.

3. Empirical results

We have calculated the productive capital stock of machinery and equipment for the total economy and for six major sectors comprising the total economy for the years from 1980 till 2000. We have used the same series of gross fixed capital formation by branch of owner at constant prices that ISTAT uses to compute its measure of net capital stock. In this section we present a comparison between the productive capital stock and the net capital stock already calculated by ISTAT (both of them evaluated at constant prices). Table 1 reports the average annual growth rates of the two measures of capital stock for the years 1980-2000, 1980-1993 and 1993-2000.

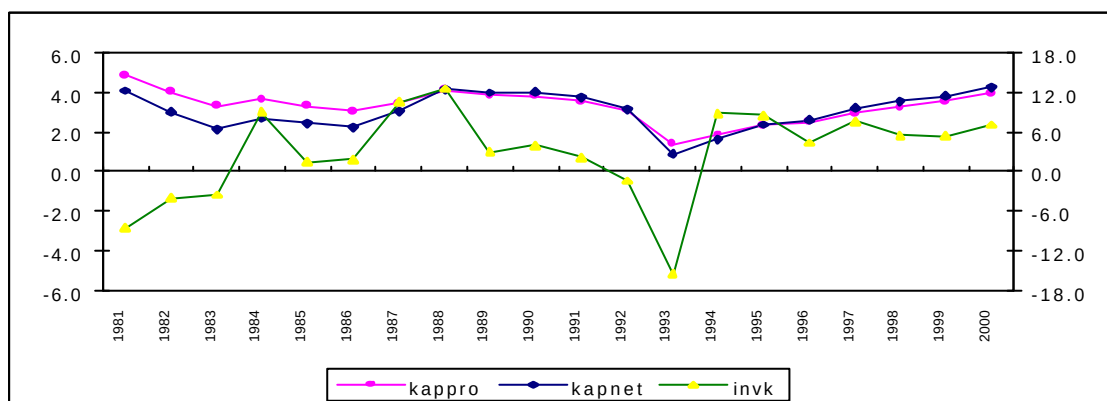
Over the full 1980-2000 period we find that only minor differences (if any) exist between the two measures, with the exception of the Construction sector. where the productive capital stock increases of 0.22% every year while the net one decreases of 0.22%.

More substantial differences emerge, however in the two sub-periods, particularly in the 1980-1993 years. During this period the average growth of the productive and the net capital stock for the total economy were, respectively, 3.48% and 3.03%. The larger differences are for the Agriculture and the Construction sectors. The productive capital in the former sector declines at the average rate of 0.38% during the years from 1980 to 1993 and it remains constant in the 1993-2000 period, while the net one declines at the average rate of 1.43% during the years from 1980 to 1993 and it grows at the rate of 1.26% from 1993 to 2000. The Construction sector shows even more striking differences. In the 1980-1993 period the productive capital grows at the rate of 0.58% while the net one declines at the average rate of 0.47%. In the years from 1993 to 2000 the productive capital declines at the average rate of 0.45% while the net capital grows at the rate of 0.23%.

Table 1: Productive and Net Capital Stock. Average annual growth rates.

		1980-2000	1980-1993	1993-2000
Agriculture	kapprod	-0,22	-0,38	0,08
	kapnet	-0,50	-1,43	1,26
Mining, Manufacturing, Electricity, Gas and Water	kapprod	2,93	3,12	2,56
	kapnet	2,62	2,57	2,73
Construction	kapprod	0,22	0,58	-0,45
	kapnet	-0,22	-0,47	0,23
Trade, Transport and Communications	kapprod	5,32	5,85	4,34
	kapnet	5,10	5,69	4,03
Banking, Finance, Real Estate and Business Services	kapprod	6,62	7,32	5,32
	kapnet	6,61	7,47	5,02
Other Services	kapprod	5,04	5,71	3,82
	kapnet	5,00	5,69	3,71
Total Economy	kapprod	3,28	3,48	2,91
	kapnet	3,04	3,03	3,05

Plotting the annual rates of change of the two measures of capital stock and of investment gives us an intuition about when the two measures of capital grow at different rates. Figure 1 shows this graph for the total economy but it is representative of the sectoral results too. Actually the net capital stock is more sensitive to investment behavior, so that when the rate of change of investment is constant or negative, the rate of change of the net capital stock declines more than the rate of change of the productive one. Instead when investment increases at a high rate the net capital grows more than the productive one.

Figure 1: Productive Capital Stock, Net Capital Stock and Gross Fixed Capital Formation for the Total Economy. Annual rates of change

References

- Blades D. (1998) *Measuring Depreciation*, paper presented at the second meeting of the Camberra Group on Capital Stock Statistics, Paris.
- Lupi C., Mantegazza S. (1994), *Ricostruzione delle serie degli investimenti per branca utilizzatrice, per branca proprietaria e calcolo dello stock di capitale*, ISTAT, Quaderni di ricerca n. 14/1994, Roma.
- OECD (2001a) *Measuring Productivity - OECD Manual: Measurement of Aggregate and Industry-Level Productivity Growth*, Paris.
- OECD (2001b) *Measuring Capital - OECD Manual: Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services*, Paris.
- OECD (2001c) *Measurement of Capital Services: Preliminary Results for Eight OECD Countries*, paper presented at the OECD Meeting of National Accounts Experts, Paris, 9-12 October 2001.