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Agriculture and Agricultural Science Procedia 1 (2010) 376–385

Agriculture and Agricultural Science Procedia

International Conference on Agricultural Risk and Food Security 2010

Trade Liberalization, domestic input and sustainability of agricultural TFP growth: A new Perspective Based on TFP growth structure

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Abstract

As one of the fundamental ways to solve the food security and promote farmers' income, agriculture Total Factor Productivity (TFP) growth has attached a great concern which is examined in a vast literature. However, there is little work that examines sustainability of the growth, which is more significant for future development of agricultural sector. Moreover, whether trade openness and domestic investment policy which are used to promote the agricultural TFP growth also could play a great role in the sustainability of the agricultural TFP growth is rarely examined. We estimate and decompose China's agricultural TFP using Data Envelopment Analysis (DEA), finding that technical change is the main source of China's agricultural TFP growth since 1978, favoring that TFP growth is lack of sustainability. In addition, using two-stage estimation procedure, we make an empirical analysis about the impact of trade openness and domestic input on TFP structure. Results show that trade openness and agricultural infrastructure is narrowing the gap between the two sources, while agricultural scientific investment is just the opposite. Therefore an in-depth trade openness and agricultural infrastructure are needed favoring the growth of China's agriculture, while agricultural scientific investment should be conducted after a higher level of trade openness and agricultural infrastructure.

Keywords: Trade openness; Domestic input; Structure of agricultural TFP growth; Sustainability; DEA; Two-stage estimation procedure;

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2210-7843 © 2010 Published by Elsevier B.V.
doi:10.1016/j.aaspro.2010.09.047

1. Introduction

China, one of the largest agricultural countries, has attracted a growing concern on agricultural development, food security and farmers' income based on the economic theories by Schultz. Especially for developing countries, increasing the agriculture productivity, treated as one of fundamental ways to ensure food security and promote the farmers' income, is important and needs continuous study at present. Therefore, the agriculture productivity has been paid extensive attention and the growth of agricultural industry's TFP, which is the key indicator, as well as its decomposition and influencing factors have been the main topics focused on in this field.

However, for Chinese low-level agriculture development, even with growing population, booming demand for food and increasing pressure of rural surplus labor shifting to city, problems in achieving food security and improving farmers' income will exist for a long time. As a long-term operation, improving agricultural productivity should be the essential issue as well as the sustainability of agricultural TFP growth which could also be the significant criterion to measure the current policy. Therefore we hereby explore the sustainability of agricultural TFP which is rarely mentioned in the relative studies to provide guidance and reference for more effective policy measures.

In order to clarify the point, it is principal to define the connotation of agricultural TFP growth's sustainability first. Generally, TFP growth stems from two sources, technical efficiency and technical change. Growth pattern could be defined as a trade-off between the two sources, which determines TFP growth. Although all the choices of growth patterns can achieve the substantive growth of TFP, the distributions between the two sources should be coordinated, as the two sources are mutually restricted: under a certain level of technology, improvement of technical efficiency is bounded; holding technical efficiency constant, incentive of technology research and development is lacking, and applicability of new technology is restrained. In other word, the sustainability of TFP growth would suffer from over-depending on either source. So, that is the structure of TFP growth which embodies and decides the sustainability of agricultural TFP. Different TFP growth patterns may result in different sustainability.

To achieve the growth of TFP, some agricultural policies related trade liberalization and domestic input (including agricultural infrastructure and agricultural scientific input) have been carried out since 1978, which are proved to be efficient by the reality. However, if we consider the sustainability of TFP growth in a long-term view, we should not jump to conclusions about whether the two policies would work positively. Thus, in the article, we would pay specific attention to the impact of trade openness and domestic input on the sustainability of TFP growth, which can be measured by the growth structure.

Since the structure of TFP growth can be decomposed into technical efficiency and technical change, the impact of trade openness and domestic input on TFP structure can be realized by its influence on technical efficiency and technical change individually. During the process, both of technical efficiency and technical change will be enhanced, while the influence degrees differ between each other, which lead to the change of TFP growth structure. Therefore, it is not easy to draw conclusions concerning the exact impact of the two policies on the growth structure and the sustainability by simple deductions. Serious study should be accomplished through empirical analysis.

In the thesis, we will summarize the evolutional trend of the TFP growth structure and analyze its sustainability, using data set from 1978 to 2008. In addition, by applying two-stage estimation procedure, we make an empirically analysis about the impact of trade openness and domestic input on TFP structure.

The paper is organized as follows. Section 2 provides the literature review. Section 3 provides a more detailed review of the context and analysis framework, paying close attention to definition and constitution of TFP growth structure, and how the structure relates to sustainability. Section 4 empirically explores the effects of trade liberalization and domestic input on productivity growth structure, based on data set 1978-2008. Section 5 gives discussions and implications.

2. Literature review

TFP, the key to sustainable economic growth, has attracted a growing concern all over the world, especially in agricultural sector due to its importance for agricultural development. For instance, some of the researches related China's agricultural TFP growth with food security by exploring factors influencing food supply and demand [20]. And the same conclusion is reached by other researchers [11, 17, 19].

Existing agricultural TFP researches fall into two categories: to quantify TFP by estimation and decomposition, and to identify the factors encouraging TFP.

As to the first category, various methods have been utilized to calculate TFP and similar results have been drawn [1, 8, 16, 12]. Meanwhile, after decomposing TFP, an immense and impressive scholarship blames downtrend of agricultural TFP in most developing countries on declination of technical efficiency [2, 5, 8, 18]. Specifically in China, scholars are consistent that technical change is the main source of TFP growth, and that contribution of technical efficiency is insignificant [9, 14, 3].

As to the second category, New Growing Theory believes they are the main impetus for TFP growth that economic exchange, domestic scientific input and infrastructure facilitating production. Indeed, there is strong support for each of the three factors as being primarily responsible for China's agricultural TFP growth [4, 7, 10, 13, 15], although some research argue that foreign advanced tech may be underutilized in domestic agricultural production [6]. However there are barely research which explores specific mechanism that each factor may affect TFP, with mixed consequences for growth pattern and sustainability.

Thus, although there is a vast literature that quantifies TFP growth and identifies the factors that may influence TFP growth magnitude, it is still unanswered what the growth pattern is, and how it relates to sustainability.

3. Wider context and theoretical framework

TFP growth stemming from two sources, technical change and technical efficiency, the growth structure, related to growth sustainability, could be denoted by ratio of contribution of the two, characterizing productivity growth pattern which is considered as an important parameter to reflect the development of TFP. In our paper, we take it as one of the most significant aspects to analyze whether TFP growth is sustainable or not. TFP growth structure is specified as:

$$STFP_t = \frac{TP_t}{EC_t}$$

where $STFP$ is growth structure, TP is technical progress, EC is the technical efficiency change, and t shows year.

If we want to explore the impact of trade liberalization, domestic investment on the sustainability of agricultural TFP growth from the angle of growth structure, the concept of TFP growth structure, its composition and influencing mechanism on sustainability should be studied first. After investigating the tendency of agricultural TFP growth structure during the past three decades, we can establish an empirical framework to study the impact.

It should be noted that the two sources of TFP growth are mutually restricted. Holding resources constant, TFP growth could be considered as an increase in output, technical change as production possibility frontier shifting outward, while technical efficiency as real production moving toward the frontier. On one hand, keeping technical level constant, improvement of technical efficiency is bounded, and it would be even harder to improve efficiency when real production is near the frontier. That is, marginal cost of technical efficiency improvement is increasing. Therefore, restricted by technical efficiency, TFP growth speed would slow down or even stand still if technical change is ignored. On the other hand, technical change, depends mainly on R&D and application of new-tech in the real world, would be affected by the demand for new-tech in a certain degree. Demand for new-tech and its application, related with technical efficiency, could be incentive for technical change. Without technical efficiency, new-tech would have poor performance in practical application, or could not be applied in a large scale, and therefore, demand for new-tech would decrease, and so would be the technology research and development, which would be another main reason of technical change's marginal decline when technical efficiency come to a standstill.

Overall, to avoid the efficiency loss by the restriction of technical change and technical efficiency, we should make sure that they can grow together harmonically. However, the most optimal structure still has to be analyzed by further research. From our point of view, depending too much on technical change or technical efficiency, both of them would be obstacles to the sustainability of TFP growth. Thus, to a great degree, TFP growth structure reflects and determines the sustainability of TFP growth.

Moreover, it mirrors the sustainability of China's agricultural TFP growth that evolutional, trend of TFP growth structure for recent thirty years since the Economic Reform, which could be denoted by evolutional trend of ratio of technical change to technical efficiency. It should be noted that changing trend is more meaningful in comparison with numeric value in each year, because we have not determined "best ratio" in terms of sustainability. Here Malmquist index method is applied to measure agricultural TFP over the period 1978-2008. Based on its result, we can analyze the changes in growth structure and its sustainability.

DEA, as a nonparametric productivity analysis method, needn't to generate specified production function and therefore avoid errors generated from model selection. Specifically, we adopt Malmquist index, fitting for panel data. The definitions and the methodology employed to estimate the index are well developed in the past decade and can be seen in Kalirajan [8]. We define distance function, and select variables following Kalirajan [8], and the data are from yearbooks or other published statistic materials. The calculation result is as follows.

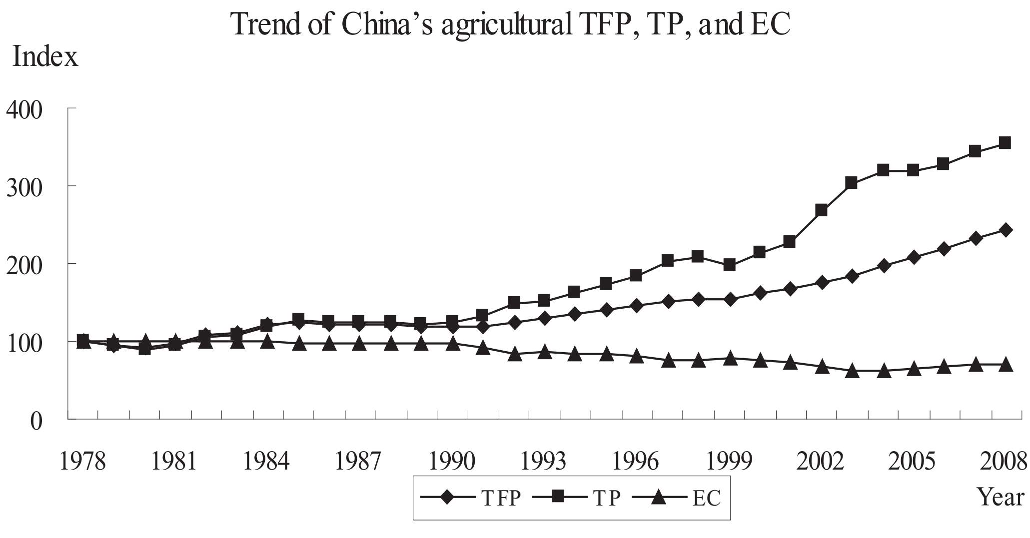

Figure 1. Trend of China's agricultural TFP, TP, and EC (1978-2008)

Note：all the three indexes are defined to be 100 in 1978.

Sources： "China Yearbook", yearbooks of provinces, yearbooks of industries.

Figure 1 shows that there is an upward trend of TFP in most years, with an increasing gap between technical change and technical efficiency. The curve of technical change is above that of technical efficiency since the base year, with an opposite change direction. Agricultural technical efficiency decreases in most years. For instance, compared with the base year, there is a 30% decrease in 2008. However, technical change increases by 4.3% per year in average, covering the loss caused by the efficiency, such that TFP develops by 3% per year generally.

As mentioned above, the relationship between technical change and technical efficiency not only affects TFP itself, but has an influence on the sustainability of TFP growth.

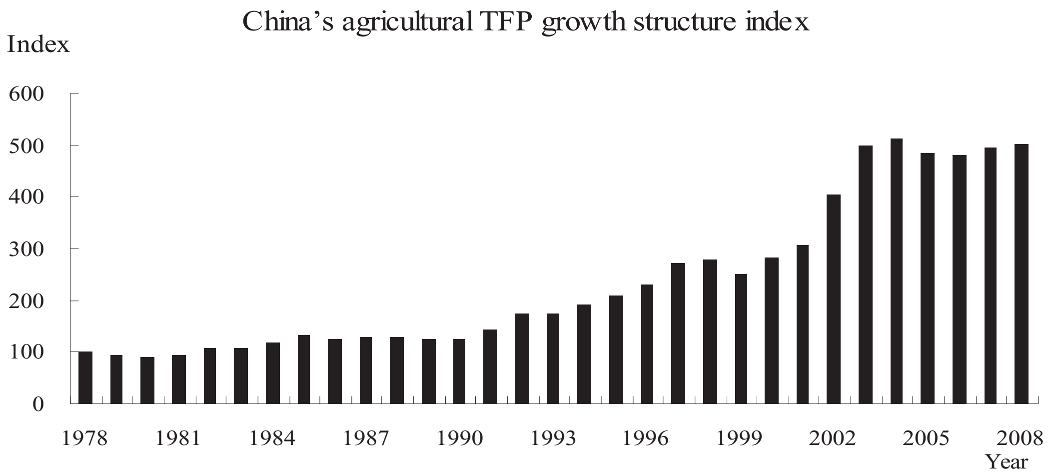

Figure 2 China's agricultural TFP growth structure index (1978-2008)
Note: index is defined to be 100 in 1978.
Sources: "China Yearbook", yearbooks of provinces, yearbooks of industries

Figure 2 shows even more evidently that structure is unbalanced since 1978, the Economic Reform. There is a tendency that TFP over depends on technical change, and this unbalanced tendency is growing by 5.5% per year in average, a substantial speed. To TFP growth, technical change contributes 138% in average per year, while technical efficiency contributes negatively, around -40% per year. According to above discussions, this unbalanced growth pattern, the one over-depend on technical change, would stunt technical improvement, and thus TFP growth as a whole. Therefore, it is concluded that China's agricultural TFP grow is lack of sustainability, and it becomes even more serious with the tendency continuing.

Another question is whether the sustainability of the TFP growth is beneficial from the trade liberalization and domestic input? According to the above conclusion, it would be positive only if they promote technical efficiency more than technical change.

To assess the impact of trade openness and domestic input on TFP, we adopt two-stage estimation procedure model and a time-serial date set over the period 1978-2008. The results are presented in the next section.

4. Model, data and results

It is possible that the impacts of trade liberalization and domestic input on technical efficiency and technical change are all positive, but with different degrees. In other words, trade liberalization and domestic input may conduct a more significant impact on technical efficiency than on technical change or on converse to further TFP growth. This article applies empirical method to analyze the impact of trade liberalization and domestic input on TFP sustainable growth, that is, by estimating how much they separately contribute to technical efficiency and technical change to analyze the direction, degree and even deviation of the impact on the structure of agriculture TFP growth, which is subject to the path and mechanism of the impact. To answer the questions, we need to discuss the possible mechanism and the possible deviation of impact on technical efficiency and technical change before we use the empirical model.

It has been a widespread belief that China's agricultural TFP growth stems from two sources: one is the trade with foreign countries, and the other is domestic input aiming at R&D (Research and development) and efficiency improvement, simplified as trade liberalization and domestic input. In our case, trade liberalization is denoted by China's agricultural trade openness, and domestic input by agricultural scientific input and infrastructure construction.

There is no doubt that agricultural trade openness promotes China's agricultural TFP growth, however, unlike production in other sectors, agricultural production is highly restricted by geographical location. Thus, international technique exchange is also restricted by some objective factors such as the eco-environmental and factor endowment, imported technique could not be used directly before it is changed and renovated in order to adopt for the local atmosphere. In the meantime, agricultural trade liberalization make it more important to comply with supply and demand, the comparative advantage displays a more significant role, the industry structure changed accordingly, and deviate to those possess more comparative advantage. Meanwhile, the production efficiency of those industries is generally better than others, thus, finally the production efficiency of whole agriculture industry improved.

Besides, labor-intensive industries, the ones with comparative advantage, upgrade the efficiency and productivity of other inefficient industries by absorbing surplus-labors from them, planting industry e.g. Therefore, agricultural market openness promote China's agricultural TFP growth by upgrading industry structure level, shifting surplus labors, rather than importing techniques. So, it is possible that the impact on TFP growth from agricultural market openness deviates more to technical efficiency improving.

Second, the increasing agricultural technical inputs offer a strong fundamental for agricultural R&D and higher the technical level directly, and conduct a positive impact to TFP growth through this path, but have no obviously influence on technical efficiency. In fact, it is true that TFP is over-depending on technical change in China, new-tech would have poor performance in practical application, or could not be applied in a large scale, and therefore, demand for new-tech would decrease, and so would be the technology research and development.

Third, Construction of agricultural infrastructure contains a large scope. In China, agricultural infrastructure constructions primarily include farmland irrigation, transportation for agricultural production, and production bases, which promote condition of agricultural production and logistics, but barely encourage technical change. It can be predicted that the impact to TFP growth could deviate more to technical efficiency.

To test the above hypotheses, we adopt estimation procedure to estimate the deviation.

For a certain country, TFP could be regarded as exogenous factor, and although it is easy to estimate the impact on TFP of agricultural trade openness, agricultural scientific input and infrastructure construction, it is difficult to estimate their impact on TFP growth structure which equals to the deviation to technical efficiency and technical change. Thus, this paper adopt two-stage estimation procedure which has been applied in the article "THE IMPACT OF OUTSOURCING AND HIGH-TECHNOLOGY CAPITAL ON WAGES" from Robert C. Feenstra (1998) to discuss this issue.

For the first step, to estimate the impact on agricultural TFP of a multitude of variables, including trade liberalization, scientific input, and infrastructure construction, such that we can get the information of contribution of each variable.

$$\Delta \ln TFP_t = \alpha_0 + \alpha' \Delta z_t + \eta_t \tag{1}$$

Where α is K*1 coefficient vector; z_t K*1 variable vector, including trade liberalization, scientific input, and infrastructure construction; and η_t error term, covering the rest factors that may influence TFP.

For the second step, we calculate the sources of TFP growth, using information about agricultural TFP, technical change, and technical efficiency, to analyze changing trend of contribution.

$$\Delta \ln TFP_t = \theta_t' x_t \qquad (2)$$

Where θ_t is K*1 coefficient vector, capturing contribution of technical change and technical efficiency on agricultural TFP growth; x_t is K*1 variable vector, including technical change and technical efficiency.

Incorporating equation (1) and (2), we regress this component of the change in TFP on its structure shares, thereby obtaining predicted changes of technical efficiency and technical change due to that structural component.

$$\alpha_k \Delta z_{tk} = \delta_0 + \delta_k' \theta_t + \mu_{\mathrm{tk}} \qquad (3)$$

Where α_{k} can be obtained from Equation (1); δ_k a coefficient vector, capturing contribution of the variables on technical change or technical efficiency; k identifies the variables, trade liberalization, scientific input, or infrastructure construction; μ_{tk} is error term.

We adopt time-serial data over the period 1978-2008, with 1978 as the base period. Equation (1) and (2) lead to the results as below:

Table 1. Estimation result (1978-2008)

Dependent variable, Change in share-weighted TP and EC explained by:	$\alpha_1 \Delta z_1$ ①	$\alpha_2 \Delta z_2$ ②	$\alpha_3 \Delta z_3$ ③
θ_1	0. 231 (0.042)	0.703 (0.011)	0.174 (0.039)
θ_2	0.719 (0.009)	0.248 (0.044)	0.771 (0.003)
Constant	1.259 （0.023）	1.294 （0.031）	1.991 （0.019）
R^2	0.669	0.566	0.571

Note：z_1、z_2、z_3 trade liberalization, scientific input, and infrastructure construction；where α_1、α_2、α_3 are coefficients of the three variables, identifying the contribution to TFP respectively; θ_1、θ_2 contribution of technical change and technical efficiency on TFP growth; with P value in bracket。

The results show that coefficients are statistically significant at 5% level, although fitting degree is not very high due to limitation of data. Since all the data contained in the analysis are treated in the form of index with 1978 as the base time, the coefficients regressed between every structural variable and technical change, technical efficiency can be compared directly, which embody their contributions to technical change and technical efficiency. Meanwhile, in the case that the dependent variables in the three models evolved from Equation (3) is not the related structural variables simply, but multiplied by the weight α , which is got from the estimation of Equation (1), the coefficient of each independent variables among the three models can be compared. The coefficients reflect the contributions of different structural variables on technical efficiency or technical change.

As we expected, the estimation results indicate that agricultural trade liberalization and agricultural infrastructure have positive impacts on technical efficiency, and more significant than that on technical change. Thus, according to discussion in section 3, agricultural trade liberalization and agricultural infrastructure would promote sustainable TFP growth in the case of China's present situation. While in model 2, impact of agricultural scientific input on technical efficiency is lower than that on technical change, indicating that agricultural scientific input contributes a lot to improvement of technical level, but are harmful for the sustainability of agricultural TFP growth. Besides, the estimation results also show that, to technical change, all the three variables work positively, and of the three variables, agricultural trade liberalization constitute the most.

In terms of technical efficiency, agricultural infrastructure construction constitutes the most, followed by trade liberalization, and scientific input the least.

Thus, agricultural infrastructure construction and trade liberalization both promote a balance and sustainable productivity growth, with infrastructure construction promoting more. While agriculture scientific input works negatively, undermining a sustainable growth.

According to discussion in section 3, potential and sustainability is decided by TFP growth pattern, and thus in the case of China, agricultural trade liberalization and infrastructure construction favor a sustainable growth, while scientific input does not, although it does promote TFP growth at present. Meanwhile, infrastructure construction would generate a better effect than trade liberalization would, in terms of sustainability of agricultural growth.

5. Conclusions and Policy suggestions

Agricultural TFP, as the fundamental way to develop China's agriculture, are widely discussed. Most of the existing literatures focus on the growth itself, while we insist the sustainability of TFP growth should be paid more attention. In this paper, we analyze the impact of trade liberalization, agricultural infrastructure and agricultural scientific input on the TFP growth sustainability from the view of the structure of TFP growth. The results show that technical change has served as the main source of China's agricultural TFP growth since 1978, while technical efficiency improved insignificantly, even decreased in certain period, suggesting that TFP growth is lack of sustainability. All of the policies, trade openness, agricultural infrastructure and agricultural scientific input, work as the three important methods to promote the growth of TFP, while only trade liberalization and agricultural infrastructure construction can improve its sustainability, and between the two policies, the impact of the latter is bigger. Agricultural scientific input plays a negative role for the sustainability.

The results above have important policy implications. First, since China is a big rather than strong agricultural country in the world, the low productivity in agriculture exists for a long time and hinders further development of China's agriculture. That is why the government always concentrates on finding ways to increase the agricultural productivity and promote the rapid growth of agricultural TFP. Policies carried out since 1978 have guaranteed the steady growth of TFP indeed, but the potential and impetus of TFP further growth should be paid more attention. Through our analysis, we find although TFP remains an upward tendency, but the structure of TFP growth is not quite proper, which implies the weak sustainability. From the study of China's TFP growth situation, it suggests both the immediate growth and its sustainability should be taken into consideration when the government makes policies. Otherwise, current growth will exact the price of further growth.

Moreover, the existing policies aiming at increasing the growth of agricultural TFP are mainly related to trade liberalization, agricultural infrastructure and scientific input. Among the three policies, agricultural scientific input is of greatest concern and develops fastest. The results show that trade liberalization and agricultural infrastructure construction can not only increase the agricultural TFP growth, also optimize the growth structure and enhance its sustainability. But raising agricultural scientific input may not be a good choice in the case of China in terms of TFP sustainable growth. Since scientific input and achievements could only be transformed into productivity if they are suitable for the existing productivity. But under China's present situation with a low level of technical efficiency, new-tech have poor performance in practical application, and demand for new-tech decreases, which could be used to explain why with increasing technical input, its promotion for technical change is decreasing. We are not, of course, against agricultural scientific input, which is needed to be conducted after higher level agricultural trade liberalization and infrastructure constructions achieved.

Last but not the least, our research has also shown that trade liberalization and agricultural infrastructure construction both improve agricultural TFP sustainable growth, with infrastructure improving more. Thus, this result favors trade liberalization, which is always a hot issue since China's entry to WTO. However, the study proves that infrastructure construction will generate more benefits. Therefore, to secure TFP sustainable growth, infrastructure construction should be the first priority of policy intervention.

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