The impact of alternative approaches to the measurement of fixed capital

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Abstract. The most recommended method used for the measuring of fixed capital is PIM (Perpetual Inventory Method). In this method, the processes of retirement, decay and obsolescence of fixed assets in national economy are modelled on the basis of average service lives, and the chosen depreciation profile.

The paper deals with the comparison of two most common depreciation profiles. The straight line depreciation profile is used by official national accounts statistics. Having no data on second hand market or rental prices, the geometric profile is derived from average service lives. As an alternative, the geometric depreciation profile is applied on the data on most important types of assets for non-market producers sector. As a consequence, the impact on gross domestic product of such change is evaluated.

Also the gradual change of service lives was tested on assets with long service lives. Subtle impact of this process on balances of fixed assets and GDP was demonstrated.

Keywords: fixed capital, national accounts, depreciation profile.

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AMS Classification: 91B25

1 Introduction

It is nearly impossible to make the stock list and its evaluation in purchaser prices of all fixed assets in the economy. But the value of fixed capital is highly demanded indicator. Fixed capital in economy is represented by a few flows and stocks. Whereas stock variables (gross and net) are estimated to some point in time (end of year) flows refer to period of time (year).

The most recommended method [6, 7] used for the computation of stocks and the consumption of fixed capital is PIM (Perpetual Inventory Method). The core of the method lies in accumulation of flows to express the stock variables. While flow of investments is possible to survey, the values of depreciation and retirement have to be estimated. The processes of the retirement, decay and obsolescence of fixed assets in national economy are modelled on the basis of average service lives, and the chosen depreciation profile [11].

To estimate the process of consumption of fixed capital (i.e. decline of assets value during some period of time "… as a result of physical deterioration, normal obsolescence or normal accidental damage" [7]) it is necessary to determine the depreciation profile. The most used are straight line and geometric profiles.

Both profiles are criticised for some reasons. Straight line depreciation profile often doesn't correspond to real economy situations; it is too slow, especially for periods of dynamic structural shifts [1]. On the other hand, geometric depreciation is often criticised for too fast depreciation and geometrically depreciated assets never reach zero value [5, 8]. Moreover, empirical evidence for geometric depreciation based on second hand market prices is hardly representative [8], such criticism can be focused also on rental prices approach (see [8] and [9] for more about empirical evidence of geometric depreciation profile). Thus, the depreciation profile is frequently chosen on the grounds of practicality or expert's judgement.

Moreover average service lives change in time and should be revised periodically [12]. Some statistical offices also assume gradual change (mostly decrease) of service lives of long-life assets [11].

The paper deals with the comparison of these two most common depreciation profiles and with the implementation of gradual change of service lives. Czech official balances of fixed assets are based on straight line depreciation profile [2]. Alternative approaches are applied on official data of Czech statistical office (CZSO) and the impact on gross domestic product of such changes is evaluated. Geometric depreciation profile

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is applied twice for average service life as constant number (i.e. simultaneous exit) and for lognormal retirement pattern that is used at CZSO [2, 13].

2 Material and Methods

Perpetual Inventory Method is based on annual accumulation of flows (gross fixed capital formation, consumption of fixed capital, holding gain/loss and other changes). Consumption of fixed capital is modelled decrease of value of old investments. Thus, investment (gross fixed capital formation) is input flow in current year and also the cause of output flow of consumption of fixed capital for certain period of following years.

Under commonly used straight line depreciation profile, the value of assets decrease by constant amount each year. Thus value loss of assets follows equation (1) where T is average service life, n is age of asset, p_0 is initial value of investment and p_n is actual value of the assets after n years [11]:

$$\frac{p_n}{p_0} = 1 - \frac{n}{T},\ n = 0,1,...,T \tag{1}$$

Value loss of asset under geometric depreciation profile is expressed by (2).

$$\frac{p_n}{p_0} = (1-\delta)^n,\ n = 0,1,... \tag{2}$$

Depreciation rate δ should be based on empirical data [11] but in case of no econometric estimates on δ, it is possible to convert assets service lives into depreciation rates. Equation (3) dependence of δ on T [11]. Under assumption of long-run equilibrium for straight line and geometric depreciation (double declining balance) [5]:
- long-run constant investment in constant price,
- long-run value of the capital is equal for both depreciation profiles.

the declining-balance rate R could be chosen equal to 2 [5]. Empirical results differ from that value in both directions – some authors find R smaller than 2, some higher [11]. This assumption (R=2) was used for the results presented in this paper.

$$\delta = \frac{R}{T+1} \tag{3}$$

Figure 1 compares different depreciation profiles on example of 100 million CZK investment into fixed assets with average service life T=5 in year 0. Horizontal axis represents age; vertical is the value of assets. Figure 1 also express importance of retirement function. Simultaneous exit assumes all assets to be retired at age T. Recommended bell-shaped function [11] is represented by lognormal retirement function with standard deviation of service life s=2.9. Such retirement functions divide each vintage of assets into groups with different service lives.

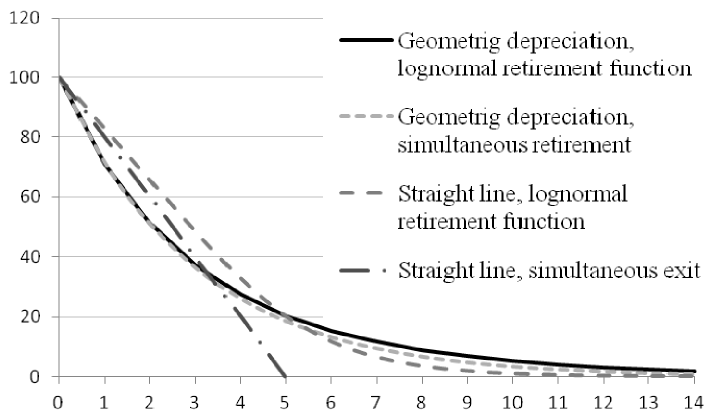

Figure 1 Value loss in time – example of different depreciation profiles, million CZK, prices of basic year

The impact is obvious especially for straight line depreciation. Value loss under straight line depreciation with lognormal retirement function is closer to geometric depreciation than to straight line with simultaneous exit retirement pattern. Straight line depreciation profile and lognormal retirement function are typical for CZSO [2, 4], thus there shouldn't be expected such change as it was for official revision of national accounts, which part was change from simultaneous exit to lognormal retirement function for non-residential buildings and application of PIM on dwellings instead of price-quantity method [4].

Figure 1 also shows why it isn't clear in which direction will the consumption of fixed capital and value of net capital stock change. The result depends on historical time series of gross fixed capital formation. Faster depreciation of historical investments could lead to smaller consumption of fixed capital in current period.

Alternative approach was applied on data on government sector and institutional sector of non-profit organisations serving households. These are institutional sectors of non-market producers where the consumption of fixed capital is necessary for GDP estimation [7]. Geometric depreciation profile was applied on following types of assets:

- Non-residential buildings;
- Dwellings;
- Transport equipment;
- Other machinery and equipment.

These kinds of assets are often subject of discussion [5, 8] and in 2010 they represented more than 86.5% of value fixed assets in Czech economy [3]. Impact of 1% decrease of T was tested for non-residential buildings and dwellings; for these purposes standard deviation for lognormal retirement pattern was set in the middle of recommended interval $\langle T/4, T/2\rangle$ [11]. For practical purposes the maximal service life is set on 99.5 percentile of original T. Service lives started to fall in 2002 for dwellings and in 2003 for non-residential buildings. For these years the official PIM is parameterised.

Calculation respects the format of data input, thus it is classified into 120 industries (average service lives and price indices often differ for different industries) and the alternative model uses transformation to Markov chain based on [10]. Data for straight line depreciation are from CZSO [3]. For year 2009 it is semi-definitive version, for 2010 it is just preliminary version of data.

3 Results and discussion

Decreasing average service lives for chosen long-life assets caused very small changes. The value of net capital stock in current prices decreased just by 0.49‰ for non-residential buildings and by 0.57‰ for dwellings in 2010 (i.e. by 1,742 billion CZK). Consumption of fixed capital in current prices increased by 0.36% for non-residential buildings and by 0.31% for dwellings for the same year (i.e. by 281 million CZK).

Geometric depreciation profile caused changes in both directions. Figure 2 compares development of consumption of fixed capital in current prices based on different depreciation profiles. Until 2004 geometric depreciation provides higher estimation of consumption of fixed capital for non-market producers from 2005 the consumption is below official linear profile (data from [3]). Consumption of fixed capital continuously grows only for transport equipment.

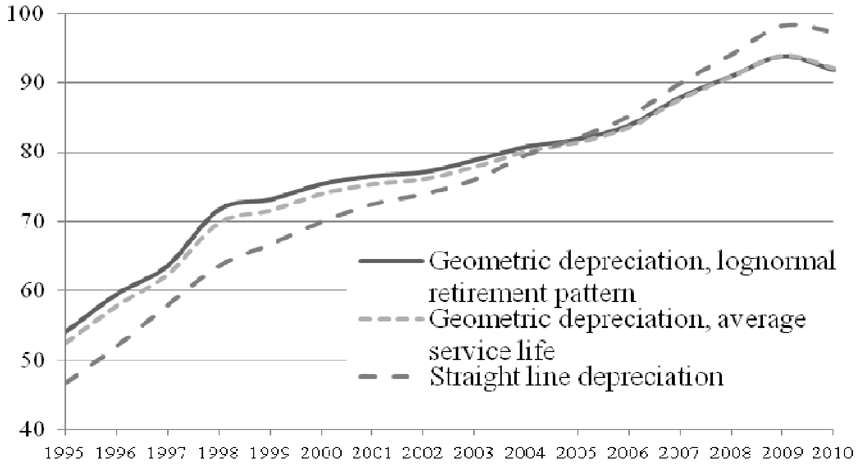

Figure 2 Non-market producers' consumption of chosen assets in billion CZK, current prices.

The biggest positive difference from official data is for 1995. It is caused mainly by non-residential buildings 86.6% of total difference for lognormal retirement function and 87.8% of the difference for simultaneous exit.

The decrease is caused mainly by decreasing consumption of dwellings and non-residential buildings. Consumption of dwellings in sector of non-market producers calculated on basis of geometric depreciation profile is under 70% of official statistics for simultaneous exit in 2010 and fewer than 60% for lognormal retirement pattern (i.e. drop by 2,414 and 2,944 million CZK in current prices).

In case of simultaneous exit, consumption of non-residential buildings dropped by 4.4% (3,118 million CZK) in 2010. For lognormal retirement function it dropped by 4.3% (3,058 million CZK). But these changes can't be generalised for whole economy. For whole economy the consumption of dwellings is higher than 92.2% for both retirement patterns in 2010. For non-residential buildings in Czech economy the consumption of fixed capital is even higher than official in 2010 (4.6% for simultaneous exit and 6.8% for lognormal retirement).

Assumption of simultaneous exit is typical for many researchers and statistical offices [5]. The difference of geometric consumption between simultaneous exit and lognormal retirement pattern is always under 3.2%. Although this result is hard to generalize, for practical purposes the computational complexity should be considered. For long-life assets (e.g. non-residential buildings) there could be more than 200 times more computations for each year of investment.

The consumption of fixed capital is necessary for calculation of production of non-market producers. Thus the estimation of their consumption influences GDP. Table 1 presents impact of different depreciation patterns on GDP of Czech republic. There is also the market production in government institutional sector. The impact on GDP presented in table 1 is caused only by consumption of fixed capital related to non-market production. In comparison, already mentioned change in consumption of fixed capital during revision of national accounts caused changes of GDP between 0.0% and 0.3% in 1995-2009 [4].

retirement pattern	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Δ lognormal	7 006	6 601	4 324	6 209	4 441	3 275	2 037	1 608	1 607	219	-809	-1 571	-1 992	-2 897	-3 855	-4 509
Δ simultaneous exit	5 425	4 964	3 097	4 364	2 908	1 922	877	524	513	-662	-1 508	-2 165	-2 583	-3 347	-4 155	-4 680
Δ lognormal (%)	0.46	0.37	0.23	0.30	0.21	0.14	0.08	0.06	0.06	0.01	-0.03	-0.05	-0.05	-0.08	-0.10	-0.12
Δ simultaneous exit (%)	0.35	0.28	0.16	0.21	0.14	0.08	0.04	0.02	0.02	-0.02	-0.05	-0.06	-0.07	-0.09	-0.11	-0.12

Table 1 The impact of geometric depreciation profile on GDP estimation, million CZK in current prices and relative change

4 Conclusion

The change of GDP under 0.5% isn't high, especially for actual period where it is 0.12% decrease. Moreover, results could be different for different R in equation (3) and also higher detail of input data (official PIM uses classification on institutional subsectors [2]) can slightly change the result. But concerning criticism of tested depreciation patterns (first is too slow, second is too fast), application of both depreciation profiles can be comprehended as interval estimation of consumption of fixed capital and other associated indicators.

Future work in this area will focus on the comparison for whole Czech economy. Concerning the change of net fixed capital stock that is -13.9% for tested sectors in 2010, the impact on factors' productivity (see e.g. [14]) will be also in the area of interest and detailed examination.

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