

Dynamic Estimation on Output Elasticity of Highway Capital Stock in China

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Abstract. By using the Perpetual Inventory Method to calculate the capital stock of highway in China from 1988 to 2016, the paper builds the State Space Model based on Translog Production Function, according to the Ridge Regression and Kalman Filter Method, the dynamic estimation results of output elasticity are measured continuously and analyzed. The conclusions show that: Firstly, China's growth speed on highway industry capital stock are divided into three stages which are respectively from 1988 to 2000, from 2001 to 2009 and from 2010 to 2016, during which shows steady growth, between which reflect rapid growth; Secondly, the output elasticity of highway capital stock, being between 0.154 and 0.248, is slightly larger than the output elasticity of human input factor, lower than the output elasticity of the technical level, shows positive effect on transport economy and rises steadily, but the output efficiency is low on the whole; Thirdly, around the year of 2010, the scale pay on highway industry begins to highlight the characteristic of increase.

1. Introduction

By the end of 2016, China's highway mileage reaches 130,000 kilometers, ranking first in the world and providing a good transportation guarantee for the stable growth of China's economy. It is estimated that the added value of the total value of society will be about 3 yuan for each 1 yuan invested in highway construction, the added value of GNP will be about 0.4 yuan, as the core of comprehensive transportation system, the construction speed and quality of highway reflect the overall level of China's economic development to some extent, the accounting of capital stock and the study of its output elasticity are the basis to clarify the role of highway construction in promoting the development of national economy. Capital stock is an important factor of production input in the process of economic growth, the constant investment of highway construction will lead to the accumulation of capital stock, the accumulation of capital stock is bound to drive the increase of national wealth and the growth of the national economy, and how much the highway capital stock contributes to the industry economy is the focus and difficulty on research related to highway.

In terms of capital stock estimation, a kind of capital stock theory estimating method generally accepted abroad is the Perpetual Inventory Method (PIM). The mainly three methods are adopted on domestic capital stock estimating. First, the perpetual inventory method (PIM). At present, most domestic scholars adopt this method to estimate the capital stock, but there are significant differences in the selection of specific indicator, the processing and assumption, etc. Second, the perpetual inventory method extended. Compared with PIM, the expanded PIM is more complicated in operation, although



the method extends the function of PIM, but it is not widely used. Third, other methods based on accounting. This kind of method belongs to a new method. It is only a case study, which does not estimate based on PIM, and cannot explain the scientific nature and rationality of its application. In the calculation of highway capital stock, Liu *et al.* (2007)^[1] calculated the capital stock of highway and waterway in China from 1952 to 2004 by using the method of PIM, the technical questions were described in detail in the process of measurement, such as the data missing and the depreciation rate, etc. Dong *et al.* (2011)^[2] only estimated the capital stock of highway in China from 1952 to 2009, the decomposition weighting method was adopted in the treatment of depreciation rate for the first time, and provided a thought for the calculation of capital stock on single asset; Xing *et al.* (2012)^[3] discussed the selection of the four indexes on China's highway based on the results of domestic and foreign research, and then estimated the highway capital stock from 1952 to 2010. At present, there are relatively few research results which estimate the capital stock for single asset such as road in China.

In terms of the output elasticity estimation, the foreign estimation literatures related mainly adopt the quantitative production function method^{[4]-[5]}. In recent years, we have learned from foreign research experience, but the research results are still relatively rare, the representative research results are as follows: Zhang *et al.* (2009)^[6] gave a detailed description and comparative analysis on advantages and disadvantages of nonparametric model, variable coefficient model, variable parameter model and panel data model, and pointed out that the combination would be the next research direction. Wang (2010)^[7] calculated the output elasticity of various energy in Shandong province and found that it was increasing year by year. Han (2012)^[8] used the expanded C-D function to measure the knowledge stock of high and new technology industry. Jin^[9] completed a complete calculation about capital stock of infrastructure and non-infrastructure in China in 2016, and finally realized the quantitative estimate of its capital stock output efficiency.

To sum up, scholars' understanding on the relationship between the output elasticity of capital stock and its related research methods have been gradually deepened and formed consensus in some ways. First, the basic method of capital stock estimation is consistent in selection; Second, that researchers use the regression method while estimating the output elasticity are mainly on the basis of production function, the results show that the positive economic effect of capital stock will fluctuate in different economic times; Third, the research on the output elasticity of capital stock of R&D and infrastructure is focused on. The consensus that people form is bound to have its reasonable place of existence and deep development, but it also exposes research defect: Firstly, it is impossible to reflect the trend of the change in the output elasticity on capital stock with the change of economic times in terms of research methods, and there are fewer dynamic improvements on them; Secondly, the scope is limited that people mainly estimate the total capital stock of R&D and infrastructure in terms of studying objects. Therefore, this paper has a great research space for the dynamic estimation of the output elasticity on the highway capital stock, which can help the highway industry to make scientific investment decisions.

The contribution and innovation points of this paper are mainly reflected as follows: 1. measurement of capital stock of single item capital on highway; 2. the paper builds the State Space Model based on Translog Production Function which includes the technical progress variable and the total output of the transportation industry in the previous year replaces the technical progress variable, eventually the dynamic value of output elastic of highway capital stock will be obtained with higher precision by using the Ridge Regression Function to solve the multiple co-linear problem of variables and the parameters of regression as the initial value for the Kalman Filter Method are used to implementing dynamic estimation of highway capital output elasticity.

2. Research design

2.1 Calculation of highway capital stock

Xiao *et al.* (2005)^[10] proved that the average reset rate was equal to the reset rate in the decline mode of geometric efficiency, which indicates that the resetting is equivalent to depreciation in the recovery process of capital productivity in this model. Therefore, this paper selects the form of PIM in the decline

mode of geometric efficiency, as shown in formula (1).

$$K_t = I_t + (1 - \delta_t)K_{t-1} \quad (1)$$

In formula (1), the letter “ t ” represents that it is the year of t in the study interval, “ K ” represents the capital stock expressed by the constant price, “ I ” represents the fixed investments expressed by the constant price, “ δ ” represents the reset rate. It can be seen that the determination of 4 indicators including δ 、 I 、 K_0 and price indices of investment are involved in the calculation process of capital stock from formula (1).

2.1.1 Determination of the capital stock of base year (K_0)

The starting point of research in existing literature is mainly based on 1952 or 1978, the former selected is mainly due to error effect and the latter is due to the reform and opening year. China's the highway construction started in 1984 and the first highway was opened to traffic in 1988, the paper selects 1988 as the base year of the research on capital stock in order to reduce the impact of estimation error on the results of subsequent years and consider the value of output and the availability of data. The estimation methods of capital stock in the base year mainly include 2 types: First, the method of capital output ratio, its estimation difference on ideas can lead to a large deviation of the estimation results; Second, the estimation method of steady state. It was widely used by authoritative scholars, such as Zhang (2004)^[11], Shan *et al.* (2008)^[12], they used the ratio of fixed investments to 10% for obtaining the data of capital stock in the base year. The study found that the capital stock of the base year had less influence on the estimation results, and any methods of calculation were advisable^[13]. In order to determine the initial capital stock of the highway, the capital stock of the fixed investments on highway in 1988 is directly used as the initial capital stock (because when the data of fixed investments which are missing are calculated, the highway mileage of 1988 is the cumulative total mileage, rather than the new highway mileage added), and no proportional division, therefore, the initial capital stock on China's highways in 1988 was 165.7 billion yuan according to calculation result of figure 1.

2.1.2 Determination of annual fixed investments (I)

He (1992)^[14] and Chow *et al.* (1993)^[15] determined the fixed investments of each year from the data of productive accumulation, Fan *et al.* (2012)^[16] determined the annual fixed investments by the product of the total fixed investments and application rate of fixed assets. In the two methods above, the former no longer had the applicability of the measurement conditions of PIM, and the application rate of the latter was not available. Then Zhang (2004)^{[11]37-40} estimated the capital stock again, directly selected the total fixed investments as the basis for the calculation of the index, and did not deduct according to proportion. Shan (2008)^{[12]22-27} explained rationality of practice of Zhang's (2004) study in detail, the paper accepted the treatment of Zhang, Shan and other scholars in order to avoid the impact of subjective factors and selected the fixed investments as the indicator of investment flow. The statistical caliber of data of the fixed investments on highway industry were adjusted twice in 1999 and 2010 during the study period, fixed investments of highway were selected as the statistical caliber of relevant data in “Comprehensive Statistical Data and Materials on 50 Years of New China” from 1988 to 1998, and the completed investments of key projects of highway were selected as the statistical caliber of relevant data in “Statistical Communique of Transportation Industry of Highway and Waterway” from 1999 to 2009, the fixed investments of highway can be taken directly from “Statistical Communique of Transportation Industry of Highway and Waterway” from 2010 to 2016. In order to obtain the data of fixed investments of highway, this paper adopts different methods to estimate the data required of the two phases from 1988 to 1998 and from 1999 to 2009. In the previous stage, starting in 1988, setting that the cost of the highway increases at a rate of 0.1 billion yuan per two years (according to estimation), and using the new highway mileage and the average cost of the highway mileage which is 0.1127 hundred million yuan per kilometer in this stage to calculate (based on the cost of highway in 1988); In the latter stage, the paper uses the radio of the new highway mileage to the sum of the new highway mileage and the new first grade highway mileage, and applies the product of annual investment of highway key project

in this stage to calculate. Finally, figure 1 shows the data determined of fixed investments on highway (unit: hundred million yuan) in each year:

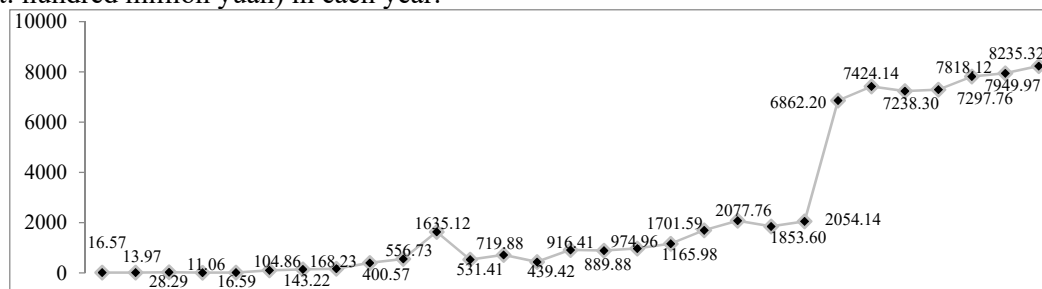


Figure 1 The trend chart of fixed investments of highway determined

2.1.3 Determination of the reset rate (δ)

Due to the relatively objective data on the annual date of fixed investments and highway capital stock in the base year, the estimation results of capital stock are greatly affected by the reset rate of assets. If the reset rate is small, the estimated results of highway capital stock will be on the high side, strictly speaking, the reset rate is closely related to the development level of the economic, social and the utilization rate of assets, etc. and changes with its change, in view of the limitations on research conditions, this paper attempts to reflect the level of the reset rate in the study period with objective estimation methods. There are four main ways to determine the reset rate: empirical estimation method; iterative method of the depreciation rate of the input-output table; depreciation weighting method; statistical method. Empirical estimation is more subjective and the science is open to discussion, the depreciation rate in iterative method is based on the accounting cost method, which does not meet the conditions of Perpetual Inventory Method, the assumption that the scale compensation is invariable in the statistical method is not necessarily applicable to the highway industry. Obviously, the service lifetime and expired relative efficiency of different assets in different years of highway are different while the depreciation weighting method can compensate for this defect in a way, namely, calculating the depreciation rate of the fixed assets of highway, giving the corresponding weight, and finally getting the comprehensive depreciation rate. "Highway Design Manual" divides the highway assets into some parts, such as pavement, subgrade, land and auxiliary facilities, etc. Assuming that the service lifetime of asphalt pavement is designed for 15 years, the service lifetime of cement concrete pavement is designed for 25 years, the service lifetime of subgrade is designed for 100 years, the service lifetime of bridges and tunnels is designed for 75 years, the land has the right to use only, and the service lifetime is designed indefinitely, the service lifetime of other buildings and facilities is designed for 15 years, the depreciation rate is the reset rate in the geometric efficiency mode, therefore, the estimation formula of the reset rate is shown in (2).

$$d_t = (1 - \delta)^t \quad (2)$$

This paper adopts the setting of the relative efficiency from Liu *et al.* (2007), which was four percent when calculating the capital stock of highway and waterway, at the same time, the depreciation weights of various assets of highway are determined by the proportion of the fixed assets investment, and the reset rate and the comprehensive reset rate of the assets of the highway are obtained, as shown in table 1.

Table 1 The reset rate of different asset types of highway

| Different Asset Type | Service Lifetime Design | Expiration Relative Efficiency | Reset Rate | Weight | Comprehensive Reset Rate |
|----------------------|-------------------------|--------------------------------|------------|--------|--------------------------|
| Subgrade | 100 | 4% | 3.17% | 0.49 | |
| Pavement | 20 | 4% | 14.87% | 0.10 | |
| (Average Lifetime) | | | | | |
| Bridges and Tunnels | 75 | | 4.20% | 0.37 | 5.48% |

| | | | | |
|--------------------|----|----|--------|------|
| (Average Lifetime) | | | | |
| Land | - | - | - | - |
| Other Structures | 10 | 4% | 19.31% | 0.05 |

Note: Since the specific investment data of different assets cannot be obtained, the data are calculated by the principle that the weight value is proportional to the design service lifetime.

According to table 1, the comprehensive reset rate is between 5% and 6%, the design service lifetime of the highway is usually less than the actual lifetime. Compare with the reset rate of total industry, the comprehensive reset rate which is 5.48% and calculated in this paper is low, but it is consistent with the reset rate of the same industry.

2.1.4 Determination of the investment price index

The price index from 1990 to 2015 comes from official data, in order to determine the price index of 1989 and 2016 (the date has not been released), this paper attempts to apply the gross fixed capital formation of social and the correspondence index to estimate the official data of the price index from 1990 to 2015, the error is between 0.09 and 0.03 and the matching effect is preferable, the specific estimation method is shown in (3).

$$\text{Fixed capital formation index (Fixed capital formation index)} = \frac{\text{gross fixed capital formation / the implicit investment deflator (the previous year was the base period)}}{\text{gross fixed capital formation last year}} \quad (3)$$

The result of the price index of 1989 is 94.3 (the data required is taken from "China's GDP Historical Accounting Data: 1952-2004"), the formula (3) cannot estimate the price index in 2016 due to the lack of the data of total fixed capital formation calculated by the price of current year in 2017. However, the price fluctuation of Shanghai is basically the same as that of the national price. The paper directly adopts the price index data of Shanghai (published by Shanghai statistics bureau, taken as 100.8) instead of the national price index in 2016. The fixed asset price index of each year (the previous year is the base period) is shown in figure (2).

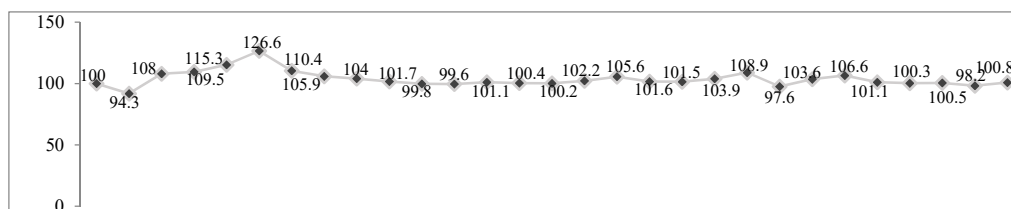


Figure 2 The price index of investments in fixed assets from 1988 to 2016

2.1.5 Results calculation

The four indicators needed in the process of measurement have been identified, the formula (1) is used to measure the capital stock of highway, and the specific calculation results are shown in figure 3.

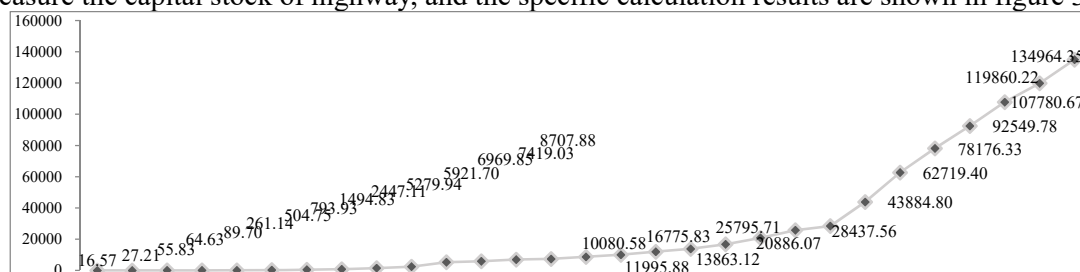


Figure 3 The calculation results of the capital stock of highway from 1988 to 2016 (based on the year of 1988)

As can be seen from FIG. 3, the capital stock of highway in China has experienced two significant changes in the research phase, which is about every 10 years for a stage. There are three periods of steady growth and three stages of rapid growth, the reason for the change may be the government's

policy changed over the 10-year period, or the statistics department was adjusting the statistical caliber for every 10 years. Eventually it resulted in the rising regularly on the capital stock of highway in China, and this paper is more inclined to the explanation of former. In particular, the development of highway in China was in its infancy stage before 2000, but it had broken through the bottleneck of highway construction and the capital stock increased slowly; The government had adopted a fast way of reinforcing infrastructure constructions to stabilize the domestic economy in response to the financial crisis, and the capital stock growth of China's highway had accelerated from 2000 to 2009; The financial crisis that broke out again caused China's economy to face the risk of a hard landing about the year of 2009, so as to expand domestic demand and stabilize the economy, transportation infrastructure had been developed as a major investment priority, in addition, due to the economic development demand for highway transportation in this stage, the highway mileage rose to the forefront of the world. Therefore, the calculation results of highway capital stock in this paper are in line with the reality of economic and social development, the validity and rationality appear in this results, this paper determines the index based on the previous research about the capital stock and the principle of high fitting and quantitative objective (currently, no scholars have measured the capital stock of highway, and it is difficult to compare and analyze the specific measurement data, therefore, it can only be explained from the level of implementation and operation level and the perspective of the rationality of the results).

2.2 Building dynamic estimation model

The essence of the output elasticity is the productivity of the input factors, at present, most scholars exploit traditional production functions to estimate the elastic coefficient of output, and the results are all fixed values, the paraphrase is the annual average production efficiency of input factors, obviously, this result is difficult to make scientific and reasonable explanation for the fluctuation of output efficiency in various years, and it is biased against the actual production efficiency of each year. Different from previous output elasticity estimation model, the paper attempts to build an improved dynamic model to illustrate preferably the fluctuating trend of the output elasticity of capital stock in China's highway industry. In the field of economic research, the basis for estimating input-output efficiency is the determination of the production function, and the coefficients of input factors in production function are the output elasticity. The production function is built and the dynamic improvement process is implemented based on the State Space Model for the purpose of the dynamic estimation.

It is assumed that x_1 、 x_2 、...、 x_n are all different input factors, the expression of the production function is shown in (4)^[17]:

$$\frac{dY}{Y} = \alpha_1 \frac{dx_1}{x_1} + \alpha_2 \frac{dx_2}{x_2} + \dots + \alpha_n \frac{dx_n}{x_n} \quad (4)$$

Because of the economic characteristics of the research object, it can only be transformed into a special production function to meet the needs of economic research and realize the simplification purpose of the quantitative process, and it's not limited to rigid mathematical meaning, therefore, the general function form shown in (4) cannot be used directly for model analysis.

In order to further clarify the fluctuation of the output elastic of capital stock of highway in China, this paper sets the production function that its assumption condition is more realistic, has a high fitting degree and a strong inclusiveness, from economic point of view, the capital factor "K" and the labor factor "L" are selected as the input factors for the total production function, so as to reduce the negative effects because of the excessive setting of variables, at the same time, technological progress variable is introduced, and the technological progress variable is assumed to be mainly influenced by economic factors^[18]. The total output of the transportation industry in the previous year (τ) expresses the technological progress variable.

In formula (4), "n" equals to 3, x_1, x_2, x_3 are replaced by "L", "K", " τ " respectively, " α_1 ", " α_2 ", " α_3 " are replaced by " $\beta_K + \beta_{KL} \ln L + \beta_{K\tau} \ln \tau + 2\beta_{KK} \ln K$ ", " $\beta_L + \beta_{Lk} \ln K + \beta_{L\tau} \ln \tau + 2\beta_{LL} \ln L$ ", " $\beta_\tau + \beta_{\tau L} \ln L + \beta_{\tau K} \ln K + 2\beta_{\tau\tau} \ln \tau$ " respectively, the general production function is simplified as the basic

form of the Translog Production Function, and random error term “ u_t ” and constant “ β_0 ” are added to correct the function expression. The formula for the expansion Translog Production Function is shown in (5):

$$\ln Y = \beta_0 + \beta_\tau \ln \tau + \beta_K \ln K + \beta_L \ln L + \beta_{KK} (\ln K)^2 + \beta_{LL} (\ln L)^2 + \beta_{\tau\tau} (\ln \tau)^2 + \beta_{KL} \ln K * \ln L + \beta_{\tau L} \ln \tau * \ln L + \beta_{K\tau} \ln K * \ln \tau + \mu \quad (5)$$

The formula (5) is defined as the measurement equation, and the equation of state is built as follows.

$$\beta_t = \gamma \beta_{t-1} + \varepsilon \quad (6)$$

For the sake of simplicity, formula (6) represents the general expression of parameter state equation with different variables, “ t ” represents the time span of the study, at this point, formula (5) is the measurement equation, formula (6) is the state equation, and the dynamic estimation model of state space is established, then the output elastic expression of capital factor “ K ”, labor factor “ L ”, and technical progress variable “ τ ” are shown in formula (7), formula (8) and formula (9).

$$\alpha_{Kt} = \beta_{Kt} + \beta_{KLt} \ln L_t + \beta_{K\tau t} \ln \tau_t + 2\beta_{KKt} \ln K_t \quad (7)$$

$$\alpha_{Lt} = \beta_{Lt} + \beta_{Lkt} \ln K_t + \beta_{L\tau t} \ln \tau_t + 2\beta_{LLt} \ln L_t \quad (8)$$

$$\alpha_{\tau t} = \beta_{\tau t} + \beta_{\tau Lt} \ln L_t + \beta_{\tau Kt} \ln K_t + 2\beta_{\tau\tau t} \ln \tau_t \quad (9)$$

According to the formula (7), formula (8) and formula (9), “ α_K ”, “ α_L ” and “ α_τ ” are the output elasticity of variables of capital stock, labor, and technical progress, the output elasticity will change with the change of the study period “ t ”, expressing the meaning of the fluctuation process of the sensitivity of the output to input elements.

3. Empirical analysis

3.1 Data acquisition, processing and testing

The data of capital stock of highway have been obtained, and now only data following are needed, such as labor variable “ L ”, total output variable “ Y ”, technological progress variable “ τ ” and so on.

In order to ensure the objectivity and authenticity of the data, this paper uses the Gross Domestic Product (GDP) of transportation, storage and post industries to describe the total industry output variable, and the data of 1987 to 2015 (due to the technological progress measure problem, the relevant data of 1987 is in need) are derived from the “China Statistical Yearbook 2016”; Due to the official data of 2016 not yet be released, the data in 2016 are derived from the sum of the average added value of GDP of transportation, storage and post from 2010 to 2015 (since 2000, the national bureau of statistics have changed the statistics' base year of GDP for every 5 years) and GDP of transportation, storage and post industries obtained at the current prices of 2015; In order to eliminate the impact of price factor, the GDP of transportation, storage and post industries is converted into the unchanged price in the base year of 1988 by the GDP deflator.

the total amount of employees of 18 listed companies of the highway industry each year express labor factor input, due to time difference, the data can only be obtained after 2002, and taken from the “Highway Listed Companies Annual Report”, the data before 2002 need to be calculated, and are deducted according to the ratio of the number of postal employed persons to the number of employees in the high-speed industry in 2002-2016, it can be reckoned backwards since 2016, the deduction ratio is 200 times, 300 times, 400 times, 500 times, 600 times, and the fixed ratio remains each 5 years. The data of transport, storage and post are taken from the “China Statistical Yearbook”.

The data of technological progress variable are showed by the preceding industry's total output, so the relevant data can be obtained from it. The descriptive statistics of relevant data are shown in table 2.

Table 2 Descriptive statistics of variables data

| Variable(29) | Minimum Value | Maximum Value | Mean Value | Standard Deviation |
|------------------|---------------|---------------|------------|--------------------|
| K (Billion) | 16.57 | 134964.35 | 27856.01 | 39441.54 |
| L (Million) | 1.24 | 4.46 | 2.09 | 1.02 |
| τ (Billion) | 518.70 | 29035.28 | 9261.19 | 8444.06 |
| Y (Billion) | 685.90 | 30512.61 | 10295.46 | 9119.76 |

Note: Except the labor variable, the variables' data remained are based the year of 1988.

For the sake of demonstrating the stationarity of time series data and the long-term equilibrium relationship between variables, EVIEWS 6.0 software is used to carry out integration test and co-integration test on variables for avoiding the phenomenon of "Spurious Regression". The results of the ADF test show that the stationarity of $\ln K$, $\ln L$, $\ln K \ln L$, $(\ln L)^2$ and $(\ln K)^2$ appear at the significant level of 1%, $(\ln \tau)^2$, $\ln L \ln \tau$, $\ln K \ln \tau$ and $\ln \tau$ show first order integration stationary sequence at the significant level of 10%. First difference on $(\ln \tau)^2$, $\ln L \ln \tau$, $\ln K \ln \tau$ and $\ln \tau$ are done by EVIEWS 6.0 software again, and making $\ln K$, $\ln L$, $\ln K \ln L$, $(\ln L)^2$, $(\ln K)^2$ and other five variables with uniformly integration. Then the Johansen Cointegration Test command is executed by establishing vector autoregressive model with a lag order (AIC/SC criterion). The results show that the co-integration of the nine variables are all significant at the level of 10% and have long-term stable equilibrium relationship.

3.2 Parameters estimation

There are 9 variables in dynamic estimation model, being highway capital stock, highway industry employees and GDP of transportation, storage and post industry, industry technological progress and interactive items of three input variables, due to the number of variables, so as to ensure the effectiveness of the model's regression, EVIEWS 6.0 software runs to diagnose the collinearity of model variables. The results show that the variables of $\ln \tau$, $\ln K \ln L$ and $\ln K \ln \tau$ appear serious collinearity. The Ridge Regression Analysis method can solve the problem well. For the integrity of the variables, in this paper, the method is used to estimate the parameters of equation (5). The estimation process is implemented by the software of NCSS 2007 and SPSS 20.0. The regression results are shown in table 3.

Table 3 Parameters estimation results preliminarily by Ridge Regression

| Variable | Regression Coefficient | Standard Error | T Statistic | VIF | F Statistic | P | K | R ² |
|--------------------|------------------------|----------------|-------------|-------|-------------|-------|-------|----------------|
| $\ln K$ | 0.080 | 0.011 | 4.724* | 0.721 | | | | |
| $\ln L$ | 0.079 | 0.075 | 3.454* | 0.775 | | | | |
| $\ln T$ | 0.213 | 0.022 | 1.621** | 0.514 | | | | |
| $(\ln K)^2$ | 0.004 | 0.001 | 3.091* | 0.168 | 108.136 | 0.000 | 0.001 | 0.981 |
| $(\ln L)^2$ | -0.005 | 0.058 | 1.281*** | 0.138 | | | | |
| $(\ln \tau)^2$ | 0.012 | 0.001 | 2.083** | 0.262 | | | | |
| $\ln K * \ln L$ | 0.006 | 0.003 | 2.983** | 0.539 | | | | |
| $\ln K * \ln \tau$ | 0.006 | 0.000 | 1.173*** | 0.518 | | | | |
| $\ln L * \ln \tau$ | 0.008 | 0.004 | 0.024 | 1.303 | | | | |
| β_0 | 0.191 | 0.007 | 0.182 | | | | | |

Note: "****", "***", "**" respectively represent the significant level of 1%, 5% and 10%.

According to the report results of Ridge Regression, the ridge values are extremely stable about 0.001, almost coincides with a straight line, the fitting degree value of the measurement equation is 0.981, and passes the significance level test of 1%, and the fitting effect is great. The sum of Variance Inflation Factor is less than 10, and the multi-collinearity of the variables is effectively eliminated. Except for the interaction of the labor force and the technological progress and the constant term, the test level of each variable is significant obviously. In addition, the coefficient of labor variable interaction is negative, the regression coefficient of other variables are all positive, indicating that China's highway capital stock, technological progress and other factors play positive impact, and labor input shows excess signs. From 1988 to 2016, China's highway labor force factor shows the trend of increasing first and then decreasing, the capital stock factor is increasing year by year. Therefore, the theoretical analysis of the Ridge Regression parameter is basically consistent with the actual economic situation. The measurement equation expresses certain explanatory power.

So as to filter the useless information on the interference of regression coefficients, and optimize the estimation error and the algorithm, the paper tries to set each estimated parameter of the Ridge Regression in table 4 as the initial value, then the unknown parameters of the equation (6) are estimated by means of Kalman Filter Method with MATLAB 2015a software realizing filtering algorithm, and the coefficient of each variable is obtained. The parameters estimation results are substituted into the equations of (7), (8), (9). The dynamic values (α_K , α_L , α_τ) of output elasticity on three elements (K, L, τ) are gotten, as shown in table 4.

Table 4 Dynamic estimation results of output elasticity by Kalman Filter Method

| Year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| α_K | 0.154 | 0.162 | 0.172 | 0.160 | 0.163 | 0.173 | 0.179 | 0.185 | 0.191 | 0.197 |
| α_L | 0.146 | 0.150 | 0.155 | 0.158 | 0.161 | 0.169 | 0.176 | 0.181 | 0.186 | 0.188 |
| α_τ | 0.378 | 0.388 | 0.396 | 0.404 | 0.411 | 0.422 | 0.430 | 0.440 | 0.447 | 0.455 |
| Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| α_K | 0.203 | 0.204 | 0.206 | 0.207 | 0.209 | 0.211 | 0.214 | 0.217 | 0.220 | 0.223 |
| α_L | 0.194 | 0.197 | 0.199 | 0.202 | 0.204 | 0.205 | 0.205 | 0.205 | 0.207 | 0.208 |
| α_τ | 0.462 | 0.464 | 0.467 | 0.472 | 0.475 | 0.479 | 0.483 | 0.487 | 0.493 | 0.498 |
| Year | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | |
| α_K | 0.226 | 0.228 | 0.233 | 0.237 | 0.240 | 0.243 | 0.245 | 0.247 | 0.248 | |
| α_L | 0.211 | 0.211 | 0.213 | 0.214 | 0.216 | 0.217 | 0.218 | 0.218 | 0.220 | |
| α_τ | 0.503 | 0.509 | 0.513 | 0.518 | 0.524 | 0.528 | 0.532 | 0.535 | 0.538 | |

3.3 Estimation results analysis

The dynamic estimation results are shown in table 4. The output elasticity of highway capital stock, highway labor force and industry technological progress are located at 0.154~0.248, 0.145~0.220 and 0.377~0.538, indicating that the elements have significant positive impact on transportation economy. Since 1988, the output elasticity of each factor has been increasing year by year, which shows that utilization efficiency of each input factor, such as capital, labor force and science and technology, is great, but the overall output efficiency is low and the input on these three elements should continue to increase. The output effect of the transportation industry brought by technological progress is higher than that of its capital and labor force, which shows that the scientific and technological plays a leading role in promoting the economic growth. In terms of growth trend on output elasticity, the fluctuation ranges of the labor force factor and the capital stock factor are basically consistent, which reflects the relative balanced proportion of the input factors on highway industry during the period of starting development, slow development and rapid development. In the framework of this study, the elasticity values of three input factors are added, being informed that capital and labor force input factors are weak in promoting economic growth of transportation industry before 2010, then gradually be greater. It shows the increased scale returns. According to the development trend, there is still room for development of transportation industry, but the development speed will slow down, because China's highway mileage has exceeded 130,000 km, the number of associated infrastructure ownership is a little bit large, the use efficiency of highway capital in underdeveloped areas is low, then its output elasticity will be on the low side. However highway mileage and network density are close to saturation in developed areas. Factors input mainly emphasis on highway maintenance and others in the next. Under the condition of total regional economic capacity, if there is strong factor input, there will be possibility of reducing the level of output elasticity on national highway capital stock.

Then the reasonable explanations for the estimation results of output elasticity are made. On the one hand, it can be seen from FIG.3 that two downturns in the study period had certain effect on the growth rate of highway industry's capital stock in China, from table 4, it indicates that the two financial crises didn't have significant negative impact on its output efficiency, because the policy tendency would make influence on it, not only the market factors, so the estimation results trend of output elasticity on capital stock are consistent with the reality; On the other hand, the study on output elasticity estimation of

highway capital stock is rare, so no analysis results relative can be compared, but the study object with same type could be selected for contrast. Based on Jin's (2016) analysis on the output elasticity of China's infrastructure, being found that the elasticity value of infrastructure capital stock was 0.23 and the elasticity value of labor force was 0.29 in the unconstrained model. In terms of hypothesis conditions in the model, it is loose in the paper, being close to reality, so the model in this thesis can be taken for the unconstrained model. In terms of estimation results, the average value of output elasticity on capital stock factor is 0.21, the average value of output elasticity on labor force factor is 0.20, the latter is roughly consistent with the former. Therefore, the method and results are valid.

4. Conclusion

The paper uses the perpetual inventory method to estimate the highway capital stock in China, uses the Translog Production Function as the measurement equation and the time lag of parameters in the function as the state equation, builds the State Space Model, uses the Ridge Regression function to solve the multiple co-linear problem of variables, and uses the parameters of regression as the initial value to implement dynamic estimation of highway capital output elasticity by using the Kalman Filter Method, draw the following conclusions:

- The capital stock of the highway industry in China has three distinct growth stages, in 2000 and 2009 as the time node, the capital stock of China's highway industry growth rate is divided into 3 stages, showing the steady growth during each phase, but rapid growth at the whole. During the period of 1988-2000, the capital stock increases slowly; during the period of 2001-2009, the capital stock growth gradually accelerated; and during the period of 2010-2016, the capital stock rises rapidly;
- The output elasticity of factors were all positive and increased gradually during 1988 to 2016, including the capital stock of highway, labor input industry technical progress, etc., showing that three variables had positive roles in promoting the economic growth of industry within the study period. The scientific and technical progress of transportation industry plays a leading role in promoting the process of economic development, the output elasticity of capital stock is slightly larger than the human output elasticity, but the output efficiency is low;
- After 2010, the gross value of highway capital stock, labor and technological progress in China is greater than 1, indicating that the scale returns of capital of industry began to highlight the nature of increasing, China could still moderately increase in capital, labor, technology and other inputs, but not too much.

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