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EMPIRICAL STUDY ON BIASED TECHNICAL CHANGE OF CHINESE ECONOMIC GROWTH BY VARYING COEFFICIENT MODEL

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Abstract. *The direction of the biased technical change is of great importance in the economic research. In this paper we extend the classical Cobby-Douglas production function to a varying coefficient form and apply it to the Chinese economic growth data from 1978 to 2006. The empirical study shows a capital biased technical change in the early years and a labor biased technical change in the recent years.*
Keywords: Varying coefficient, biased technical change.

1. **Introduction.** Economic growth is one of the most important questions in the economics. Among the numerous studies on the economic growth, the analysis of technical change is one of the central problems. Hicks (1932) had established a set of classifications of technical change and tons of research was done on it since then, for instance, see Harrod (1948), Solow (1959), Uzawa (1961), Acemoglu (2002) and among others.

Since China is among the fastest developing country, its economic growth has drawn a lot of attention. Recently many scholars have studied the technical progress in Chinese economic growth both theoretically and empirically. See for instance, Ran and Cao (2007) discussed the relation between technical progress and employment promotion in China; Liu (2010) pointed out the capital biased technical change influences average labor wage rate; Su (2010) had done a theoretical and empirical research on how the biased technical change impacts the Chinese labor market, and so on.

In this paper the classical Cobby-Douglass production function will be extended to a varying coefficient form, which relaxes the constrain of the fixed capital elasticity and labor elasticity. Then an empirical study will be applied to show the direction of the biased technical change.

The paper is organized as following, the next section we explain the theoretical method and estimation model. The section three will be the empirical data analysis and we draw a conclusion in the last section.

2. **Methodology.** The classical Cobby-Douglass production function is as following:

$$Y = AK^{\alpha}L^{\beta},$$

where A is the FTP, K refers to the index of the capital and L refers to the index of labor. Under the condition of constant return to scale, we require $\alpha + \beta = 1$. In this classical model, the α and β are the time independent capital elasticity and labor elasticity.

Although the above model is widely used, the constrain of the time independent elasticity is not practical especially in developing countries like China. Recently some scholars havd developed the production model with time dependent elasticities, for instance, see

Zhang and Xu (2009), Luo, Yang and Zhou (2009). Here we extends the Cbby -Douglass production function under the assumption of constant return to scale.

By the constant return to scale, we have

$$y = Ak^{\alpha},$$

where $y = \frac{Y}{L}$ and $k = \frac{K}{L}$. Now take logrithm on both sides,

$$lny = lnA + \alpha lnk.$$

Here we extends the constant elasticity α to a functional form as following

$$lny = lnA + \alpha(t)lnk, \tag{1}$$

which means the elasticity is time dependent though an unknown function form.

For the bias of the technical change, Hicks pointed out that the technical change is labor-saving if the marginal product of the capital increases more than the marginal product of the labor under the fixed capital labor ratio, and it is now called the capital biased. Denote

$$r = \frac{\partial Y}{\partial K} \quad w = \frac{\partial Y}{\partial L} \quad and \quad p = \frac{r}{w},$$

we have that under fixed k the technical change is capital biased if

$$\frac{dp}{dt} > 0,$$

and is labor biased if

$$\frac{dp}{dt} < 0.$$

If the derivative of p is zero, then it is called the Hicks neutral. It is easy to see that under the classical Cobby-Douglas production function, the technical change is Hicks neutral since the elasticities are time independent.

Under the assumption of constant return to scale, we have

$$r = \frac{\partial lny}{\partial lnk}\frac{y}{k},$$

and

$$w = y - kr.$$

Therefore

$$\begin{aligned} p &= \frac{r}{w} \\ &= \frac{\frac{\partial lny}{\partial lnk}\frac{y}{k}}{y - \frac{\partial lny}{\partial lnk}y} \\ &= \frac{\frac{\partial lny}{\partial lnk}}{k(1 - \frac{\partial lny}{\partial lnk})} \\ &= \frac{\alpha(t)}{k(1-\alpha(t))}. \end{aligned} \tag{2}$$

Now we can do the empirical study by the above equations (1) and (2).

3. **Empirical Results.** In this section an empirical study is applied on the Chinese economic growth data from 1978 to 2006. The output Y is the real GDP of each year, which is adjusted to the RMB value of year 1978. The capital index K is the Fixed Capital Stocks, which is also adjusted to the RMB value of year 1978. The labor index L is the number of employed people in the year, which is the average of the number of working people in the beginning of the year and that number in the end of the year. The FTP is assumed to be determined by education index, the standard road mileage and the ratio of urbanization. All the data are from "The Chinese Statistics Year Book" and "The Historical Data of Chinese GDP".

The specific model is as following:

$$lny_t = \beta_1 Z_{1t} + \beta_2 Z_{2t} + \beta_3 Z_{3t} + \alpha(t) lnk_t, \tag{3}$$

where $y = \frac{Y}{L}$, $k = \frac{K}{L}$, Z_1 is the index of education level, Z_2 is the standard road mileage and Z_3 is the ratio of urbanization.

The model (3) is a typical semiparametric varying coefficient model, and we apply the profile likelihood method to estimate the model. For detail, please see Fan and Huang (2005).

The estimate results are as in the following table and graph,

Table 1. The estimates of elasticity and p

	p	α	k	$diff_p$
1	31.25989	0.851205	-1.69825	1.652295
2	32.91218	0.860867	-1.67134	1.538521
3	34.4507	0.870782	-1.63164	1.567808
4	36.01851	0.881061	-1.58152	1.081907
5	37.10042	0.891703	-1.50537	1.34206
6	38.44248	0.902591	-1.42282	1.727785
7	40.17026	0.913496	-1.33604	2.529274
8	42.69954	0.924097	-1.25483	4.559421
9	47.25896	0.93401	-1.20566	5.469844
10	52.7288	0.942819	-1.16251	4.719607
11	57.44841	0.950114	-1.10405	2.376081
12	59.82449	0.955531	-1.02395	-1.43
13	58.39449	0.958779	-0.9205	-4.99803
14	53.39646	0.959654	-0.80866	-7.46672
15	45.92974	0.95799	-0.70018	-8.49934
16	37.4304	0.953572	-0.60017	-8.28983
17	29.14057	0.946038	-0.50813	-7.45148
18	21.68909	0.934944	-0.41156	-5.76536
19	15.92373	0.920124	-0.32378	-4.23442
20	11.68931	0.902115	-0.23773	-2.97699
21	8.712324	0.882104	-0.15223	-2.14982
22	6.562507	0.861295	-0.05528	-1.61392
23	4.948583	0.840367	0.061863	-1.18899
24	3.759593	0.819417	0.188089	-0.9198
25	2.839797	0.798176	0.331202	-0.70274
26	2.13706	0.776225	0.484371	

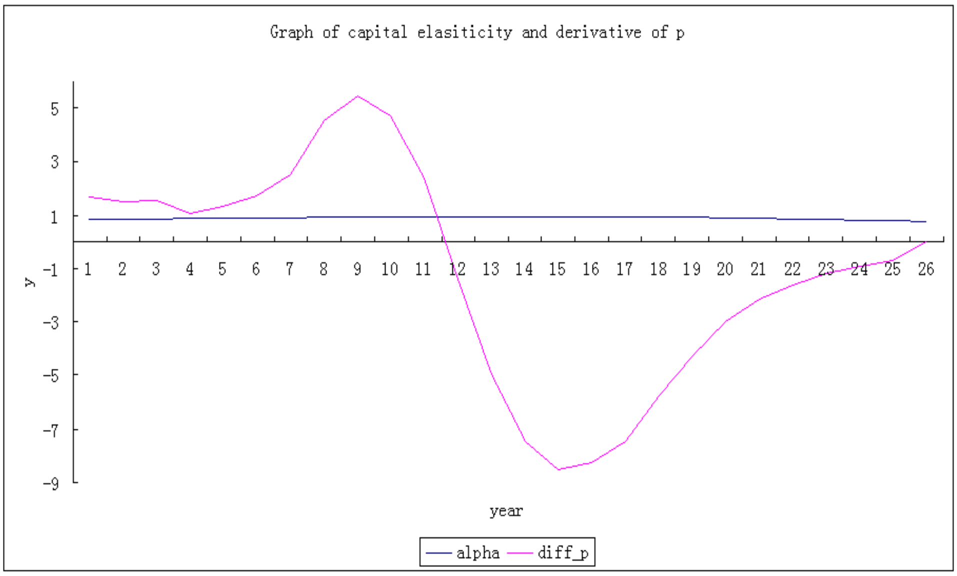

Figure 1. Results

From the equation (2), the directions of biased technical change can be told from the sign of $\frac{dp}{dt}$, which was approximated by $diff_p$ in the above table. However we need to be careful when interpreting the result. Notice that according to Hicks we need to fix the capital-labor ratio k in the comparison, which is not possible for the real data. Therefore when checking the sign of the $diff_p$, we also need to check whether the capital-labor ratios are roughly the same in the neighboring years. The results are meaningful only when the neighboring years have nearly the same k.

According to the Table 1, it seems that the technical change was capital biased before 1989 and was labor biased from 1991 to 1997. After 1997 it is hard to interpret the results by signs since the change of capital labor ratios is a bit high from year to year. We also observe a small magnitude of p difference from the year 2003 to year 2005, which might indicate possible capital biased change though the sign is negative.

4. **Conclusion.** We generalized Cobby-Douglass production function by allowing the change of capital and labor elasticities depending on time. It also changes the Hicks neutral technical change to biased technical change. When applying to the real data of Chinese economic growth, it shows different types of technical change biases before 1989 and after. The result of labor biased technical change after 1989 is different from the results of other papers, like Liu (2010) and Liu and Ren (2008). From the perspective of wage rate, the capital biased technical change explains well for the low wage of Chinese workers. So the capital biased results before 1989 fit well for the reality, but the results after 1989 are not so good since the wage of workers were still kept in a low level after 1989. The reason behind could be the choice of variables, like the capital index and labor index since there is no fixed rules for the selection. It also might due to the fact that the assumption of the model is not met, for instance, the constant return to scale.

However the model introduced here can provide an alternative way to check the direction of technical change though it has limits. The method we used here is data driven and relatively less variables are needed in the model. The limitation is that we can not draw a conclusion when the capital-labor ratio differs too much. It is still an open question on how to identify the direction of technical change under this situation and needs further exploration.

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