Productivity Change and Agricultural Policy Reform in China: Village Level Evidence for 1995 to 2009

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Abstract

Adopting Stochastic Frontier Analysis and the multivariate regression model and employing 1995-2009 village-level data, the paper evaluates and interprets the effect of China's agricultural policy reform on agricultural productivity change in the past fifteen years. The results show that China's agricultural productivity has made significant growth in the past fifteen years under the influence of China's agricultural policy reform. Furthermore, the effects of different agricultural policies on technical change and technical efficiency have significant differences with obvious periodic and regional features. The economic development pattern combining liberty with regulation has also led to frequent changes in China's agricultural policies, which results in great fluctuation among different years. Meanwhile compared with technical change, technical efficiency has a smaller contribution to the improvement of China's agricultural productivity, and effective agricultural subsidy policy is undoubtedly helpful to overcome this problem.

Keywords: Chinese agricultural policy, Agricultural productivity, Stochastic frontier analysis, Multivariate regression model

JEL Code: Q18, Q47

1 INTRODUCTION

China's economic reform started at the end of 1970s finally set up the ultimate framework of the economic development trend in 1994 after years of lingering. On one hand, the Chinese central government started to put the market-oriented reforming policies into full practice so that the micro-foundation of China's market economy system could be established gradually (Zheng, 2004); one the other hand, the Chinese central government completely abandoned the previous fiscal system that had been implemented for more than 40 years and set up the tax distribution system officially, which was regarded as an important basis for the central government to grasp the final decision-making authority of economic reform policies (Naughton, 2010). In this way, the macro-scope system that enables the central government to implement effective control over the local governments was established ultimately.

Economic system reform in rural China was completed based on the framework of the above system. On one hand, the Chinese central government's direct control force over the price of agricultural products, rural laborer and agricultural credit started to drop gradually, continuing the development trend of economic liberalization started from the late 1970s; one the other hand, the Chinese central government had always controlled the overall progress and direction of the rural economic system reform, while basic systems such as the rural land system, the household registration system and other systems that determined the speed and efficiency of rural economic system reform got no significant improvement. The economic reform pattern combining liberty with regulation became the basic characteristics for economic system reform in rural China after 1995.

Economic system reform in rural China has always been a hot topic in economics research field. Discussions over Chinese agricultural production and agricultural policies in the last three decades can be seen earlier in dissertation of scholars such as McMillan et al.(1989), Stavis (1991) and Lin (1992). Since then, some scholars started to analyze the above issues by measuring the agricultural productivity (Fan,1991, 1997; Wen, 1993; Kalirajan et al. 1996; Carter and Estrin, 2001). These research findings well explained the main reasons for success in rural economic system reform in which Household Contract Responsibility System was applied by Chinese government as main content. Some scholars also analyzed the shortcomings of the above policy reform (Prosterman and Hansted, 1996; Ho, 2005). However, except Brümmer (2003), few researches over that in the period after middle 1990s were done, especially in empirical study of village level.

In fact, China's agricultural policies since middle 1990s have changed a lot under the economic reform pattern combining liberation with regulation, including granting peasants permanent land use rights, allowing free leasing and transfer of cultivated land, the revocation of agricultural tax, significant increases in production subsidies, substantial growth in investment for agricultural technology and the lifting of price controls for agricultural products. With these policy reforms, the grain output in China, getting over sharp falls during the period of 1998–2003, continued the growing trend during the period of 1995–1997 and constantly broke the historical highest record. Apparently, the above effect of policy reforms on the agricultural production should never be ignored.

This paper applies the data of village level from 1995 to 2009 for 50 villages in 5 provinces to evaluate the effects of the Chinese agriculture policy reforms on agricultural productivity. The organization of the paper is as follows: Section 2 provides an overview of agriculture policy reforms in China form 1995 to 2009. Section 3 discusses the estimation method and model. The data used in the empirical evaluation are briefly summarized in section 4. The empirical results are reported by section 5. The last section is conclusion

2 CHINESE AGRICULTURAL POLICY REFORM

China's agricultural policies before 1990s were mainly about "decentralization of power and transfer of profits", i.e., abolishing People's Commune System and "state monopoly over purchase and marketing" policies, setting up rural land system and agricultural production pattern with Household Contract Responsibility System as main content, gradually recovering the market price system's allocation of agricultural products and agriculture material and finally canceling price control. The above reform produced great impact on high-speed growth of Chinese agriculture from late 1970s to middle 1980s. As research by Lin (1992), the contribution factor of the Household Contract Responsibility System alone to increase in grain yield of China was as high as 46.89％. However, as incentive function of above reform had been released gradually, policy factor's incentive function to agricultural development was, step by step, replaced by technical factors which finally became the main driving force to support China's agriculture that was developing slowly after 1984 (Fan, 1997). After that, because policy reform badly lagged behind the demand of China's agricultural development, problems such as "difficult to sell grains" and heavy load in tax on farmers emerged successively, which led to reduction in grain output of China year by year after 1998. The output in 2003 dropped to the level of late 1980s. The reason for sharp fall of grain output in China was summed up as "agriculture, countryside and farmer" issues.

Figure 1 can clearly divide the change of grain output in China from 1995 to 2009 into three phases, i.e.: slow growth from 1995 to 1997; sharp fall from 1998 to 2003; resumption of growth from 2004 to 2009. The impact of agricultural policies in this period (mainly including agricultural produce price policy, agricultural taxation policy, agriculture subsidy policy and rural land policy) on agricultural development of China will be reviewed systematically in this section and will be explained further in Section 5 combined with the empirical research findings.

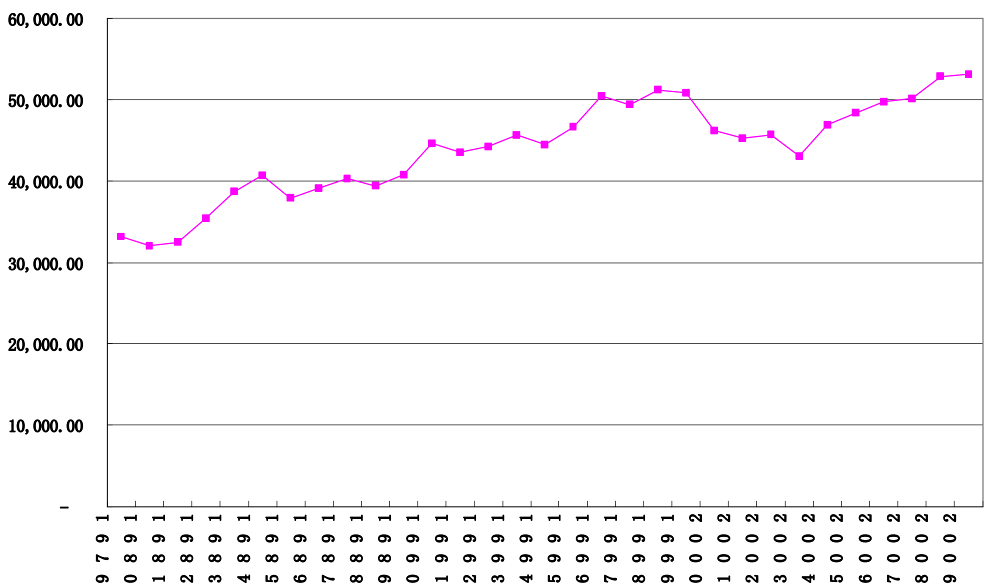

Figure 1: the Change of Grain Output in China from 1979 to 2009

2.1 Reform of agricultural product price policy

From 1995 to 1997, China's agricultural product pricing mechanism still was double-track price system, without completely eliminating the co-existence of policy prices and market prices. From 1998 to 2003, the reform of agricultural product pricing mechanism entered a key stage, and the Chinese government implemented a series of policies including purchasing surplus grain from farmers at a price higher than the market price of the same period ("protective price" policy), establishing grain trading market, reforming the management system of grain purchase funds, reforming the state-owned grain purchase and storing business operation modes. It enabled a complete break with the grain price system formed during the planned economy period and the government monopoly price was gradually replaced by the market price. By the year 1999, the quantity of agricultural products with government-led prices had decreased to 17% from 94% in

1978 (Lardy, 2001). Since 2004, to further stabilize periodic price fluctuation of agricultural products and lower agricultural production risks, the Chinese government has officially established the "protective price" as a long-term agricultural product price policy.

2.2 Reform of agricultural taxation policy

The agricultural taxation of the P.R.C. was established officially in 1958. Since then with the implementation of Household Contract Responsibility System, China's agricultural taxation had gradually realized its transformation of tax accounting unit from production team to farmer household and transforming from tax in kind to money tax. Although the tax rate varied greatly from different regions, the average tax rate basically maintained at about 15.5% of the year-around grain output, with the upper limit not exceeding 25%[1]. This taxation system continued until mid 1990s. After 1998, the Chinese government began reforming the agricultural taxation policy including canceling part of agricultural taxes, reducing overall tax rate and adjusting the taxation scope. However, these reformed policies begun their gradual implementation in some regions only until 2002. The most important policy reform took place in 2004 when the Chinese government finally determined to cancel completely instead of only continuing the agricultural tax lasting for decades at a lower level. The root causes for such a significant policy reform laid in the following: on one hand, the proportion of agricultural tax in the total tax revenue of the government had decreased from 11.23% in 1955 to 1.87% in 2001[2], showing very limited contribution of the agricultural tax to the revenue; on the other hand, the long-term existence of agricultural tax had increased farmers' expenditure, giving rise to many social problems. For example, some local governments illegally collected other taxes in the name of agricultural tax, which worsened the conflict between the local governments and the farmers. The cancellation of agricultural tax undoubtedly played a significant part in easing social conflicts and encouraging agricultural production.

2.3 Reform of agricultural subsidy policy

China's early agricultural subsidy policy was mainly realized by enlarging the input of agricultural production technology and construction of agricultural infrastructures. After 1980s, while continuing its input of agricultural technology and infrastructures, the Chinese government began its gradual implementation of direct subsidy policy for agricultural production materials which were limited only to fertilizer, diesel oil, etc. In 2004, the Chinese government formally carried out the policy of "four agricultural subsidies", i.e. grain production subsidy, find breed subsidy,

[1] Data Source: China Statistical Yearbook.
[2] Data Source: China Statistical Yearbook.

subsidy for purchase of agricultural machinery and general subsidy for agricultural production materials (mainly were fertilizer subsidy and diesel oil subsidy), with the total subsidy amount increased from 10 billion yuan in 2004 to 127.45 billion yuan in 2009[1], which promoted the growth of agricultural production effectively.

2.4 Reform of rural land policy

Compared with other agricultural policies, China's rural land policy after 1970s tended to be more stable, namely, dividing the rural land property right into ownership and use right, among which the former one was still collectively owned while the latter one (mainly was residual claim) was contracted to the farmer for a given period of time. After 1998, the above land property right began to be established gradually in long run by law. Since 2005, the Chinese government gradually allowed the farmers to trade the land-use right in the manner of lease, interchange, transfer, subcontract and so on. Rural land use right trading market even appeared in some regions in Hunan province, Sichuan province, etc. These policies greatly expanded the farmers' private land property right scope (Cheung, 2009).

In short, China's agricultural policy reform after 1995 can be summarized as follows: long-term stabilization of rural land property right, great increase in agricultural input by the government, cancellation of agricultural tax, and gradual establishment of market trading mechanism for land and agriculture products. These reform measures created important conditions for another rapid growth of China's agriculture after 2004.

3 FUNCTIONAL FORM SPECIFICATIONS

The process of empirical research is divided into two stages. At the first stage, Stochastic Frontier Analysis (SFA) is applied to estimate and decompose China's agriculture productivity from 1995 to 2009; at the second stage, Total Factor Productivity Growth (TFPG), Technological Change (TC) and Technical Efficiency Change (TEC) are taken as the indexes for measuring the agricultural production performance in China and are used to carry out multiple regression analysis over impact of policy reforms on the production performance.

3.1 Estimation and decomposition model of China's agriculture productivity

In the traditional production functions, it is assumed that all producers are technically efficient (Solow, 1957). Therefore, the remaining part of the output after deduction of the contributed part by essential input is attributed to technical progress. However, Farrell (1957) deemed that not all producers achieved the best productivity at the production frontier and certain gap existed between

[1] Data Source: China Statistical Yearbook.

absolutely majority of actual productivity and the best productivity, which was called technical inefficiency. Then Aigner and Chu (1968) further decomposed Total Factor Productivity (TFP) into such two parts as the frontier technique and technical efficiency, so as to be capable of more accurate description of actual change of productivity. Thereafter Meeusen and Broeck (1977), Aigner et al. (1977), Battese and Corra (1977) introduced random perturbation item based on confirmed frontier technique model, creating SFA method which made the productivity measurement more compliant with the actual situation. The basic model can be defined as follows:

$$Y_{it} = f(X_{it}, t) \exp(v_{it} - u_{it}) \tag{1}$$

Where Y_{it} represents output of producer i (i = 1,2, …, N) during t(t = 1,2, …, T) period; f (·) represents the production function, indicating the output at the production frontier, i.e. the maximum output of essential input under the existing technical conditions; X_{it} represents the essential input; exp ($v_{it} - u_{it}$) is the composite disturbance term, and v_{it} represents the observation error and other stochastic factors; exp (u_{it}) represents technical inefficiency.

Take logarithm form of formula (1), and work out partial derivative of t:

$$\frac{d\ln f(X,t)}{dt} = \frac{\partial \ln f(X,t)}{\partial t} + \sum_{it} \frac{\partial \ln f(X,t)}{\partial X_{it}/X_{it}} \frac{dX_{it}/X_{it}}{dt} \tag{2}$$

Where ∂lnf(X,t)/∂t, i.e. TC, means the output change at the production frontier under the condition that the essential input remains the same. For v_{it} can be defined as White Noise, and the average value observed of it is zero, the change rate of the producer's output can be defined as follows:

$$\dot{Y} = \frac{\ln Y}{dt} = \frac{d\ln f(X,t)}{dt} + \sum_{it} \frac{\partial \ln f(X,t)}{\partial X_{it}/X_{it}} \frac{dX_{it}/X_{it}}{dt} - \frac{du}{dt} = TP - \frac{du}{dt} + \sum_{it} \frac{\partial \ln f(X,t)}{\partial X_{it}/X_{it}} \frac{dX_{it}/X_{it}}{dt} \tag{3}$$

According to Solow (1956, 1957)'s understanding of TFP, TFP means the remaining part of the output after deduction of the contributed part of the essential input, then the following can be obtained:

$$\dot{TPF} = \dot{Y} - \dot{X} = TC - \frac{du}{dt} + \sum_{it} \frac{\partial \ln f(X,t)}{\partial X_{it}/X_{it}} \frac{dX_{it}/X_{it}}{dt} - \dot{X} \tag{4}$$

Since the contribution rate of essential input can be elastically replaced with output, (4) can be simplified as follows[1]:

$$\dot{TPF} = \dot{Y} - \dot{X} = TC + \left(-\frac{du}{dt}\right) \tag{5}$$

Formula (5) is a model for calculating the TFPC. Where TEC is −(du/dt).

Here, the production function of China's agricultural productivity is introduced to embody the abovementioned model. Both Fan (1991) and Lin (1992) adopted the Cobb-Douglas

[1] Note: for specific process, see Li (2010).

production function as the basic calculation model in their papers on measuring China's agricultural productivity. Thereafter, the production function was also adopted by Zhang and Carter (1997), Qiao et al. (2006) and relevant research subjects of Chinese government. It can be seen that the Cobb-Douglas production function can satisfy the requirements of measuring China's agricultural productivity. Therefore, Cobb-Douglas production function is also adopted here, and the formula (1) is introduced.

$$Y_{it} = A(t) K_{it}^{\alpha K} L_{it}^{\alpha L} M_{it}^{\alpha M} \exp(v_{it} - u_{it}) \quad (6)$$

Where, $A(t) = \exp(A_0 + \delta t)$ represents the frontier technique in the trade during $t(t=1,2, \ldots, T)$ period; δ represents the progressing speed of frontier technique; K_{it} represents the input amount of capital; L represents input amount of labor; M represents input amount of arable land; α_K, α_L and α_M represent the output elasticity of capital, labor and arable land, and all are parameters to be estimated. $\exp(v_{it} - u_{it})$ is the composite disturbance term; $\exp(u_{it})$ represents the gap between the observed output of agricultural production and potential output; v_{it} is White Noise. Therefore, the technical efficiency (TE) of producers may be determined by using the specific value of the expected output of the producer in the sample and the expected value at the stochastic frontier, i.e.:

$$TE_{it} = E(y_{it} | u_{it}, x_{it}) / E(y_{it} | u_{it}=0, x_{it}) = \exp(-u_{it}) \quad (7)$$

Since the return to scale of China's agricultural is not much obvious (Schultz, 1964; Lin, 2005), the presumed constant returns to scale. Formula (6) is transformed to be an intensive form for land production factor:

$$y_{it} = k_{it}^{\alpha K} l_{it}^{\alpha L} \exp[(A_0 + \delta t) + (v_{it} - u_{it})] \quad (8)$$

$$y_{it} = Y_{it} / M_{it}$$

$$k_{it} = K_{it} / M_{it}$$

$$l_{it} = L_{it} / M_{it}$$

Where, y_{it} represents producer i's average output on arable land during t period; k_{it} represents producer i's average capital input on arable land during t period; l_{it} represents producer i's average labor input on arable land during t period.

Additionally, for the distribution of u_{it} have different definitions, resulting in a lot of SFA models. Among the models, B-C model proposed by Battese and Coelli (1992) renders better understanding of the time change trend, and thus is adopted here[1]. u_{it} is defined as a time-changing form:

$$u_{it} = \beta(t) u_i \beta(t) = \exp[-\eta(t-T)] \quad (9)$$

Where, u_i is subject to nonnegative normal distribution (truncations at zero), i.e. $u_i \sim N^+(\mu, \sigma_u^2)$. η

[1] Note: relevant documents overview includes Battese (1992), Bravo-Ureta and Pinheiro (1993) and Coelli (1995).

is a parameter to be estimated, representing the change rate of technical efficiency.

$$TEC = -(du/dt) = \eta u_i exp[-\eta(t-T)] = \eta u_{it} \quad (10)$$

The estimation of parameters of SFA determined by (9) and (10) can be obtained through building variance parameter $\gamma = \sigma_u^2/\sigma_s^2(0\leq\gamma\leq1)$, $\sigma_s^2 = \sigma_u^2 + \sigma_v^2$ adopting three step maximum Likelihood Estimation (Li, 2008). The calculating software is Parametric Production Frontiers Ver 2.0(Sun, 2010).

3.2 Estimation model of performance of agricultural policy reform

According to the foregoing model, parameters such as TFPG, TC and TEC can be obtained respectively. Here the multiple regression model is adopted, taking the above three indexes as the explained variables of agricultural production performance, and the mentioned rural land policy, agricultural product price policy, agricultural taxation policy and agricultural subsidy policy as the explaining variables, to analyze the impact of such policy reforms on agricultural production in different areas in China. The multiple regression model is defined as follows:

$$Y_{i,t}^k = \beta_0 + \beta_1 LA + \beta_2 PR + \beta_3 AE + \beta_4 SU + \varepsilon_{i,t} \quad (11)$$

Where, Y^k(k=1,2,3) represents the performance of agricultural performance, and are represented by TFPG, TC and TEC respectively; t represents time; LA,PR,AE and SU represent land policy index, agricultural product price policy index, agricultural taxation policy index and agricultural subsidy policy index, respectively; $\beta_1,\beta_2,\beta_3,\beta_4$ represent the coefficients respectively; β_0 represents the constant item, and $\varepsilon_{i,t}$ represents the random disturbance term.

To compare the performance of agricultural policy reform in different time periods, the quantitative analysis will be divided into three time periods: 1995-1997, 1998-2003, and 2004-2009.

4 DATA AND VARIABLE

4.1 Data

Data in this paper are related to 50 villages in 5 provinces of China, where three provinces in Eastern China, Shandong, Jiangsu and Fujian are selected and 10 sample villages are selected in each province; 10 sample villages of Hunan are selected in Central China; and 10 sample villages of Sichuan Province are selected in Western China. The above five provinces are all major grain producing areas in China, with total annual grain output accounting for more than one quarter of that in China. Shandong, Jiangsu and Fujian have high level of economic development and represent the regions with best economic development level in China at present; while Hunan and Sichuan have low level of economic development but have advantages in labor quantity and natural resources. Therefore, above samples can well reflect China's agricultural development in the past 15 years.

Data cited in the paper mainly come from "*Cost and Income of Chinese Agricultural Products*" prepared by National Development Reform Commission of P. R. China as well as statistics bulletin reported by sample villages to county-level governments. Since families that have been investigated are relatively centralized and the annual change of data source is relatively limited, data can be used as panel data. Meanwhile, in order to remove impact of resource and other objective factors on data of village level and better reflect the overall local situation, instead of each village data, average data (arithmetical means) of 10 sample villages for each province are adopted as study data.

4.2 Variable

Phase I of empirical study is related to the following variables:

Output variable (y): expressed by unit area output of grains in different years, unit: kg/ha. According to China's statistical standard, grains mainly include cereal (including rice, wheat and corn), beans and potatoes.

Investment variable (k): expressed by various unit area direct investment for grain production within a year, mainly including farm machinery, seeds, fertilizers, irrigation, fuels and farm tools, etc., unit: yuan/ha. 1978 is taken as the base year, regardless of the price change.

Investment variable (l): expressed by various labor investment for grain production within a year, mainly including days of rural household labor investment and days of a few wage workers investment, unit: day/ha. It is calculated based on 8-hour working system.

Phase II of empirical study is related to the following variables:

Rural Land policy (LA): Since the Chinese government set up Household Contract Responsibility System all over China in 1982, though rural land policies have been adjusted, they have never been separated from above system. Because of Household Contract Responsibility System is an incomplete land property right system (Ho, 2005), farmers' long-term capital investment in agricultural production will vary with the stability of land property right. According to this finding, Yao (2000) and others took the lead in using agricultural investment intensity as a substitute index of land policy, which has been well verified. Therefore, we continue to use agricultural capital investment in unit area to represent land policy, mainly including farm machinery, seeds, fertilizers, irrigation, fuels and farm tools, etc., unit: yuan/ha. 1978 is taken as the base year, regardless of the price change.

Agricultural product price policy (PR): expressed by trade liberalization index of domestic agricultural products, i.e., ratio of index of agricultural products purchasing prices to index of agricultural means of production prices (Lin, 1992). 1978 is taken as the base year, with impact of price change excluded.

Agricultural taxation policy (AE): calculated by the proportion of agricultural tax and expenses charged by the government out of taxation in farmers' net income. 1978 is taken as the base year, regardless of the impact of price change.

Agricultural subsidy policy (SU): The unit area agricultural subsidiary amount acquired by farmers, unit: yuan/ha. 1978 is taken as the base year, regardless of the price change.

5 RESULTS

5.1 The decomposition of Chinese agriculture productivity

The empirical research findings show that TFPG, TC, TEC and TE differed greatly in terms of region, time and fluctuation from1995 to 2009.

TFPG: Regionally, Jiangsu got the highest average TFPG (2.35%), followed by Shandong (1.92%), Fujian (1.29%), Hunan (0.42%) and Sichuan (0.06%); from the aspect of time, the maximum average TFPG value appeared in 2008 (4.77%) while the minimum one in 2002 (-3.96%); in terms of fluctuation, Hunan had the smallest difference between the maximum value and the minimum value of TFPG (10.11%), followed by Sichuan (16.8%), Shandong (23.46%), Fujian (25.2%) and Jiangsu (39.93%). The great change in TFPG was closely related with the quickened market reform of China's economic system. On one hand, the planned economy system entirely withdrew from the agricultural production field during this time period; on the other hand, both the lag of Chinese government's agricultural policy reform behind the withdrawal of the old policies and the once "vacuum" or frequent regulation of agricultural policies led to fierce fluctuation in TFPG, especially in the first years of 21st century, the grain output of China even fell back to the level of late 1980s. Meanwhile because Hunan and Sichuan are inland areas and their mobility of agricultural labor and rural land was slow due to their lower market level than that in such coastal areas as Jiangsu, Shandong and Fujian, their fluctuation was relatively small.

TC: Regionally, Jiangsu hit the highest average TC (2.05%), followed by Shandong (1.51%), Fujian (0.80%), Hunan (0.25%) and Sichuan (0.17%); in terms of time, the maximum average TC value appeared in 2000 (5.24%) while the minimum one in 2002 (-4.40%); from the aspect of fluctuation, Hunan had the smallest difference between the maximum value and the minimum value of TC (10.86％), followed by Sichuan (22.76%), Shandong (23.66%), Fujian (25.07%) and Jiangsu (39.29%). Compared with TEC, TC changed more sharply, from which it could be inferred that drastic change of TFPG mainly resulted from TC rather than TEC. Since 1990s, the Chinese government has substantially increased its agricultural technology input which mostly centralized in agricultural research institutions, while the input for villages to promote advanced technologies and to encourage farmers' use of advanced technologies was relatively limited. Besides, the above five provinces were all labor intensive regions, and therefore labor was a significant substitute for technologies. Such a situation has been relieved in the past few years to some extent, and especially the subsidies for fine breed, agricultural machinery, fertilizer, etc. from the Chinese government have played an active role in encouraging more farmers to utilize new technologies. The regional distribution characteristics of TC are consistent with the level of economic development of this region, which shows that the level of economic development in a region has a significant active impact on TC.

TE: Regionally, Hunan got the highest average TC (94.88%), followed by Sichuan (90.09%), Shandong (84.17%), Fujian (82.11%) and Jiangsu (81.46%); in terms of time, the maximum average TE value appeared in 2009 (89.95%) while the minimum one in 1995 (83.83%); from the aspect of fluctuation, Jiangsu had the smallest difference between the maximum value and the minimum value of TE (6.03%), followed by Fujian (7.81%), Shandong (8.75%), Hunan (9.16%) and Sichuan (10.04%). TE reflects remarkable regional difference while compared with TC. Because TE depends more on the level of technology diffusion while TC more on the level of technological improvement, when major technological innovation occurs yet without effective popularization, TC will change greatly while TE may not change at all.

TEC: Regionally, Jiangsu hit the highest average TEC (0.51%), followed by Fujian (0.47%), Hunan (0.23%), Shandong (0.20%) and Sichuan (0.14%); in terms of time, the maximum average TEC value was in 1999 (0.34%) and 2009 (0.34%), while the minimum one in 2005 (0.25%); from the aspect of fluctuation, Jiangsu had the smallest difference between the maximum value and the minimum value of TEC (0.16%), followed by Shandong (0.18%), Sichuan (0.23%), Hunan (0.24%) and Fujian (0.26%). Compared with TFPG, TC and TE, TEC only had a limited change. On one hand, TC has realized great change in the past fifteen years, which pushes the production frontier outwards constantly and thus increases the difficulty for TEC to change; on the other hand, because China's existing agricultural R & D and popularization system can not totally meet the diversified needs of agricultural production and the related financial input from the government is limited, the progress of China's modern agricultural industrial development is slow coupled with the influence of regional difference in resource endowment and shares consistency among all regions.

The above part investigates the changes of agricultural productivity of some regions in China in the past fifteen years. Although there are great differences among indexes, the following observations can be drawn from their common change trends: firstly, China's agricultural productivity has achieved significant growth which was driven mainly by TC; secondly, the impact of agricultural policy reform on each region was consistent from the aspect of change trend; thirdly, in the economic development pattern combining liberty with regulation, the frequent changes of agricultural policies aggravated the fluctuation degree of agricultural productivity; fourthly, the key factor restricting the improvement of China's agricultural productivity is the new technology popularization, so the improvement of relevant agricultural policies will help solve this problem.

5.2 Effect of agriculture policy reforms on agriculture productivity

Based on the review of China's agricultural policy reform and the changes of agricultural productivity over the past fifteen years as well as the empirical research findings, the impacts of agricultural product price policy, agricultural taxation policy, agricultural subsidy policy and rural land policy during the three stages of 1995-1997, 1998-2003 and 2004-2009 on the agricultural productivity are evaluated as follows.

5.2.1 The first stage 1995-1997

During this stage, China's agricultural product pricing mechanism was loosened, and the market price gradually replaced the policy price and became a major factor regulating the production and selling of agricultural products. Meanwhile, influenced by rapid macroeconomic growth, the growth rate of selling prices of agricultural products was higher than that of agricultural taxes, allowing the negative influence of agricultural taxes to be eased off to some degree. The empirical research findings indicate that agricultural product price policy made a relatively big contribution to TC, showing that the pricing mechanism begun to influence TC, and thus the Schmookler-Griliches Hypothesis (Griliches, 1957; Schmookler, 1966) was verified in China's agricultural development.

Since the expiration date of rural land contract was around 1997, the worry for a smooth extension of the contract reduced the growth rate of China's agricultural productivity to some extent after 1996. The empirical research findings show that rural land policy made a relatively big contribution to TEC, illustrating that the land system had a relatively balanced impact on the agricultural technology in different regions and that the development of agricultural production can be promoted by changing the technical efficiency under the condition of unchanged agricultural technologies. The stimulating role of institutional factors was well reflected in this point. However, because China's rural land system has been stable since the late 1970s, it has fundamentally finished such a role to 1984 (Lin, 1992). Therefore, its contribution to TEC only remained at a low level and the frequency and the extent of its fluctuation were very limited.

5.2.1 The second stage 1998-2003

In this stage, China's agricultural productivity underwent significant fluctuation which was closely related with the frequent changes of agricultural policy in the same period. On one hand, the phase-out of regulations on agricultural product prices made the negative influence of the international financial crisis and the downturn of the domestic economy of the same period have a severe impact on the selling prices of agricultural products and thus caused poor selling; on the other hand, agricultural taxes increased largely in this period and illegal collections of agricultural taxes often occurred in some regions. The empirical research findings indicate that agricultural product price policy and agricultural taxation policy have relatively great negative impacts on TC, especially in regions of high market level like Jiangsu. Moreover, the extension of the rural land contract period by the Chinese government in 1998 allowed rural land policy to keep their contribution to TEC.

5.2.1 The third stage 2004-2009

Facing increasingly severe problems of agricultural production, the Chinese government has implemented a series of new reformed policies since 2004, which guaranteed China's growth of agricultural productivity again. These policies included: (1) complete cancellation of agricultural tax to eliminate its negative effect on the agricultural productivity; (2) implementing the policy of "four agricultural subsidies", which not only enhanced farmers' enthusiasm for production but also allowed significant growth of agricultural productivity since subsidies were helpful to popularize new technologies; (3) completing the reform of agricultural product pricing mechanism; the farmers' income was increased significantly due to the great increase in the agricultural product prices under the influence of rapid macroeconomic growth in the same period; (4) gradually liberalizing controls over trading activities of rural land use right. According to the empirical research findings, the changes in China's agricultural productivity after 2004 were much better than the previous period. The policy of "four agricultural subsidies" made a relatively big contribution to TC and TEC, especially had even a greater impact in such less-developed areas as Hunan and Sichuan. Obviously, agricultural subsidy policy could better facilitate new technology popularization. In addition, agricultural product price policy made a relatively big contribution to TC, especially in such developed areas as Jiangsu, Shandong and Fujian. The contribution of rural land policy to TEC was improved in a limited extent.

The following observations can be drawn from the above analysis: firstly, rural land policy has a relatively great impact on TEC, agricultural product policy and agricultural taxation policy have a relatively great impact on TC, and agricultural subsidy policy have a relatively great impact on both TEC and TC; secondly, agricultural subsidy policy have relatively great effect in less-developed areas, agricultural product price policy have relatively great effect in developed areas, and both rural land policy and agricultural taxation policy have great effect in the above regions.

6 CONCLUSION

This paper evaluates and interprets the impact of China's agricultural policy reform on agricultural productivity in the past fifteen years. The results demonstrate that under the influence of agricultural policy reform, China's agricultural productivity has achieved significant growth over the past fifteen years. It is also found that different agricultural policies had quite different impacts on TC and TEC, with obvious periodic and regional characteristics. Additionally, the existing agricultural policies have imbalanced impacts on TC and TEC, and the growth drive mainly comes from TC rather than TEC.

It is worth notice that the above agricultural policy reform was accomplished within the economic development pattern combining liberty with regulation. According to China's present agricultural productivity, the positive role of the above economic pattern shall be fully affirmed. However, it shall not be overlooked that this pattern also leads to frequent changes of agricultural policies resulting in great fluctuation in agricultural productivity each year. The empirical research findings reflect this to some extent.

The agricultural products involved in this paper are limited to grain crops, and therefore the comprehensiveness of relevant measurements of evaluation indexes are affected to some degree. Besides, such factors as natural disasters, agricultural product trades and agricultural industrialization are not taken into consideration.

This paper helps us better understand the impact of agricultural policy reform on the changes of agricultural productivity. Firstly, in most cases, we attach more attention to agricultural technical progress but less to new technology popularization. However, a major factor restricting the agricultural growth in some regions now may be related more closely with the latter one. Therefore, it is more urgent to establish effective incentive policies for promoting new agricultural popularization. As to this respect, agricultural subsidies are undoubted a good policy choice, especially for less-developed areas. Secondly, different agricultural policies have significantly different impacts in regions with different levels of economic development, but with the gradual upgrading of market level in such regions, such a difference will be reduced step by step. Thus, the agricultural policies including agricultural product price policy which are more affected by market fluctuation shall receive more attention. Finally, although rural land policy have stable impacts on agricultural productivity, it is still quite necessary to maintain their long-term existence, stability and continuity because of their persistent support for agricultural development.

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Table 1 Change and decompose of TFP from 10 villages in Hunan Province 1995-2009

Year	TFPG	TC	TEC	TE	Year	TFPG	TC	TEC	TE
1995	-2.79	-2.87	0.31	92.66	2003	1.56	1.24	0.17	95.62
1996	3.83	4.48	0.34	92.97	2004	2.61	3.10	0.15	95.96
1997	-3.44	-3.41	0.28	88.43	2005	-0.04	-0.19	0.17	97.09
1998	0.28	0.09	0.24	93.33	2006	-2.67	-3.48	0.14	96.25
1999	-0.72	-0.89	0.27	93.80	2007	2.28	1.94	0.12	97.37
2000	2.32	2.68	0.22	95.00	2008	2.81	3.29	0.25	96.50
2001	0.11	-0.11	0.19	95.23	2009	5.16	4.32	0.36	97.59
2002	-4.95	-6.38	0.22	95.43	average	0.42	0.25	0.23	94.88

Table 2 Change and decompose of TFP from 10 villages in Jiangsu Province 1995-2009

Year	TFPG	TC	TEC	TE	Year	TFPG	TC	TEC	TE
1995	2.34	1.77	0.57	78.34	2003	14.64	14.46	0.49	81.94
1996	1.36	0.82	0.58	78.77	2004	10.34	9.68	0.48	82.31
1997	2.42	2.37	0.56	79.19	2005	6.16	6.73	0.45	82.67
1998	-7.02	-7.53	0.56	79.60	2006	-5.12	-4.61	0.44	83.37
1999	7.68	8.16	0.51	80.01	2007	2.38	1.17	0.43	83.71
2000	2.05	1.54	0.50	80.80	2008	16.13	15.73	0.42	84.04
2001	7.64	7.44	0.52	81.19	2009	-1.89	-3.45	0.58	84.37
2002	-23.80	-23.56	0.49	81.57	average	2.35	2.05	0.51	81.46

Table 3 Change and decompose of TFP from 10 villages in Sichuan Province 1995-2009

Year	TFPG	TC	TEC	TE	Year	TFPG	TC	TEC	TE
1995	-0.12	-0.14	0.018	84.90	2003	-3.82	-3.86	0.200	85.62
1996	-3.88	-3.76	0.033	93.27	2004	2.31	2.20	0.053	84.25
1997	8.17	7.89	0.119	93.73	2005	2.27	2.11	0.096	91.11
1998	-3.93	-3.86	0.116	93.24	2006	5.44	5.10	0.182	92.26
1999	-4.03	-4.34	0.240	94.65	2007	-3.77	-3.87	0.248	90.73
2000	3.01	10.91	0.217	85.67	2008	-7.21	-11.85	0.087	84.55
2001	-8.63	-8.53	0.245	92.06	2009	8.11	7.65	0.163	93.32
2002	7.03	6.84	0.052	91.93	average	0.26	0.17	0.14	90.09

Table 4 Change and decompose of TFP from 10 villages in Fujian Province 1995-2009

Year	TFPG	TC	TEC	TE	Year	TFPG	TC	TEC	TE
1995	1.34	0.98	0.34	81.21	2003	-9.3	-9.78	0.58	78.71
1996	7.34	6.88	0.40	79.31	2004	1.38	0.90	0.46	83.33
1997	0.45	0.05	0.40	83.04	2005	7.1	6.78	0.32	78.54
1998	-2.46	-3.12	0.53	81.88	2006	2.34	2.00	0.42	84.38
1999	5.67	5.41	0.51	80.98	2007	-3.45	-4.21	0.52	85.83

2000	3.45	2.84	0.55	83.11	2008	15.98	15.29	0.53	81.97
2001	-7.08	-7.52	0.52	83.61	2009	-4.12	-4.67	0.38	86.35
2002	0.78	0.20	0.57	79.34	average	1.29	0.80	0.47	82.11

Table 5 Change and decompose of TFP from 10 villages in Shandong Province 1995-2009

Year	TFPG	TC	TEC	TE	Year	TFPG	TC	TEC	TE
1995	5.90	5.86	0.19	82.03	2003	2.55	2.41	0.17	84.64
1996	7.90	7.24	0.18	85.28	2004	3.71	3.34	0.20	85.03
1997	-3.38	-3.66	0.20	84.73	2005	0.30	0.12	0.21	82.67
1998	6.02	5.52	0.20	86.19	2006	-1.13	-1.30	0.21	85.23
1999	-4.42	-4.66	0.20	79.39	2007	13.37	13.06	0.24	86.70
2000	8.71	8.26	0.19	81.06	2008	-3.86	-4.61	0.23	88.14
2001	-10.09	-10.60	0.20	83.22	2009	2.02	0.80	0.23	88.11
2002	1.16	0.89	0.18	80.14	average	1.92	1.51	0.20	84.17

Table 6 Effect of Agricultural Policy Reform on the Agricultural productivity 1995-1997

Variable	TFPG	TC	TEC
rural land policy	-1.34***	0.82***	-2.33***
	（0.08）	（0.13）	（0.72）
agricultural produce	5.02***	4.46***	1.42***
price policy	（0.98）	（0.81）	（0.27）
agricultural tax policy	-2.92***	-2.46***	-0.25***
	（0.41）	（0.38）	（0.13）
agriculture subsidy policy	0.01**	0.002**	0.004**
	（0.02）	（0.001）	（0.001）
constant term	163.85***	198.39***	147.52***
	(52.46)	(62.45)	(38.82)
Time of dummy variable	yes	yes	yes
sample size	15	15	15
time	3 years	3 years	3 years
Adk-R2	0.47	0.41	0.38
logarithm likelihood	-281.34	-391.98	-328.82

Note: *** and ** represent1%and 5% significance levels
Standard errors in parenthesis

Table 7 Effect of Agricultural Policy Reform on the Agricultural productivity 1998-2003

Variable	TFPG	TC	TEC
rural land policy	5.28***	1.31***	4.37***
	（0.93）	（0.26）	（0.62）
agricultural produce	-2.77***	-5.28***	0.83***

price policy	（0.98）	（0.81）	（0.27）
agricultural tax policy	-4.35***	-3.42***	-1.28***
	（0.93）	（0.72）	（0.61）
agriculture subsidy policy	0.006**	0.001**	0.002**
	（0.002）	（0.001）	（0.001）
constant term	176.92***	198.45***	183.32***
	(59.93)	(51.06)	(48.39)
Time of dummy variable	yes	yes	yes
sample size	30	30	30
time	6 years	6years	6 years
Adk-R2	0.97	0.94	0.97
logarithm likelihood	-471.38	-372.65	-324.92

Note: *** and ** represent1%and 5% significance levels

Standard errors in parenthesis

Table 8 Effect of Agricultural Policy Reform on the Agricultural productivity 2004-2009

Variable	TFPG	TC	TEC
rural land policy	4.37***	0.92***	3.85***
	（0.51）	（0.03）	（0.42）
agricultural produce	6.82***	5.53***	1.37***
price policy	（1.04）	（0.82）	（0.69）
agricultural tax policy	0.00**	0.00**	0.00**
	（0.00）	（0.00）	（0.00）
agriculture subsidy policy	8.55***	3.82***	7.29***
	（0.83）	（0.48）	（0.92）
constant term	214.83***	192.58***	172.96***
	(74.29)	(61.04)	(52.29)
Time of dummy variable	yes	yes	yes
sample size	30	30	30
time	6 years	6years	6 years
Adk-R2	0.96	0.98	0.93
logarithm likelihood	-530.04	-487.94	-423.48

Note: *** and ** represent1%and 5% significance levels

Standard errors in parenthesis