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The Characteristics Study of Element Marketization to Chinese Technology Progress

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Abstract: The paper studys the mathematical model between element marketization and technology progress though Chinese provinces data. Empirical test showed that capital and labor element marketization promote Chinese technology progress significantly. Finally, threshold model showed the existence of threshold range that capital and labor element marketization promoting TFP (total factor productivity) growth. When the two crossed a certain threshold, effects of element marketization on Chinese technology progress had shown. Based on this, the article shows that achieving economic growth from the consumption of material resources to relying on technological progress needs to promote the elements market-oriented reforms.

Keywords: Element Marketization, International Technology Spillovers, Technology Innovation, TFP

1. Introduction

Technological progress reflects the quality of economic development. China has achieved great economic success which mainly relies on stimulating consumption of material resources. Therefore, it is urgent to promote economic development mode to technology-driven. But over the years, the local government controls pricing and distribution rights of the key elements for the pursuit of GDP (gross domestic production) which leads to non-market prices. We should know that elements marketization help to mobilize resources to promote rapid economic growth or lose the soil which technology spillover and technological innovation required, and thus can not move towards the upstream industry chain and reduced economic colony. When domestic element marketization promoted rapid economic growth, whether brought promoting effect to the source of sustainable economic development - technological progress? If so, whether the promoting effect shows different characteristic with different degree of marketization? And what conditions should be addressed in order to maximize the benefits of the market? This paper not only reflect the new perspective of such studies and, more importantly, provide a theoretical basis for the establishment of the free flow of goods and elements of modern market system of equal exchange, improving efficiency of resource allocation and fairness which is pointed out by Eighteen Third Plenary Session.

At present, the existing literature focuses on effects of elements market marketization on corporate behavior from the perspective of microscopic. As Zhang et al. (2011) [1], Mao (2013) [2], Shi and Xian (2012) [3] respectively have used micro-enterprise database to research elements marketization on R & D, business productivity, export behavior. But few research have given the theoretical and empirical analysis of such characteristics between market effect and technological progress from macro perspective of international technology spillover and innovation. To compensate for the lack of research, the focus of this article examine whether elements marketization promote technological progress, and then sort out the relationship between them, providing theoretical and empirical basis for the perfection of the market price mechanism.

The innovation of this paper is, first, different from existing research, to deduce mathematical model between elements

marketization and technological advances under the framework of monopolistic competition, which scientifically proves the affecting relationship and provides a reference for further research. Second, to build capital and labor marketization indicators which are quantified and empirical effects of elements marketization on technological progress, to make up for the gaps in existing research. Third, to explore the threshold characteristics of elements marketization effects on technological advances, setting capital and labor as elements marketization the threshold variables included in the model to study elements marketization threshold effect of technological progress. The remainder of the paper is organized as follows. In Sect. 2 we would construct the mathematical model which is our theoretical frame. In Sect. 3 we show the model, data and methods. In Sect. 4 we get the results and analysis of empirical test. In Sec. 5 we conduct tests in threshold characteristic test. The concluding conclusions follow in Sect. 6.

2. Marketization and Technology Progress

This section sketches a standard model of monopolistic competition with heterogeneous firms to illustrate the effect of resource marketization on innovation. In addition to differing in their efficiency levels [4], we assume that firms potentially face different output and capital marketization.

We assume there is a single final good Y produced by a representative firm in a perfectly competitive final output market. This firm combines the output Y_i of i manufacturing industries using a Cobb-Douglas production technology:

$$Y = \prod_{i=1}^{i} Y_i^{\theta_i}, where \sum_{i=1}^{i} \theta_i = 1 \tag{1}$$

Cost minimization implies:

$$P_i Y_i = \theta_i PY \tag{2}$$

Here, P_i refers to the price of industry output Y_i and $P \equiv \prod_{i=1}^{i} \left(\frac{P_i}{\theta_i} \right)^{\theta_i}$ represents the price of the final good (the final good is our numeraire, so P=1). Industry output Y_i is itself a CES aggregate of M_i differentiated products:

$$Y_i = \left(\sum_{s=1}^{M_i} Y_{is}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma-1}{\sigma}} \tag{3}$$

The production function for each differentiated product is given by a Cobb-Douglas function of firm TFP, capital, and labor:

$$Y_{is} = A_{is} K_{is}^{\alpha_i} L_{is}^{1-\alpha_i} \tag{4}$$

Note that capital and labor shares are allowed to differ across industries, but not across firms within an industry.

Since there are two production elements, we can separately identify marketization that affect both capital and labor from marketization that change the marginal product of one of the elements relative to the other element. We will denote marketization that increase the marginal products of capital and labor by the same proportion as an output marketization τ_Y. For example, τ_Y would be high for firms that face government promoting on size or high transportation costs, and low in firms that benefit from public output subsidies. In turn, we will denote marketization that raise the marginal product of capital relative to labor as the capital marketization τ_K. For example, τ_K would be high for firms that do not have access to credit, but low for firms with access to cheap credit (by business groups or state-owned banks) [5].

Profits are given by:

$$\pi_{is} = (1-\tau_{Yis}) P_{is} Y_{is} - wL_{is} - (1+\tau_{Kis}) RK_{is} \tag{5}$$

Note that we assume all firms face the same wage, an issue we will return to later. Profit maximization yields the standard condition that the firm's output price is a fixed markup over its marginal cost:

$$P_{is} = \frac{\sigma}{\sigma\text{-}1} \left(\frac{R}{\alpha_i} \right)^{\alpha_i} \left(\frac{w}{1-\alpha_i} \right)^{1-\alpha_i} \frac{(1+\tau_{Kis})^{\alpha_i}}{A_{is}(1-\tau_{Yis})} \tag{6}$$

The capital-labor ratio, labor allocation, and output are given by:

$$\frac{K_{is}}{L_{is}} = \frac{\alpha_i}{1-\alpha_i} \cdot \frac{w}{R} \cdot \frac{1}{1+\tau_{Kis}} \tag{7}$$

$$L_{is} \propto \frac{A_{is}^{\sigma-1}(1-\tau_{Yis})^{\sigma}}{(1+\tau_{Kis})^{\alpha_i(\sigma-1)}} \tag{8}$$

$$Y_{is} \propto \frac{A_{is}^{\sigma-1}(1-\tau_{Yis})^{\sigma}}{(1+\tau_{Kis})^{\alpha_i\sigma}} \tag{9}$$

The allocation of resources across firms depends not only on firm TFP levels, but also on the output and capital marketization they face. To the extent resource allocation is driven by marketization rather firm TFP, this will result in differences in the marginal revenue products of labor and capital across firms [6]. The marginal revenue product of labor is proportional to revenue per worker:

$$MRPL_{is} \triangleq (1-\alpha_i) \frac{\sigma-1}{\sigma} \frac{P_{is} Y_{is}}{L_{is}} = w \frac{1}{1-\tau_{Yis}} \tag{10}$$

The marginal revenue product of capital is proportional to the revenue-capital ratio:

$$MRPL_{is} \triangleq \alpha_i \frac{\sigma-1}{\sigma} \frac{P_{is} Y_{is}}{K_{is}} = R \frac{1+\tau_{Kis}}{1-\tau_{Yis}} \tag{11}$$

Intuitively, the after-tax marginal revenue products of capital and labor are equalized across firms. The before-tax marginal revenue products must be higher in firms that face disincentives, and can be lower in firms that benefit from subsidies.

We are now ready to derive an expression for TFP as a function of the marketization of capital and labor. We first solve for the equilibrium allocation of resources across sectors:

$$L_i \equiv \sum_{s=1}^{M_i} L_{is} = L \frac{(1-\alpha_i)\theta_i / \overline{MRPL_i}}{\sum_{i'=1}^{i} (1-\alpha_{i'})\theta_{i'} / \overline{MRPL_{i'}}} \quad (12)$$

$$K_i \equiv \sum_{s=1}^{i} K_{is} = K \frac{\alpha_i \theta_i / \overline{MRPK_i}}{\sum_{i'=1}^{i} \alpha_{i'} \theta_{i'} / \overline{MRPK_{i'}}} \quad (13)$$

Here, $\overline{MRPL_i} \propto \left(\sum_{i=1}^{M_i} \frac{1}{1-\tau_{Yis}} \frac{P_{is} Y_{is}}{P_i Y_i} \right)$ and $\overline{MRPK_i} \propto \left(\sum_{i=1}^{M_i} \frac{1+\tau_{Kis}}{1-\tau_{Yis}} \frac{P_{is} Y_{is}}{P_i Y_i} \right)$ denote the weighted average of the value of the marginal product of labor and capital in a sector, and $L \equiv \sum_{i=1}^{i} L_i$ and $K \equiv \sum_{i=1}^{i} K_i$ represent the aggregate supply of labor and capital. We can then express aggregate output as a function of K_i, L_i, and industry TFP:

$$Y = \prod_{i=1}^{i} \left(TFP_i \cdot K_i^{\alpha_i} \cdot L_i^{1-\alpha_i} \right)^{\theta_i} \quad (14)$$

Under the competitive equilibrium conditions with element price marketization, S manufacturing industries' output can be given as:

$$Y_i = TFP_i \left(\frac{\theta_i \alpha_i}{\alpha} \tau_{Ki} K \right)^{\alpha_i} \left(\frac{\theta_i (1-\alpha_i)}{1-\alpha} \tau_{Li} L \right)^{(1-\alpha_i)} \quad (15)$$

Take a logarithmic processing:

$$\ln Y_i = \ln TFP_i + \ln \left(\theta_i \left(\frac{\alpha_i}{\alpha} \right)^{\alpha_i} \left(\frac{(1-\alpha_i)}{1-\alpha} \right)^{(1-\alpha_i)} \right) + \alpha_i \ln(\tau_{Ki}) + (1-\alpha_i) \ln(\tau_{Li}) + \alpha_i \ln K + (1-\alpha_i) \ln L \quad (16)$$

$$\ln TFP_i = b_0 + b_1 \beta_{Ki} \ln(\hat{\gamma}_{Ki}) + b_2 \beta_{Li} \ln(\hat{\gamma}_{Li}) + b_3 \beta_{Ki} \ln K + b_4 \beta_{Li} \ln L + b_5 \ln Y_i \quad (17)$$

so, b_0, b_1, b_2, b_3, b_4 and b_5 represent the constant t erm and the coefficient term.

Thus, this paper proves the mathematical theory between capital and labor elements marketization and technological progress which laid the theoretical foundation for later empirical model.

3. Models, Data and Methods

3.1. Basic Model

Based on the above derivation of the mathematical model, the model is set as follows:

$$\ln TFP_{it} = c_1 DistK_{it} + c_2 DistL_{it} + c_3 \ln X_{it} + C_{it} + \mu_{it} + \xi_{it} \quad (18)$$

where, i is for provinces and t is for time. $DistK_{it}$ and $DistL_{it}$ represent capital and labor element price marketiz ation.

Control variable X_{it} includes: domestic R & D capital investment, domestic investment in R & D personnel, imports overflow, FDI overflow and foreign patents overflow, which were used S_{it}^{d-rdk}, S_{it}^{d-rdl}, S_{it}^{f-im}, S_{it}^{f-fdi} and S_{it}^{f-pat} to be represented, $C_{i,t}$ is constant term, μ_i represents unobserved individual effects, $\xi_{i,t}$ is a random disturbance term.

3.2. Variable Selection and Measurement

The paper selects 1998-2014 inter-provincial panel data. The definition and measurement of each variable is as follows:

3.2.1. Technological Progress and Element Price Marketization Measurement

Technological progress uses TFP to measure and calculated by Solow residual method [7]. The output is represented by the regional calendar year GDP; the stock of fixed capital calculated by the perpetual inventory method, select the depreciation rate of 9.6% [8].

This paper mainly examines the impact of factor marketization on the explanatory variable. In the process of index measurement, we select the degree of factor market marketizationion as the reverse index of factor marketization. Because the higher degree of factor market marketizationion, the lower degree of factor marketization. We would not give a special explanation for this in the later section. Referring to the approaches of other relevant researches, we select C-D production function method to measure the element price marketization. The basic idea is to estimate the production function to get the marginal output of elements. It is the pay which element is due to get. And then we calculate the ratio with the actual reward of elements to get the marketization index. So we assume the form of production function as the following:

$$Y_{it} = A_{it} K_{it}^{\alpha_{it}} L_{it}^{\beta_{it}} \quad (19)$$

The marginal output and total element productivity of elements are respectively as follows:

$$MP_{Kit} = A_{it} \alpha_{it} K_{it}^{\alpha_{it}-1} L_{it}^{\beta_{it}} = \alpha_{it} Y_{it} / K_{it} \quad (20)$$

$$MP_{Lit} = A_{it} \beta_{it} K_{it}^{\alpha_{it}} L_{it}^{\beta_{it}-1} = \beta_{it} Y_{it} / L_{it} \quad (21)$$

$$\ln TFP_{it} = \ln A_{it} = \ln Y_{it} - \alpha_{it} \ln K_{it} - \beta_{it} \ln L_{it} \quad (22)$$

In the process of estimating α_{it} and β_{it}, for the choice of the regression equation, we can use panel data for overall regression, or respectively by year, by province, and we found that the results calculated by all kinds of regression methods are basically consistent, so we choose integral regression, the simplest method here. The r_{it} represents the factual price of capital, while w_{it} is the factual reward for labor. After getting marginal output MP_{Kit}, MP_{Lit}, capital price r_{it}, labor price w_{it}, we can calculate the marketization indexes:

$$DistK_{it} = MP_{Kit} / r_{it} \tag{23}$$

$$DistL_{it} = MP_{Lit} / w_{it} \tag{24}$$

$$Dist_{it} = DistK_{it}^{\frac{\alpha_{it}}{\alpha_{it}+\beta_{it}}} DistL_{it}^{\frac{\beta_{it}}{\alpha_{it}+\beta_{it}}} \tag{25}$$

3.2.2. Measurement of S_{it}^{d-rdk}, S_{it}^{d-rdl}, S_{it}^{d}, S_{it}^{f-im}, S_{it}^{f-fdi} and S_{it}^{f-pat}

The measurement of S_{it}^{d-rdk} and S_{it}^{d-rdl}. Based on 1998, with perpetual inventory method to calculate R & D stock, $S_{it}^{d} = (1-\delta) S_{it-1}^{d} + RD_{it}$, used the method of Griliches and Pakes (1980) [9]:

$$S_{i1998}^{d} = RD_{i1998} / (g + \delta) \tag{26}$$

g is average annual R & D investment spending logarithmic growth, δ =5% is R & D capital depreciation rate.

The S_{it}^{f-im} stands for import overflow. We select accum ulative data of the top ten economies from which China i mported from 1998 to 2014, according to the data of *Chin a statistical yearbook,* the top ten countries or regions fro m which China imported from 1998 to 2014 include Japa n, South Korea, the United States, Germany, Malaysia, Au stralia, Thailand, Russia, Singapore and Brazil, using the method of Lichtenber and Potterie (1996) [10] to measure the R&D spillover stock of import trade in China:

$$S_{t}^{f-im} = \sum_{j=1}^{10} \frac{IM_{jt}}{GDP_{jt}} \times S_{jt}^{d} \tag{27}$$

In this formula, the IM_{it} represents Chinese import volume from country j in the year t, while GDP_{it} is the GDP of country j in the year t. We use the import share of GDP as the weight, and then measure the provincial import spillage with the proportion of import in each region accounting for the annual national import as the weight (JK_{it}).

$$S_{it}^{f-im} = \left(\sum_{j=1}^{10} \frac{IM_{jt}}{GDP_{jt}} \times S_{jt}^{d} \right) \times JK_{it} \tag{28}$$

The S_{it}^{f-fdi} stands for FDI overflow. We use accumulati ve data of the top ten economies from 1998 to 2011 with actual FDI to China. According to the data of *China statis tical yearbook*, the top ten countries or regions from 1998 to 2014 on total actual foreign direct investment to China include Hong Kong, China, Japan, the United States, Sou th Korea, Singapore, Germany, Britain, the Netherlands, Fr ance, Canada [11]. We take reference of LP method like measuring S_{it}^{f-im} to calculate the R&D spillover stock in China over the years:

$$S_{t}^{f-fdi} = \sum_{j=1}^{10} \frac{FDI_{jt}}{GDP_{jt}} \times S_{jt}^{d} \tag{29}$$

$$S_{it}^{f-fdi} = \left(\sum_{j=1}^{10} \frac{FDI_{jt}}{GDP_{jt}} \times S_{jt}^{d} \right) \times W_{it} \tag{30}$$

The measurement of patent overflow S_{it}^{f-pat} is as the same as the S_{it}^{f-im} and the S_{it}^{f-fdi}. According to the data of China statistical yearbook, the top ten nations or regions with cumulative total applications for patents in China from 1998 to 2014 include Japan, the United States, Germany, Korea, France, Holland, Britain, Italy, Sweden and Finland.

$$S_{t}^{f-pat} = \sum_{j=1}^{10} \frac{VP_{jt}}{GDP_{jt}} \times S_{jt}^{d} \tag{31}$$

$$S_{it}^{f-pat} = \left(\sum_{j=1}^{10} \frac{VP_{jt}}{GDP_{jt}} \times S_{jt}^{d} \right) \times YF_{it} \tag{32}$$

3.2.3. Measurement of Y, K and L

Y is the provincial historical GDP, processed with CPI deflator numbers, which chose 1998 as the base period. K represents capital stock, which also chooses the year 1998 as base period, estimated with perpetual inventory method. L is the data of labor.

3.3. The Data Sources

We select Chinese provincial panel data of 1998-2014 for empirical analysis. Among them, the regional GDP, CPI and patent application quantity, labor remuneration, price index of investment in fixed assets, and the whole society fixed assets investment are from *China Statistical Yearbook*. The lending rate of each year is derived from the People's Bank of China. The number of provincial patents granted each year is from the science and technology statistics database of Chinese science and technology department. The gross imports from technology spillover countries, the total amount of foreign direct investment and patents from technology spillover countries in China are respectively from *China Statistical Yearbook* and *State Intellectual Property Office Statistics Annals*. The national employment data comes from the *China Labor Statistical Yearbook*. The province data of Tibet autonomous region is seriously absent, so we have got rid of it from the sample.

4. Empirical Results and Analysis

4.1. Preliminary Estimated Results

In general, the promotion of technological progress of a country mainly gets from international technology spillovers and innovation. In the case that the key elements of capital and labor are by regulated government, price marketization in element markets would not stimulate companies and entrepreneurs intensively using tangible elements, and there is more pressure and power to learn advanced technology and implement technology research and development. This will not only promote international technology spillovers, and would have a positive impact on business innovation.

The estimated results of the FE model showed that capital and labor element price marketization coefficient is negative, but the former did not pass the significance level while the latter passed 1% significance test. For low-income people, the low wages would increase basic necessities and other basic necessities of life in the proportion of total revenue expenditure, thus squeezing their own and future generations of investment in education, it is not conducive to the formation and training of human capital [12]. To high-income earners, the lack of appropriate pay would lead outflow, on the one hand enterprises lose more R & D resources, on the other hand the brain drain further widen the gap with foreign R & D (research and developement) investment and produce a positive effect on innovation. In addition, low income workers will lead to lower levels of demand.

In addition, the test results showed that the coefficient of R & D capital investment, investment in R & D personnel, international trade, FDI and patent applications are all positive, and passed by at least a 5% significance level test, which showed that all five has positive role in promoting TFP growth, which is the basic experience and the basic facts of existing research in good agreement. However, the coefficient of capital marketization items were not significant which may be due to the presence of endogenous problems. The above results are in line with expectations of this article, but needs further testing.

4.2. Instrumental Variables 2SLS (2 Stage Least Squares) and GMM (Gaussian Mixture Model) Estimation Results

Due to the variables in the model may well be affected by TFP in the same time acting on the TFP, namely the presence of endogenous problems. Endogenous problems will lead to preliminary estimates biased and non-uniform, so this article by means of Hausman endogeneity test and over recognition test to determine the existence of endogenous and validity of instrumental variables. The first condition of selecting instrumental variables is relevant with endogenous variable. To regress all variables in the model (including the instrumental variable) found that all instrumental variables are t the 5% level of statistical significant. The fit of the regression equation was 0.84. This indicates that the first condition by instrumental variables between test and endogenous variables are strongly related to compliance with instrumental variables. Sargan over-identification test using test results obtained by the method accepts instrumental variables independent of the 2SLS estimation residuals original assumptions, showing instrumental variables is appropriate.

In the presence of endogenous variables, the paper further takes two-stage least squares instrumental variables to estimate the regression results which reported in column 3 of Table 1. Compared with the preliminary regression results, we can conclude that: in control of the capital endogenous variable price marketization, the estimated regression coefficient term of capital marketization indicates that capital element price marketization indeed promoted TFP growth; labor element price marketization term results is similar with initial regression. Thus, the test results show that capital and labor elements marketization both promote TFP growth. The reason:

First, from the perspective of international trade, capital and labor elements caused the prices of domestic products on the market undervalued, promoted imports of foreign consumer goods and intermediate goods containing the technical expertise. While to some extent, the domestic export trade has been promoted, but such low-tech products export trade, single-level structure, hindering the international technology spillovers, thus losing the opportunity to upgrade their technological stock and innovation capabilities.

Table 1. *Empirical results of element marketization' effects on TFP.*

Explanatory variables	FE	2SLS	GMM
$DistK_{it}$	-0.093	-0.3	-0.094
	(-2.12) *	(-2.56)**	(-6.88)***
$DistL_{it}$	-0.099	-0.078	-0.084
	(-5.36)***	(-4.92)***	(-4.85)***
$\ln S_{it}^{d-rdk}$	0.326	0.281	0.372
	(5.09)***	(6.70)***	(6.69)***
$\ln S_{it}^{d-rdl}$	0.062	0.064	0.076
	(39.43)***	(35.56)***	(9.27)***
$\ln S_{it}^{f-im}$	0.068	0.066	0.063
	(8.98)***	(7.24)***	(7.45)***
$\ln S_{it}^{f-\mathrm{fdi}}$	0.21	0.23	0.041
	(2.32)**	(2.43)**	(2.21)**
$\ln S_{it}^{f-\mathrm{pat}}$	0.207	0.414	0.415
	(2.50)**	(4.74)***	(4.66)***
C_{it}	0.67	1.88	1.9
	(6.00)***	(8.87)***	(8.74)***
R^2	0.73	0.75	0.78

Note: Figures in brackets in the table is the t statistic, symbols ***, **, * represent the 1%, 5% and 10% significance level variables significantly.

Secondly, from the point of view of foreign direct investment, capital and labor element price marketization would attract a lot of FDI (foreign direct investment), foreign companies at that time is more advanced in knowledge and management experience, but with the rise of local business

competition, FDI companies lost relative technological advantage. This cured the level of industrial structure, so that the introduction of low-level redundant construction in vogue is a suppression of international technology spillovers. For domestic enterprises, they can not enjoy the preferential conditions resulting in unbalanced financing structure and high financing costs. Domestic enterprises had to increase capital investment, science and technology infrastructure investment when accumulated to a certain extent, thereby promoting the enterprise technology innovation.

In addition, the test results show: coefficients of R & D capital investment, investment in R & D personnel, trade and international patent applications are positive, and all passed the 1% significance level, the coefficient of FDI item is also significant. As mentioned earlier, this indicates that all five has a positive role in promoting TFP growth, which is the basic experience and basic facts existing research more consistent.

To prevent heteroskedasticity causing biased estimate, while give the 2SLS estimation robustness test, GMM regression coefficients of each variable and 2SLS estimation are close, which fully reflect the test effectiveness and robustness of the model results. Capital and labor element price marketization is significantly positive role of TFP growth, which is consistent with the theoretical analysis above.

5. Threshold Characteristic Test

We have been tested for the effects of capital and labor elements marketization on technological progress which shows that its promoting is more significant on technological advances. But based on the fact of TFP growth, coupled with the presence of larger regional differences of elements marketization, we want to know whether capital and labor elements marketization can promote TFP growth at different region. Studying on threshold characteristics is beneficial to adopt different conditions for different elements of marketization, to maximize the effectiveness of market elements. Under the new situation, China's economic development pattern change and improving the market price determination mechanism, the progressive realization of high-quality economic growth has important practical significance.

Therefore, to study the threshold characteristics of technological progress on elements marketization, this section will feature marketization of capital and labor variables included in the model as the threshold to investigate its effect on the TFP growth.

5.1. Setting the Threshold Model

Based on threshold test model, respectively give threshold test of capital and labor elements marketization, the presence of in this setting variables $x_{i,t}$ existing threshold level τ, and setting an example of dual threshold in following model:

$$\begin{aligned}\ln TFP_{it} &= w_1 DistK_{it} * I(x_{it} \le \tau_1) + w_2 DistK_{it} * I(\tau_1 < x_{it} \le \tau_2) + w_3 DistK_{it} * I(x_{it} > \tau_2) + c_1 \ln TFP_{it\text{-}1} \\ &+ c_2 DistL_{it} + a_1 \ln S_{it}^{d-rdk} + a_2 \ln S_{it}^{d-rdl} + a_3 \ln S_{it}^{f-im} + a_4 \ln S_{it}^{f-fdi} + a_5 \ln S_{it}^{f-pat} + C_{it} + \xi_{it}\end{aligned} \tag{33}$$

$$\begin{aligned}\ln TFP_{it} &= w_1 DistL_{it} * I(x_{it} \le \tau_1) + w_2 DistL_{it} * I(\tau_1 < x_{it} \le \tau_2) + w_3 DistL_{it} * I(x_{it} > \tau_2) + c_1 \ln TFP_{it\text{-}1} \\ &+ c_2 DistK_{it} + a_1 \ln S_{it}^{d-rdk} + a_2 \ln S_{it}^{d-rdl} + a_3 \ln S_{it}^{f-im} + a_4 \ln S_{it}^{f-fdi} + a_5 \ln S_{it}^{f-pat} + C_{it} + \xi_{it}\end{aligned} \tag{34}$$

Among them, $\tau_1 < \tau_2 < \tau_3$, $x_{i,t}$ is variable threshold, τ is specific threshold value, ω_1, ω_2 and w_3 is threshold variabl e, x_{it} is the coefficient of element price marketization on T FP growth when it in $x_{it} \le \tau_1$, $\tau_1 < x_{it} \le \tau_2$ and $x_{it} > \tau_2$, $I(\cdot)$ is an indicator function, When the conditions are met in parentheses, $I = 1$, otherwise, $I = 0$, $\varepsilon_{it} \sim iid(0, \sigma^2)$ is random disturbance term.

5.2. Testing the Threshold Model

Upon examination, two threshold variables and the dependent variable is weak correlation, based on this, in order to determine the number of threshold, threshold effects need to be tested. In this paper, under the assumption that there is no threshold, a threshold, two thresholds and three thresholds model in turn estimated (33), (34) to yield F statistics and the threshold value, and then we can see the results of model (33) showed that there is a double threshold in the process of capital element price marketization affecting TFP growth. Model (34) test results show that there is the triple threshold.

5.3. Parameter Estimation and Results Analysis

Respectively, estimating model (33) and models (34) to get parameters, the results are presented in Table 2 below. When each of the following variables at different threshold intensity intervals, we give following analysis of influence on TFP:

5.3.1. Capital Element Marketization

Model (33) regression results show that when the capital element price marketization is in low, medium and high intensity interval, its impact coefficients on TFP growth are 0.052, -0.079 and -0.094; with increasing degree of marketization, its role showing the suppression trend after promotion. At low capital element torsional degree ($x_{it} < 6.311$), the capital element prices is closer to market equilibrium price which can better reflect the value of the capital and be more efficient use of capital elements. Therefore, it has a significant role in promoting TFP growth. Capital element marketization statistics shows Guangxi, Yunnan, Qinghai, Xinjiang and other places are in this range,

indicating that the phenomenon generally occurs in remote provinces where capital is relatively scarce, this may be due to local scarcity of capital and the overall capital element marketization [13].

Test results show capital elements marketization in intermediate and advanced range, that produced TFP growth promoting provinces are: Hebei, Shaanxi, Gansu, Liaoning, and Beijing, Shanghai, Guangdong, Jiangsu and Zhejiang. As can be seen, the developed eastern region and more developed central region exist obvious capital elements marketization, and such a serious marketization promotes our technological progress.

5.3.2. Labor Element Marketization

Test the model (34) by Bootstrap, we can see when labor element marketization is in low intensity interval, there is a big role in promoting TFP growth; when a certain threshold is crossed, it turned to a significant promoted effect. Test results show that when the labor element marketization in the low intensity marketization ($x_{it} < 3.133$) and the intermediate level ($3.133 \le x_{it} < 3.512$), it can promote the growth of TFP, contained in these two types of provinces: Qinghai, Ningxia, Xinjiang, Guangxi and Beijing Hebei, Anhui, Fujian and other areas. Relatively backward central and western remote areas belong to low labor marketization level which is relatively easy to explain, as noted above, it is caused by the scarcity of local human capital. But the human capital supply of Beijing, whether in terms of quality and quantity, it is clearly sufficient or even excess. Its low degree of marketization may be because of the intense competition resulting that human capital labor market-oriented price is relatively high, from this perspective, to strengthen our market development efforts, reducing the degree of element marketization in China will have a significant technical progress enhancement.

Table 2. *Threshold model parameter estimation results.*

Model (33)	**Regression coefficients**	**Model (34)**	**Regression coefficients**
Explanatory variables	**Capital element marketization**	**Explanatory variables**	**Labor element marketization**
$DistK_{it}$ -1	0.052(2.82)***	$DistL_{it}$ -1	0.064(3.82)***
$DistK_{it}$ -2	-0.079 (-3.44)***	$DistL_{it}$ -2	0.075(4.46)***
$DistK_{it}$ -3	-0.094 (-4.53)***	$DistL_{it}$ -3	-0.101(-6.18)***
$DistK_{it}$ -4		$DistL_{it}$ -4	-0.124(-3.85)***
$\ln TFP_{it\text{-}1}$	0.74(6.77)***	$\ln TFP_{it\text{-}1}$	0.72(6.76)***
$\ln S_{it}^{d-rdk}$	0.057(4.23)***	$\ln S_{it}^{d-rdk}$	0.058(4.25)***
$\ln S_{it}^{d-rdl}$	-0.013(-0.50)	$\ln S_{it}^{d-rdl}$	-0.013(-0.51)
$\ln S_{it}^{f-im}$	0.015(2.25) **	$\ln S_{it}^{f-im}$	0.018(2.31) **
$\ln S_{it}^{f-fdi}$	0.046(3.73)***	$\ln S_{it}^{f-fdi}$	0.047(3.76)***
$\ln S_{it}^{f-pat}$	0.034(2.95)**	$\ln S_{it}^{f-pat}$	0.036(2.97)**
C_{it}	1.068(5.23)***	C_{it}	0.977(4.93)***
F	13.91***	F	16.90***

Note: ***, **, * represent the 1%, 5%, 10% significant level of statistical variables.

With the degree of labor marketization increasing, when the labor marketization is in the second highest and high level range, its promoting influence on the TFP converted to promote. Contained in these two types of interval provinces are: Jiangsu, Zhejiang, Chongqing, Guangdong and Shanghai, Tianjin, Shandong, Heilongjiang. Higher labor element marketization level happened in more developed eastern and central areas, as described above, from the perspective of workers, government and businesses artificially give low wages, access to get so-called "demographic dividend", this not only squeezes their own and future generations investment in education, but makes a serious brain drain and extrusion on technology innovation efficiency. From a business point of view, when labor price marketization come to a certain extent, labor low income will lead to lower levels of demand, the lack of market demand for product development, technological innovation and thus produce a positive promoting.

To sum up, in different thresholds of the capital and labor elements marketization, there are respectively threshold range which can promote TFP growth, but after crossing a certain threshold, it turns to significantly promote features. It can be seen, when capital and labor element marketization are smaller, it would be more conducive to technological progress. China should improve price mechanism mainly determined by the market, establish the free flow of goods and elements of modern market system, focus on removing the market barriers, improve resource efficiency and equity, and thus enhance the efficiency of technological progress and economic growth potential.

6. Conclusions

This article linked element marketization and technological progress under monopolistic competition framework, induced the mathematical model between element marketization and technological advances, and then set the framework of capital and labor price marketization index, select 1998--2014 years of inter-provincial panel data, use the system GMM regression analysis and threshold characteristics empirical analysis method test their impact characteristics. Preliminary empirical test results of panel data comprising 30 provinces show: labor element marketization promoted technological progress, while no significant promoting from capital marketization. When gradually overcome multicollinearity, endogeneity and heteroskedasticity, further tests showed that China's capital and labor element price marketization performed significant promoting characteristics on the technical progress. Threshold regression results indicate that the presence of threshold range which capital and labor elements marketization could promote TFP growth, but after a certain threshold crossed, element marketization' effects on technological progress turned to be promoting. By raising the level of element markets, thus making the capital and labor elements marketization placed more conducive to technological progress threshold range, it will be beneficial to our technology spillover and technological innovation.

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