

# Analysis on the Effect of R&D on Technological Progress in China's Agriculture

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## Abstract:

Agriculture development is the foundation for propelling rural modernization stably and persistently, which is also an important way to increase peasant income. Because of agricultural resources draining out and ecological environment degenerating, technological progress is the key force to maintain agricultural development, and agricultural R&D investment is the vigorous measure to promote technological progress. By using production function and accounting technological progress in China agriculture, the empirical research has found that effects of agricultural R&D input and of foreign trade on agricultural productivity are strong positive respectively, and effect of acreage under cultivating on productivity is weak negative. The suggestions that makes agricultural productivity progress constantly are increasing agricultural R&D input, trade guiding and market construction.

**Keywords: Production Function; Total Factor Productivity; R&D Input; Enlightenment of Results**

## 1. Introduction

Since 1978, there has been made a great development in China agriculture, the output of all kinds of agricultural products grows by a wide margin. According to the data from statistical yearbook of China, during 1978-2010, total grain yield grows by 0.793 times from 32.301 million ton in 1978 to 546.477 million ton in 2010, while oil plants by 5.19 times from 5.218 million ton to 32.301 million ton, aquatic product by nearly 14 times from 3.595 million ton in 1978 to 53.73 million ton in 2010, the total of fruit product by 31.57 times from 6.57 million ton in 1978 to 214.014 million ton in 2010, total output of meat grows by 6.46 times from 10.624 million ton in 1978 to 79.258 million ton in 2010. The great development in agriculture gives a steady safeguard for carrying forward the construction of industrialization and urbanization in China, which

enriches and raises people's living level in necessary provisions. All these are in favor of maintaining stable order in economy and society.

However, environment in modern times makes huge challenge to agriculture development, such population growth and quantity and quality of food enhancing, marginal profit reducing progressively in traditional production factor input, price of energy and fertilizer rocketing, ecological degeneration such as fertility of soil fading. These challenges make it more difficult in keeping on agriculture development, then dependence on technological innovation and promoting agricultural productivity has become more and more important. Many literatures consider that *R&D* investment is the most driving factor to boosting agricultural productivity progress. Through paths such as reducing input and protecting natural resources etc. to meet challenges, *R&D* may promote agriculture productivity progress. During the development process of decades, how does agriculture productivity change and how is the effect of *R&D* investment on agriculture productivity? Songqing Jin et al(2010) applied stochastic frontier production function to analyze the efficient and technique change in China agriculture. However, there is few current literatures on exploring the effect of *R&D* on agriculture productivity specially. That studying the intrinsic law possesses practice significance to agricultural sustainable development and enforcing *R&D* investment. There are diversified products and resources and labor time wasting is different in production. Then from the angle of total output value of agriculture products, output of agriculture over the years has been accounted in comparable price, incorporating into capital, labor force and land etc. as main input factor variables, computing agriculture productivity in China, and analyzing the effect of *R&D* investment on agriculture productivity.

## 2. Production Function Model and Theory Analysis

According to technological progress definition and production function, here total factor productivity is regarded as agriculture productivity, ie. The Output growth rate that can not be explained by the input factors growth rate (Solow,1957;Jorgenson,1995) , includes the effect of knowledge increase and technological progress (Denison,1967). Supposing that the main determinants to agriculture productivity is agriculture R&D investment, while other economic variables and non economic variables are regarded as controlled variables, then agriculture total factor productivity model is :

$$TFP = f(R, ST, D) \quad (1)$$

where  $R$  denotes the total investment of R&D in agriculture,  $ST$  denotes variables such as the scale of agriculture, agriculture production, agriculture product trade etc. structure change,  $D$  is dummy variable.

The relationship between explained variable  $TFP$  and explanatory variables is as follows: R&D investment in agriculture create new knowledge and technology continuously, which increases the stock of knowledge and technology in agriculture area and promotes the agriculture knowledge use and new technologies coming into being (Ruttan, V.W., 2002), then R&D investment raises agriculture productivity greatly (Chang, H.S. and Zepeda, L., 2001). That the scale of agriculture production expands is beneficial to technology application and product commercialization, product diversification and quality elevating is beneficial to realize product value, and foreign trade structure optimization favors production factor allocation and product sale, that joining product production with market demand will allocate resources efficiently and boost agriculture productivity progress(Chandrachai, A. et al,2004).

## 3. Data Resource and Variable Accounting

By use of *Statistical Yearbook of China, Agriculture Yearbook of China, China Yearbook of Science and Technology* etc., the data of agriculture capital input, labor force and land has been selected to build agriculture production function to compute the  $TFP$  in China agriculture. By incorporating Cobb-Douglas

production function and deriving its econometric model as follows:

$$Y_t = A_0 e^{\alpha_T t} K_t^{\alpha_K} Labor_t^{\alpha_{LB}} \quad (2)$$

Making natural logarithm on equation (2) each side yields:

$$\ln Y_t = \ln A_0 + \alpha_T t + \alpha_K \ln K_t + \alpha_{LB} \ln labor_t + \mu_t \quad (3)$$

Or according to actual requirement, it will choose logarithm production function or trans-log production function. Through accounting agriculture fixed capital investment and making it comparable by depreciation and price discounting, then the capital stock over the years will be selected (Zipeng Yu, Yong Liu, 2011). By regression analysis, the production factor output elasticity coefficients will be computed, the capital and labor force output elasticity coefficients denoted as  $\alpha_K$  and  $\alpha_{LB}$  respectively(Chen Shiyi, Zhang Jun, 2009).

$$\frac{\Delta Y_t}{Y_t} = TFP_t + \alpha_K \frac{\Delta K_t}{K_t} + \alpha_{LB} \frac{\Delta Labor_t}{Labor_t} + \mu_t \quad (4)$$

In equation (4), where  $TFP_t$  denotes the growth rate of agriculture productivity,  $\mu_t$  is disturbance term which obey to normal distribution with expectation value 0.

By use of equation (4), the growth rate of agriculture productivity may be computed as follows:

$$TFP_t \cong \frac{\Delta Y_t}{Y_t} - \alpha_K \frac{\Delta K_t}{K_t} - \alpha_{LB} \frac{\Delta Labor_t}{Labor_t} \quad (5)$$

In the following, the explained variable  $TFP$  has been computed and analyzed its influence factors. Applying with gross output value in agriculture, forestry, herd and fishery, agriculture fixed capital investment agriculture labor force and agriculture cultivated land over the years, and using consumption price index and fixed capital price index to deal agriculture gross value and investment so as to be comparable. Through testing whether production function is satisfied to constant-return and choose the best logarithm format, the finding is production function satisfies to constant-return earnings and by regressing yields the

equation as follows:

$$\ln Y_t = 0.97 + 0.384108 \ln K + 0.615892 \ln labor \quad (6)$$

$$(9.47) \quad (14.27) \quad (14.28)$$

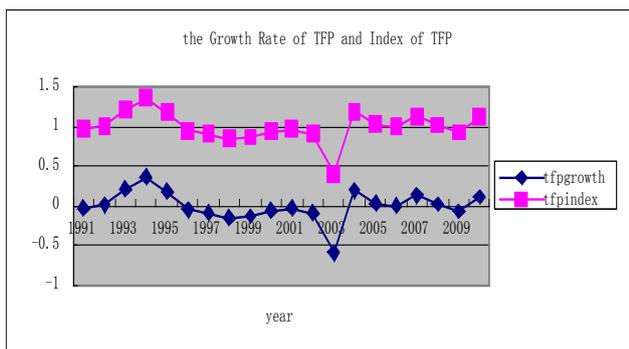
$$\text{Adj.R.sq.} = 0.884, \quad \text{D.W.} = 2.265.$$

Notes : 1% significance level, the number in parenthesis under each coefficient is the t-test value respectively, and following as the same.

According to equation (4) and (5), the growth rate of *TFP* may be calculated. Supposing that agriculture productivity index in 1990 is 1, then the *TFP* index over the years can be computed as chart 1, where *tfpgrowth* and *tfpindex* are the growth rate of *TFP* and *TFP* index, their relationship is:

$$tfpindex_t = tfpindex_{t-1} (1 + tfpgrowth_t) \quad (7)$$

Correlation coefficient between is near to 1. Therefore, on analyzing the determinants of productivity, it is necessary to choose only one indicator from them to solve the equation. The real relation between *tfpindex* and *tfpgrowth* is described as figure 1.



**Fig.1 The Index and Growth Rate of Agriculture Productivity**

The explanatory variables over the years has been collected such as: agriculture *R&D* investment, agriculture cultivated area, trade product structure etc. According to equation (1), econometric model can be incorporated to analyze effect of *R&D* on agriculture productivity, while other factor variables are regarded as controlled variables into the model. *RRD* is the ratio of agriculture *R&D* investment to gross agriculture output, *lnalnd* is the logarithm of agriculture cultivated area, then through regression yields the equation as follows:

$$TFP_t = 46.58 + 35.69RRD_{t-1} - 4.742 \ln alnd_t \quad (8)$$

$$(1.91) \quad (1.40) \quad (-1.87)$$

$$\text{Adj.R.squ.} = 0.74 \quad \text{D.W.} = 2.09$$

By analyzing agriculture operating structure, findings show that the lagging 2-period proportion of agriculture

trade product has granger-cause to the growth of agriculture productivity, and the regression equation is:

$$TFP_t = 0.5896 + 8.50RRD_{t-1} + 29.82REX_{t-2} \quad (9)$$

$$(3.47) \quad (2.46) \quad (2.60)$$

$$\text{Adj.R.sq.} = 0.84, \quad \text{D.W.} = 2.25$$

The analysis shows that in the first place, supposing that other condition keep constant, the more higher the proportion of agriculture *R&D* investment, the stronger positive effect on next period growth of agriculture productivity. In the second, keeping other variables constant, the more higher the proportion of agriculture trade product, the more significant positive effect on agriculture productivity of 2-lagging period. In the third, keeping other variables constant, the expansion of agriculture cultivated area, in the other hand, brings negative effect on the same period agriculture productivity. Then *R&D* investment in agriculture can promote agriculture production efficiency, while foreign trade of agriculture product can be the engine for agriculture productivity, but the expanding in agriculture cultivated area leads agriculture productivity reduce, the reason is because that cultivated area is expanded, the agriculture product output enlarges, which leads to agriculture product supply expansion and supply circulation has become non smooth, finally make the prices of agriculture product fall greatly, in the result, earnings in agriculture business lowers so that agriculture productivity goes down.

#### 4. Conclusion and Policy Suggestion

By calculating China agriculture productivity index since 1990 and analyzing the effect of agriculture *R&D* investment on agriculture productivity, the conclusion is as follows:

In the first instance, the growth of agriculture productivity in China shows obvious fluctuation. During the period from 1990 to 1995, agriculture productivity grows positively. During the period from 1996 to 2003, the growth of agriculture productivity is negative. And during the period from 2004 to 2010, after agriculture productivity grows positively in 2 years, it has become to fall negative in the next year. This finding does conform to the reality in China agriculture. In the early 90's of 20<sup>th</sup> century, with great positive energy from institution reform, China agriculture

productivity grows continuously, but during the period from middle 90's to 2003, the environment in China agriculture production has been worsening gradually, with increasing heavier burden of tax and charge on agriculture production, that disparity between city and countryside pulls bigger leads to the agricultural resources flow out, which constrains agriculture productivity as a result that agriculture productivity falls continuously. Since 2004, with reduction and exemption on agricultural taxation, agriculture production environment become better gradually. But because market mechanism affects, agriculture productivity growth has undulated with 2-year positive and 1-year negative. Market fluctuation has obviously influenced agriculture productivity.

In the second place, agriculture R&D investment in China has positive effect on afterwards agriculture productivity, and export of agriculture product has strong effect on lagging 2-period agriculture productivity. Expansion of agriculture cultivated area, however, leads to that earning of agriculture production falls down slightly, which imposes negative effect on agriculture productivity.

The development in agriculture and rural society is favor to increase peasant income and to lift peasant human quality, which is the very important content in China modernization. Under the affecting of socialist market mechanism, the ability of agriculture production to meet market mechanism is very weak. But from the view of agriculture positive externality, agriculture development has the function to keep society and economy stable. Then, based on the analysis above, it has given some policy suggestions as follows:

Government at all levels should increase R&D investment in agriculture, and popularize agriculture technology application, while making measures to prevent agriculture resource out-flowing and restrain agriculture ecology from worsening continuously, so that agriculture productivity growth is transferred from raising production factor input to depending on technology progress.

It is necessary to pay more attention to research and open up international market, which can promote agriculture product export out of China. Though cultivated area per capita in China is less with bigger population, the labor-intensive agriculture and

horticulture have very sound competitive power. Promoting export of these agriculture products is favor to take the advantage of labor quantity.

It is more urgent to perfect market system and to train peasants' market operating skill so as to reduce the risk of agriculture product sale and enhance agriculture production earnings. In China, the high-quality rural labor force flows out from agriculture continuously, while the employee in agriculture falls from 0.39 billion in 1991 to 0.266 billion in 2011. Peasants are not familiar with market mechanism and not used to utilize market for operating business. Governments and market administer should undertake in collecting and releasing the information of agriculture production and product circulation channel in order to improve peasant ability to master market, which can prevent market blindness to bring about excessive supply and demand imposing heavily negative impact on agricultural production.

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