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Estimating the Capital Services of Beijing: 1978-2012

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Abstract

In macroeconomics, the measure of capital input and its contribution to production has been a spot in research. This paper takes Beijing city as the research object, referring to the 2008 SNA concepts and categories on capital service, making the full use of existing data, applying the PIM method to estimate the capital service and its index of 1978-2012. Because the capital service estimate is a new research field in China, the conclusions of this research can provide data support for the accurate accounting of total factor productivity and the decision support for the economic growth policies making in Beijing.

Key words: Capital service; Beijing; Productive capital stock; Age-efficiency profile

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INTRODUCTION

The contribution of capital to economic growth has been widely studied in macroeconomics. However, the estimation of capital input is regarded as “the most difficult work that economists gave statisticians”. From Karl Marx to the Cambridge Controversies, economists have been arguing about the definition of capital and the measurement method of capital input for a long time. People defined and estimated capital with durable stock during a long period. Goldsmith pioneered the idea of perpetual inventory method in 1951 and the US commerce department started to estimate American annual capital stock with this method in 1970s. Then most OECD countries got official capital stock data. But as time passed, many economists have realized that it is the capital service flow not the capital stock that determines output, which means the capital input is equal to the capital service provided by capital goods during a period.

The chapter of capital service is specially introduced into the new version SNA to present the accounting and recording of the capital input as capital flow. With the change of capital range in SNA2008, macroeconomic indicators including GDP and capital scale are facing a new estimate. America and Japan are the first two countries that adjust their historical data of GDP in 2013. And the re-estimate of capital has also been the hot spot in theoretical circle, which is widely discussed as a separate unit in the 33rd income and wealth research conference.

China has no available official capital data at present, no matter measured in stock or flow. Original value of fixed assets and net value of fixed assets are comparatively similar to capital in concept, but they are not associated with the relative efficiency of capital goods. As a result, they can’t reflect the actual quantity of contribution of capital to production. Limited by data availability, researchers use their own estimate of capital stock as the substitution of capital input in practice.

Among the domestic researches on capital stock, He (1992), Chow (1993), Wang and Fan (2000), Zhang (2002), Li and Tang (2003), Zhang and Zhang (2003) and He (2003) have done some research on aggregate level. As for study on industry level, Huang and Ren (2002) have estimated the capital stock of 13 manufacturing industries and the aggregate stock; Wang and Wu (2003) have measured the capital stock of 16 industries along with the aggregate stock; Jin (2012) has estimated the capital stock of China's infrastructure from 1993 to 2008. There are also many researches on regional level: Wang and Chen (2009) have calculated the capital stock of Shanghai from 1978 to 2007; Xu and Li (2009) have estimated the fixed capital stock in rural areas; Ye (2010) has measured the capital stock of each provinces from 1978 to 2008; Sun (2011) has studied ICT capital stock of Beijing; Zeng and Chen (2013) have estimated the capital stock of Qingdao from 1990 to 2011. To sum up, these studies all focus on capital stock with no regard to capital flow.

On the account of capital input flow, Sun and Ren (2005) firstly review the theory on capital investment and calculate total factor productivity of China. Then in 2008 they have estimated the capital input indices on industry level from 1981 to 2000. Since there are some differences between the infinite geometric depreciation model and the actual use of capital, Chai (2009) firstly applies age-efficiency profile to the calculation of the capital input index of China from 1978 to 2007 on the aggregation level. Cao and Qin (2012) also estimate the capital service index of China from 1978 to 2010. With contrast to the researches before, they do an excellent work in the technical details, such as how to choose the depreciation rate, but the calculation result that the productive capital stock is smaller than the wealth capital stock contradicts the basic theory of capital services.

In conclusion, there are still some problems in the capital service research in China: not only is the amount of study small (1 paper on theoretical research, 3 papers on empirical research), but also the research perspective is limited (just focusing on aggregate analysis with no account of regional analysis). Moreover, there are some controversies about research method and technical details. Honestly speaking, the research on capital service in China is just at the stage of exploration. This paper estimates the capital service indices in Beijing from 1978 to 2012, which can provide data and decision support for the economic growth policy in Beijing.

1. ESTIMATING METHOD OF CAPITAL SERVICES

Capital and labor are combined in production and they each make contributions to production. The contribution of labor is regarded as employee compensation, and the contribution of capital is treated as capital services. Except for employee compensation, the added value includes consumption of fixed capital and operating surplus. They two make up capital services, with full consideration of the contribution made by all the capital to production.

1.1 The Concept Definition of Capital Services

Since capital service is the service value of capital in current production, rent is a proper measurement for capital services' value. Rent usually makes up for the following costs: (a) the direct cost of capital owner, including capital maintenance cost; (b) the decrease of capital value during the lease term (consumption of fixed capital); (c) the interest cost of capital value at the beginning of lease. Interest cost can be the actual interest payment for the borrowed fund or the interest loss for investing in the fixed asset instead of financial assets. The third cost is interest cost, commonly called fixed capital return. As well as consumption of fixed capital, capital return is also a part of the added value. The sum of consumption of fixed capital and capital return is the capital services provided by this asset. But there is a premise to measure capital services with rent: the rental market is perfect, which means all the assets are obtained in rental market. However, the existence of vast self-use capital in reality breaks down the assumption. Therefore, the measurement of capital service is converted to the measurement of user cost.

1.2 The Accounting Scope of Capital Services

According to SNA2008, the assets that provide capital services are non-financial assets that make contributions to production, including fixed assets, inventories, natural resources and contracts related to production. Holding valuables as a store of value will bring earning, but the valuables make no contribution to production. Though the capital service measures all the non-financial assets excluding valuables in principle, it is hard to estimate the capital services provided by non-financial assets excluding fixed capital. Take inventories for example. As not all the inventories are of value, it will be difficult to isolate those inventories which make no contribution to production. Thus this paper limits the capital service to be measured to only fixed capital.

1.3 The Calculation Approach of Capital Services

Once capital formation data (I) was collected, we need to get information on capital retirement function (Y(t)) and its age-efficiency profile(g(t)) to calculate an intermediate production, that is the productive capital stock ($K^p(t)$). Rates of return (r) and user costs (f) will be used as aggregation weights to measure the total capital services. And user cost is calculated on the basis of depreciation model and age-price profile. Since there is a one-to-one correspondence between age-price profile and age-efficiency profile, the key to calculate capital service index is the selection of the following parameters and variables:

1.3.1 Age-Efficiency Profile

Age-efficiency profile is used to describe how the efficiency of a single asset declines over time. Its exact morphological character is an empirical question. And hyperbolic curve model and geometric model are relatively common in practice. The productive efficiency of assets declines rapidly at the very beginning but slowly in the later stage in geometric model. However it is just the opposite in hyperbolic curve model. Generally, the hyperbolic curve model is more proper for the actual situation of the decline of capital efficiency from experience.

$$g_s^i = \frac{T^i - s}{T^i - b^i s} \quad (1)$$

Formula (1) is the functional form of the hyperbolic curve model of age-efficiency profile. And i denotes asset type; T^i indicates the maximum service life of the asset i; s indicates the age of the asset i ranging from 1 to T^i. Since it is impossible for the assets to retire at the same time, T^i is a random variable following retirement function distribution. g_s^i satisfies the inequality $1 = g_0^i > g_1^i > \ldots\ldots g_T^i > g_{T+1}^i = 0$. Since the efficiency of a new asset is 1, g_s^i indicates the relative efficiency of assets at different ages compared to new assets. Besides, b denotes diminishing efficiency factor. According to the service life of different assets, b equals to 0.75 for construction and installation engineering, 0.5 for purchase of equipment and instruments and 0.6 for other expenses.

1.3.2 Retirement Function

Age-efficiency profile defines the functional form of a single asset. Since not all the assets retire at the same time, we need to know the retirement distribution. It is common to choose bell-shaped distribution and its specific functional form is displayed as follows:

$$Y(t) = [(\frac{1}{s}) \times 2\pi^{-\frac{1}{2}}] \times EXP[(-\frac{1}{2})(\frac{t-\overline{T}}{s})^2] \quad (2)$$

As shown in formula (2), Y(t) denotes the retirement ratio of some asset after it has been serving for t years; $\overline{T}$ indicates the average service life of the asset; s denotes the standard deviation of the service life(generally s equals to $\overline{T}/4$). We can get the comprehensive efficiency vector parameter $h^i = (1, h_1^i, h_2^i, \ldots\ldots)$ of investment flows with age-efficiency profile and retirement function.

1.3.3 Productive Capital Stock

Productive capital stock is different from wealth capital stock. Not only the decline in asset efficiency but also the decline of asset price presents the change in investment over time. Accordingly, productive capital stock is displayed with age-efficiency profile while wealth capital stock is displayed with age-price profile. The previous research on capital input measures wealth capital stock mainly based on perpetual inventory method (PIM).

$$K_t^p = K_{t-1}^p(1-\delta) + I_t = \sum_{\tau=1}^{\infty} h_\tau^i I_{t-\tau} \quad (3)$$

K_t^p indicates productive capital stock and h_t^i denotes the comprehensive efficiency parameter considering retirement function in formula (3). The measuring principle of productive capital stock is consistent with PIM. What is to note is that δ is relative to efficiency loss not the decline of price.

1.3.4 User Costs

Since capital service is usually considered as a proportion of the productive capital stock, for a single asset, the indicator that measures the change of its productive capital stock over time is its capital service index. As it is correlated with the aggregation of different assets to calculate the aggregate capital service indices, we should carefully determine the formula form and aggregation weights. Production theory indicates that we should use chained superlative indices to aggregate capital input. Tornqvist index and Fisher index are two concrete forms of superlative indices, and it is more common to use Tornqvist index in practice. The aggregation weights of each asset is relative to the average percentage of its capital return in the gross capital return, so it is necessary to get information on the user cost of each asset.

$$f_t^i = q_t^i \times (r_t^i + d_t^i) - (q_t^i - q_{t-1}^i) \quad (4)$$

Formula (4) is the expression of user cost derived by asset pricing formula. In the formula, q_t^i denotes the acquisition price of capital goods in the year t and q_{t-1}^i denotes the price in the year (t-1); r indicates the rate of return of capital goods; d denotes the depreciation rate of capital goods. Therefore user cost is composed of three parts: capital return, capital consumption and changes in capital value brought by inflation.

1.3.5 Rates of Return

There are two tapes of the rate of return: internal rate of return and external rate of return. Taking full account of all the assets' contribution to production, capital service is the sum of consumption of fixed capital and operating surplus. Internal rate of return is calculated according to the following identity.

$$\sum_i f_t^i K_t^i = \sum_i q_t^i \times \left(r_t^i + d_t^i - \frac{q_t^i - q_{t-1}^i}{q_t^i} \right) \times K_t^i \quad (5)$$

The left side of the equation is the sum of capital return, which can be obtained from manufacturing account. And r in equation (5) is the internal rate of return. While external rate of return is directly assigned to be equal to bond yield or borrowing rate, without regard to the equilibrium relation of the account. Capital income is equal to capital service applying the internal rate of return; when external rate of return is used in calculation, there is residual value subtracting capital service from capital income.

No final conclusion has yet been reached on the matter of applying which return in academic research. We assume all the assets are involved when using internal rate of return, which means there is no unobservable asset, or we will get a biased result. However, external rate of return can't explain the yield differentials of different industries and sectors. Furthermore, the user cost may be negative influenced by different choices. So we tend to use internal rate of return in empirical research and external rate of return is mainly applied to calculating the output of non-market sectors.

2. EMPIRICAL ANALYSIS

2.1 Data

From the above, to estimate the capital services of Beijing, we need these data including categorized capital formation series of Beijing, constant price index, base year stock, asset service lives, depreciation rate and other information.

2.1.1 Capital Formation Data

Concerning investment flow, there are two sets of data in statistics: fixed capital formation data and fixed capital investment data. On the one hand, the purchasing cost of old equipment and old buildings is included in total investment of fixed assets, which is repetition in calculation. On the other hand, total investment in fixed assets excludes the fixed capital investment which below 0.5 million and capital expenditure of intangible assets such as mineral exploration and computer software. Hence OECD suggests using total fixed capital formation to calculate capital services. This paper uses capital formation series by convention, and divides the assets into three categories: construction and installation, purchase of equipment and instruments and other expenses. The data is from "Beijing Statistical Yearbook".

2.1.2 Constant Price Index

In order to avoid the influence of inflation upon capital services calculation, we use adjusted data by price index of investment sequences in calculation. We can only find unclassified price index of investment in fixed assets of Beijing after 1990. For this reason, we substitute national price index of investment in fixed assets for the required data before 1990. And the base year of price index is adjusted to 1978.

2.1.3 Base Year Capital Stock

As for formula (3), due to lack of investment data longer than the maximum service life, we have to set the productive capital stock of the base year. There are many researches on the base year wealth capital stocks. However, there are barely studies on productive capital stock of the base year. Generally speaking, the longer the researching period, the less influence the capital stock of the base year will make on the adjusted current data. Therefore, this paper applies the method of Zhang Jun (2004) that substitutes wealth capital stock of Beijing in 1978 for productive capital stock of the base year.

2.1.4 Capital Service Life

Formula (1) and (2) require the maximum service life and the average service life of all kinds of assets. According to the estimation of Sun and Ren (2005a), the average service life of construction and installation is 40 years; that of purchase of equipment and instruments is 15 years; and that of other expenses is 20 years. On this basis, we deduce the maximum service life of construction and installation is 55 years, that of purchase of equipment and instruments is 20 years, and that of other expenses is 27 years.

2.1.5 Depreciation Rate

Depreciation rate reflects the decreased capital value along with the increase of capital service years. So it can be derived from the age-price profile. In the capital service theory, the age-price profile and the age-efficiency profile have one-to-one correspondence. Then we can get depreciation rate without other new data.

$$\frac{p_s^i}{p_0^i} = \frac{(h_s^i + h_{s+1}^i(1+r) + h_{s+2}^i(1+r)^2 + \cdots)}{(1 + h_1^i(1+r) + h_2^i(1+r)^2 + \cdots)} \quad (6)$$

On the left side of the equation, the price rates of capitals with different service lives reflect the depreciation rates. From the right side of the equation, it can be seen that the depreciation rates are described by age-efficiency profile (h) and return rate (r). So the age-price profile and the age-efficiency profile have one-to-one correspondence. Once the age-efficiency profile is determined from formula (1) and (2), we can endogenously obtain capital depreciation rates.

2.2 Results

We calculate the capital services and the related indices of Beijing from 1978 to 2012, on the basis of the measuring procedure of capital service and the capital investment related parameters. First we obtain the age-efficiency profiles of the three kinds of assets as shown in Figure 1.

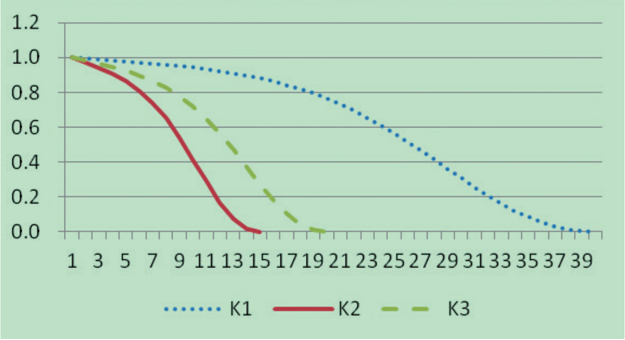

Figure 1
Comprehensive Age-Efficiency Profile

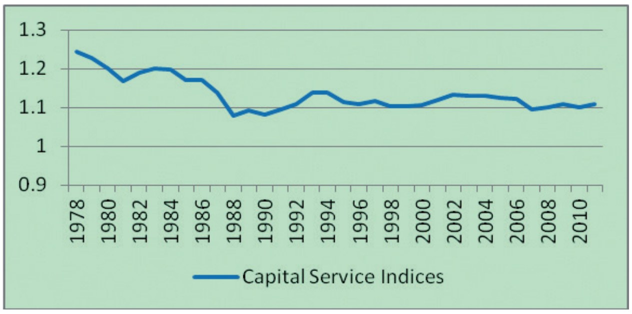

Figure 2
Beijing Capital Service Indices

Based on the age-efficiency profiles of the three kinds of assets, we can calculate the productive capital stock categorized by asset of Beijing from 1978 to 2012 according to formula (3). The result is displayed in Table 1.

Table 1
Productive Capital Stock of Beijing (1978-2012) (Unit: Hundred million)

Year	K1	K2	K3	K	Year	K1	K2	K3	K
1978	80.87	26.24	5.52	112.63	1995	948.92	232.06	105.65	1286.63
1979	100.95	32.16	6.83	139.94	1996	1059.28	248.72	123.74	1431.74
1980	124.56	39.01	8.35	171.92	1997	1169.36	271.74	144.00	1585.11
1981	150.10	46.17	9.98	206.25	1998	1301.61	299.58	170.42	1771.61
1982	175.93	53.25	11.85	241.03	1999	1433.82	328.03	194.62	1956.47
1983	209.41	63.21	14.25	286.88	2000	1576.47	360.11	221.96	2158.54
1984	249.89	77.21	17.54	344.63	2001	1736.45	398.04	254.95	2389.45
1985	297.20	93.60	22.07	412.87	2002	1929.94	443.92	301.21	2675.07
1986	347.74	108.89	26.73	483.36	2003	2164.45	504.02	361.80	3030.27
1987	406.57	126.39	32.69	565.65	2004	2428.52	574.36	422.89	3425.78
1988	463.66	141.67	38.25	643.58	2005	2720.42	656.44	489.99	3866.84
1989	505.33	146.78	41.31	693.43	2006	3045.06	740.97	564.66	4350.69
1990	555.90	155.01	45.77	756.69	2007	3402.64	831.92	646.35	4880.91
1991	604.58	162.35	50.77	817.71	2008	3722.19	906.77	712.82	5341.78
1992	663.65	173.89	58.15	895.70	2009	4097.23	988.92	787.55	5873.69
1993	734.38	188.55	69.82	992.75	2010	4540.13	1086.10	881.65	6507.88
1994	832.67	212.36	85.21	1130.25	2011	5026.69	1172.13	965.49	7164.31
1995	948.92	232.06	105.65	1286.63	2012	5597.98	1277.36	1064.83	7940.16

Note: K1 indicates the productive capital stock of construction and installation; K2 indicates the productive capital stock of purchase of equipment and instruments; K3 indicates the productive capital stock of others.

As shown in Table 1, the productive capital stock of each asset is increasing in researching period. The total amount of productive capital stock increases by 70 times from 112.6 hundred million in 1978 to 7940.2 million in 2012. As for the structure, the proportion of construction and installation is kept about 70% in the researching period; the share of purchase of equipment and instruments changes slowly from 23% in 1978 to 16% in 2012; the ratio of other expenses increases from 5% to 13%. On the whole, the capital scale of purchase of equipment and instruments is close to that of other expenses. In terms of the increment speed, the increase of productive capital stock experiences three stages: the capital accumulation expands rapidly from 1978 to 1986, in which period the growth rate of capital is above 17%, even over 20% at several years; the increment speed of capital accumulation slows down significantly from 1987 to 1992, basically maintaining above 7% and below 10%; since 1993, the growth rate of productive capital stock has increased keeping at a level above 10%.

CONCLUSION

Capital plays an important role in production. And in macroeconomics, the measure of capital input and its contribution to production has been a spot in research. Although OECD has successively issued two capital manuals to guide the measurement of capital in the world, there are many technical details to be completed in practice because of the differences in the market efficiency and data foundation. This paper takes Beijing city as the research object, referring to the 2008 SNA's concepts and categories on capital service, making the full use of existing data, applying the PIM method to estimate the capital services and its indices of 1978-2012. Because the capital service estimate is a new research field in China, the conclusions of this research can provide data support for the accurate accounting of total factor productivity and the decision support for the economic growth policies making in Beijing.

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