

# Measuring and Analyzing the Contribution Rate of Agricultural Science and Technological Progress in Heilongjiang Reclamation Area

Zhang Lin , Tan Feng

Heilongjiang Bayi Agricultural University  
52080063@qq.com

## Abstract

*This paper estimates the contribution rate of agricultural science and technological progress on state farm's agricultural production in Heilongjiang reclamation with the method of Cobb-douglas production function model of solow residual value . It analyzes the constantly varying of the contribution rate of agricultural technological progress since 2000. Study has shown that, the contribution rate of agricultural science and technological progress in Heilongjiang Reclamation has risen at a faster rate. In addition, the growth of the contribution rate of scientific and technological progress depends not only on the application and promotion of supporting technology , but also on the modern management model likes "state farm + family farm".*

**Keywords:** reclamation agriculture the contribution rate of science and technological progress analysis

## 1. Introduction

Scientific and technological level is an important factor to measure the development of productive forces, which includes natural scientific and technological application, technological promotion, management, policy and so on. The quantitative research of science and technological progress originated from the mid-19th century and the qualitative measurement began from Cobb - Douglas production function published in 1928. Cobb - Douglas production function with the contribution index of scientific and technological progress was used to describe the contribution of scientific and technological progress on output levels. During this time, the calculation of the contribution rate of science and technological progress mainly depends on Cobb - Douglas production function , Solow residual method and CES production function method. Wu PengPeng estimated the contribution rate of science and technological progress from 1994 to 2009 with the Cobb - Douglas production function and analyzed the effects of capital and labor to Chongqing Economic Growth<sup>[1]</sup>. The model reflects the relationship between inputs and outputs of each element and estimates that technological progress makes contribution to the new value in a certain period<sup>[2]</sup>. But we can not calculate that the technological progress makes contribution to the increasing rate of output value directly<sup>[3]</sup>. Gaoxincai proposed the neutral technical progress theory in 1957 with Solow residual method  $Y_t = F[A(t)K, L]$  that researched economic growth dynamic from 1990 to 2009 in Shanxi Province, which is easy to measure a large technical system in a complex situation<sup>[4]</sup>. Arrow proposed CES production function model  $Y = A[\delta L^{-\rho} + (1-\rho)K^{-\rho}]^{\frac{1}{\rho}}$  in 1961. Jiangsong estimated that science and technological progress has influences on food production from 1985 to 2010<sup>[5]</sup>. In this model, labor output is a function of the marginal product of labor and the time-varying factor function of nonlinear technical explanation, which reflects that the contribution rate

of science and technological progress has influences on the output elasticity of labor and capital-output elasticity .Because the model contains many parameters and the calculation conditions are harsh, the resulting data is difficult to interpret<sup>[6]</sup>.

Heilongjiang reclamation with 4320 acres of arable land, 1380 acres of woodland, 527 acres of grassland and 378 acres of water is located in one of the three black belts. In 2013, it provided 22.17 million tons of commodity grain and stood the first in the national grain output<sup>[7]</sup>. It belongs to an important commodity grain base, strategic grain reserve base and the largest green, organic, pollution-free food base in china<sup>[8]</sup>. Heilongjiang reclamation area that adopts large-scale, mechanized, standardized modern agricultural production put the production of the state farms on the first place, which is the representative of modern agriculture in China. The research on scientific and technological progress making contribution to Reclamation and Ways in exploring the contribution rate of scientific and technological progress are not only beneficial for enhancing the level of agricultural production but also have great significance for the development of modern agriculture demonstration<sup>[9]</sup>.

## 2. Research Methods and Selecting Data

### 2.1. Concept Definition

Agriculture is referred as the primary industry in the paper, including farming, forestry, animal husbandry and fisheries and It is the foundation and pillar industries of Heilongjiang Reclamation<sup>[10]</sup>. In 2013, Gross production is 109.5 billion yuan in Heilongjiang reclamation area, among which gross agricultural production accounted for 47.6 percent in GDP. In the gross production of the secondary industry, the processing industry that regarded agricultural products as raw materials accounted for more than 60%. It is visible that agriculture still plays a key role in the economic development of reclamation<sup>[11]</sup>.

The national economy and the five-year plan for social development are one of the most important parts in national economic plan of China. Measuring the contribution rate of agricultural science and technological progress in a planning cycle units not only can reduce the impact of concentration of investment in fixed assets investment on the annual data but also can remove the effects of natural disasters and other random factors<sup>[12]</sup>. Therefore, we should use the planning cycle that adapted to the contribution rate of scientific and technological progress stage to calculate.

### 2.2. Research Methods

Heilongjiang Reclamation estimates the contribution rate of science and technological progress during the 2000 to 2012 with extended CD production function model - Solow residual method , As shown in Equation (1)

$$Y_t = Ae^{\lambda t} K^\alpha L^\beta S^\gamma \quad (1)$$

In this equation

$Y$  ——Output value, gross production of agriculture, forestry, animal husbandry and fishery;

$A$  ——Technology level, under the condition that the same amount of capital, labor and arable land, when A is larger, the profit technical level is higher and the parameter is a constant in the short term;

$K$  ——Capital, replaced with intermediate consumption, GDP can be found directly on the Statistical Yearbook, then get the intermediate consumption through the difference between output value and GDP ;

$L$  —— Employees;

$S$  —— cultivated area;

$\alpha$  —— the output elasticity of capital stock in Agriculture, forestry, animal husbandry and fishery ;

$\beta$  —— the output elasticity number of employees in Agriculture, forestry, animal husbandry and fishery ;

$\gamma$  —— the output elasticity of crop acreage

$t$  —— years

Calculating two data like  $Y$  and  $K$ , which use constant prices in 2000.

Meanwhile, assumed the returns to scale is constant, then  $\alpha + \beta + \gamma = 1$ .

In order to reflect the actual situation of agricultural production more objectively, Equation (1) ends logarithmic formula, which can be transformed into a linear equation (2):

$$\lambda_t = \ln Y_t - \ln A - \alpha \ln K_t - \beta \ln L_t - \gamma \ln S_t \quad (2)$$

As the non-continuity of real economic activity and statistics, differential can be replaced with difference, showing:

$$\lambda_t = \frac{dY_t}{Y_t} - \alpha \frac{dK_t}{K_t} - \beta \frac{dL_t}{L_t} - \gamma \frac{dS_t}{S_t}$$

Another  $GY_t = \frac{dY_t}{Y_t}$  ,  $GK_t = \frac{dK_t}{K_t}$  ,  $GS_t = \frac{dS_t}{S_t}$  , as shown in equation (3):

$$\lambda_t = GY_t - \alpha GK_t - \beta GL_t - \gamma GS_t \quad (3)$$

equation(3) is Solow residual value, where:

$GY_t$  ,  $GK_t$  ,  $GL_t$  ,  $GS_t$  represents the growth rate of  $Y$  ,  $K$  ,  $L$  ,  $S$  in year  $t$ . The function through regression calculation with equation(3) needs normalization process. Assumed fixed return to scale,  $\alpha + \beta + \gamma = 1$  , after determining these factors like  $\alpha$  ,  $\beta$  ,  $\gamma$  , then we can calculate the contribution rate of scientific and technological progress, as shown in equation (4):

$$TP_t = \frac{\lambda_t}{GY_t} \quad (4)$$

Using data come from "Statistical Yearbook of Heilongjiang Reclamation", in order to eliminate the impact of price factors, we should use the constant price in 2000 in calculating.

As follows (calculating the constant price):

At first, calculating the price index, as shown in equation(5):

$$\text{Price index } t = \text{current prices } t / \text{comparable prices } t \quad (5)$$

Then , calculating the constant prices of the  $i$  year , which regarded 2000 as the base year , as shown in equation(6):

Constant prices  $i =$

$$\text{current prices } i \times \text{price index } i \times \text{price index } i - 1 \times \dots \times \text{price index}_{2001} \quad (6)$$

## 2.3. Selecting Data

Datas come from "2001-2015 Statistical Yearbook of Heilongjiang Reclamation", Agriculture, forestry, animal husbandry and fishery production value is regarded as gross product; the total capital is equal to total output minus gross product; practitioners and arable land are accessible directly; total output and gross product are calculated with comparable prices in 2000.

**Table 1. Yearly Agricultural Productive Indexes of Heilongjiang Reclamation Area from 2000 to 2013**

Year <i>t</i>	Gross agricultural production(million) <i>Y</i>	Capital (million) <i>K</i>	Labor force (people) <i>L</i>	Arable land ( hectare) <i>S</i>
2000	791863	653701.00	421900	1980732
2001	865574	710407.00	452056	2011437
2002	874150	687249.00	437878	2012107
2003	1011681	844078.00	439954	1967419
2004	1301394	1043140.00	465737	2152183
2005	1484469	1391343.00	465073	2155968
2006	1649741	1476815.82	497173	2349243
2007	2011111	2016244.88	594990	2396780
2008	2449720	2521591.74	611059	2501994
2009	2922173	3100050.54	603106	2643866
2010	3656133	4082502.41	602140	2801189
2011	4226398	4528777.96	599512	2842779
2012	4885930	5183537.32	598771	2870592
2013	5215024	5482177.19	485109	2879922

### 3. Empirical Analysis

#### 3.1.The Contribution Rate of Agricultural Science and Technological Progress in Heilongjiang Reclamation Continues to Rise

Based on the "Statistical Yearbook of Heilongjiang reclamation ", the contribution rate of scientific and technological progress is divided into the following three stages: "Fifth period" from 2001 to 2005; "Eleventh Five period" from 2006 to 2010; "Twelve Five period" from 2011 to 2015; Statistics in 2015 are not yet available, we use statistical data in calculating from 2009 to 2013.

We can use the extended CD production function model - Solow residual value method. Based on the datas in Table 1, we can get the results shown in Table 2.

**Table 2. By Calculating the Contribution Rate of Scientific and Technological Progress Regression Algorithm Results in 2001 – 2013**

Project	Gross product	capital	Labor force	cultivated area	technological progress
growth rate	0.1306	0.0922	0.0059	0.0304	
Coefficient of elasticity		2.47%	-8.46%	106.00%	
Impact rate		0.23%	-0.05%	3.22%	9.66%
Contribution share		1.74%	-0.38%	24.65%	73.99%

According to data in table 2, the coefficient of elasticity  $\alpha$ 、 $\beta$ 、 $\gamma$  of  $K$ 、 $L$ 、 $S$  from 2001 to 2013 are 2.47%、-8.46% and 106.00%. Model and coefficients are qualified and goodness of fit is 98.91% and the model is reasonable.

**Table 3. The Regression Results from 2001 to 2012**

variable	Regression coefficients	Standard deviation	T-test
C	-35.51084805	11.66755485	-3.043555269
K	0.083251762	0.41352817	0.201320655
L	-0.285687897	0.38360625	-0.74474255
S	3.57763394	1.334657398	2.680563525

$$R^2 = 0.989098461699554 \quad F\text{-test} = 90.7301735259729$$

We can calculate the contribution rate of agricultural science and technological progress in Heilongjiang reclamation during the time of "Fifth period" "Eleventh Five period" "Twelve Five period" based on  $\alpha$ 、 $\beta$ 、 $\gamma$  in table 2, the results are shown on table4, table5, table6.

**Table 4. By Calculating the Contribution Rate of Scientific and Technological Progress Regression Algorithm Results in 2001 - 2005**

Project	Gross product	capital	Labor force	cultivated area	Technological progress
Growth rate	0.1288	0.0649	0.0071	0.0436	
Coefficient of elasticity		2.47%	-8.46%	106.00%	
Impact rate		0.16%	-0.06%	4.62%	8.16%
Contribution share		1.24%	-0.47%	35.86%	63.37%

**Table 5 . By Calculating the Contribution Rate of Scientific and Technological Progress Regression Algorithm Results in 2006 - 2010**

Project	Gross product	capital	Labor force	cultivated area	Technological progress
Growth rate	0.1474	0.1084	0.0491	0.0450	
Coefficient of elasticity		2.47%	-8.46%	106.00%	
Impact rate		0.27%	-0.42%	4.77%	10.12%
Contribution share		1.82%	-2.82%	32.35%	68.66%

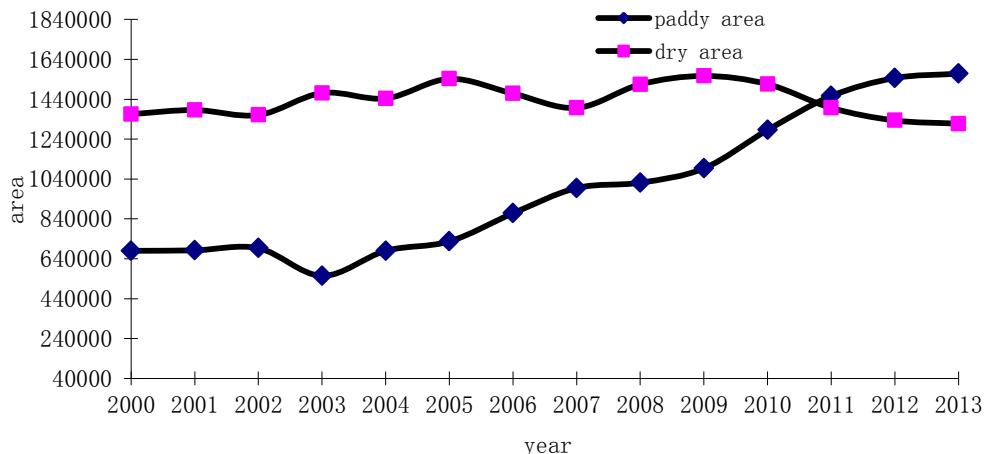
**Table 6. By Calculating the Contribution Rate of Scientific and Technological Progress Regression Algorithm Results in 2009- 2013**

Project	Gross product	capital	Labor force	cultivated area	Technological progress
Growth rate	0.1286	0.0913	-0.0530	0.0216	
Coefficient of elasticity		2.47%	-8.46%	106.00%	
Impact rate		0.23%	0.45%	2.29%	9.90%
Contribution share		1.75%	3.49%	17.81%	76.95%

During the time of "Fifth period" "Eleventh Five period" "Twelve Five period" in Heilongjiang reclamation, the contribution rate of agricultural science and technological progress are 63.37%、68.66% and 76.95% respectively, which keep rising. The contribution rate level of scientific and technological progress has been completed and has surpassed the development goal that put forward in China's "long-term technology development Plan". In 2020, the contribution rate of scientific and technological progress will reach 60%.

Cold rice breeding, seedling, planting, and other supporting technology promotion are important factors in promoting rapid growth of the contribution rate of scientific and technological progress in Heilongjiang Reclamation . Paddy cultivation compared with

dry cultivation requires higher skills and the income is also higher and the natural anti-risk capability is higher than dry cultivation. Lin yifu has used paddy field area in measuring the index of technological progress. From 2001 to 2013, the paddy field area in Heilongjiang reclamation increased from 682,200 ha to 1,568,100 ha, an increase of 2.3 times; The percentage of paddy area accounts for the cultivated area increased from 32.99% to 54.35%; In the new cultivated land, 92.26% are paddy area (table1). Over the last decade, rice yield gradually increased from 7782 tons / ha in 2001 to 8842 tons/ ha in 2013, an increase of 13.17%.



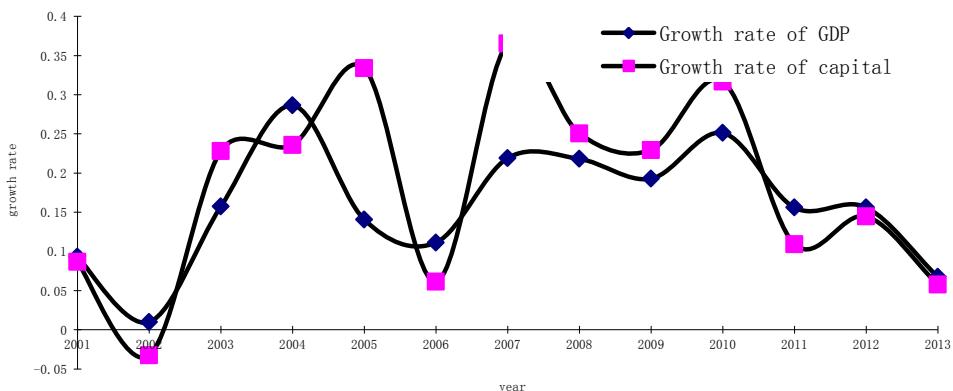
**Figure 1. Paddy Area and Dry Area from 2000 to 2013**

Agricultural Organization of the mode of operation that likes "State Farm + family farm" in Heilongjiang Reclamation is the system foundation of the rising contribution rate of scientific and technological progress . At first, cultivated land resources in reclamation that combined with beneficial crop in a broader space formed the economies of scale, which not only effectively reduces production costs but also can get favorable technical services. Secondly, State farms and family farms keep clear division of labor and cooperation, which develops the advantages of production and management fine for family farms and promotes the professional services in state farms in order to achieve a division of labor economy. At last, This model is conducive to promote the advanced machinery technology, breeding technology and planting techniques .

### 3.2. The Growth Rate of Capital Slowed

The contribution rate of agricultural science and technological progress of "Eleventh five period" increased by 5.29 percentage points than the "Fifth period" in Heilongjiang Reclamation . "Twelfth Five" increased by 8.29 percentage points than the "Eleventh Five" , whose growth rate is faster than the former. By comparing the growth rate of capital and GDP(table 2) , it is clear that the capital investment remained at a high growth level during the time of "Eleventh five period" from 2006 to 2010, which is higher than GDP growth rate; From 2011 to 2013, the growth rate of capital investment decreased and lower than the GDP in the same period. Capital growth slowed, which slowed the agricultural GDP growth, but the contribution rate of scientific and technological progress significantly increased. It is clear that agricultural production of reclamation is gradually transforming the epitaxial growth of high input and output into the organic growth of steady input and high-yield. Promotion and application of technology and improvement of the management level gradually increase the growth of agricultural GDP . It is noticed that the growth rate of capital and the growth rate of agricultural production keep the

same trend, we can conclude that the capital growth rate is one of the most important factors of agricultural GDP growth rates. At the same time, In the case of a slowdown of the growth rate of capital, improving capital efficiency will be the next choice.



**Figure 2. 2001-2013 Comparison of Agricultural GDP Growth and Capital Growth**

Note: In the year 2000 as the base year, calculating the growth rate with the MoM

### 3.3. Absolute Reduction in Labor Input

Agricultural labor input in Heilongjiang Reclamation appear to be periodic varying . A small increase in labor input during the "Fifth period" from 2001 to 2005 kept the same trend with the same period of arable land. From 2006 to 2008, the labor input increased rapidly. The labor force in 2008 reached a net increase of 145,986 people than in 2005, increasing of 31.39%. The adjustment of structural planting of "Dry water improvement" made the labor input increase continuously under removing the effects of acreage growth of 16.05% in the same period . In the case of arable land increasing steadily, the labor input reduced 125950 people absolutely, which has reduced 20.61% (Table 1). This change indicates that agricultural production in reclamation adopted labor-saving technology corresponding with agricultural mechanization technology generally, which is an important factor in increasing the contribution rate of scientific and technological progress.

### 3.4. The Growth of Arable Land is Limited

The arable land in Heilongjiang Reclamation from 2006 to 2010 increased of 451,946 hectares, reaching the average annual growth of nearly 4%. On the one hand the growth of arable land can get benefits from national abolition of agricultural tax and agricultural subsidies , on the other hand it is due to the promotion of high-yield and high-quality varieties, such as transformation of low-lying land for planting cold rice in Sanjiang Plain. Arable land increased by only 1.31% (Table 1) from 2011 to 2013 and the growth rate of arable land decreased obviously, which indicates that the arable land has reached its limit. It is explained that quantitative expansion of arable land has a smaller impact on GDP and the scientific and technological progress that leads to the increasing output of per unit area has played more important role in GDP.

#### 4. Conclusion and Discussion

By calculating and analyzing the contribution rate of agricultural science and technological progress, we can draw the following conclusions: (1) the contribution rate of scientific and technological progress in Heilongjiang Reclamation increased rapidly and technological progress made the agricultural GDP grow in a faster rate; The contribution of capital element to the growth of agricultural GDP weakened, but both still have a strong correlation; The quantitative growth of investment in the Labor force and land contribute to the growth of agricultural GDP less and less; (2) The improvement of contribution rate of scientific and technological progress in Heilongjiang Reclamation from 2001 to 2010 depends on mechanized, high-input, high-yield varieties of labor resource-saving technologies; Since 2011, gradually it has transformed into automatic matching variable fertilization technologies and environment-friendly technologies; (3) The modern management model of "state farm + family farm" in Heilongjiang Reclamation adapted to the application and promotion of advanced science and technology , which is an important factor in promoting the scientific and technological progress.

Further study will carry out as the following aspects. (1) We should make a deep research on specific technological contribution to the gross agricultural production; (2) We should make a deep research on specific supporting technological contribution to gross agricultural production; (3) We should research the contribution of management model and the qualities of labor force and other social scientific and technological progress.

#### References

- [1] Wu pengpeng,He haijun. An Empirical Study of Chongqing Economic growth based on C-D production function [J].Statistics Market Forum ,2011,07.
- [2] Maolin Cheng、Min Yin Xian. Application of a combination production function model[J]. Applied Mathematics and Computation,2014, (236) : 33-40.
- [3] Wang zhengbing、Ji weibin、Yangling. The contribution rate of science and technology research in the agricultural High-tech Industries Demonstration Zone [J].Agricultural Economics and Management,2014, (01) .
- [4] Gao xincai、Li junheng.Dynamic Research on Economic Growth of Shanxi[J].Northwest University Journal,2011,03.
- [5] Jiang song、Wang zhao、Huang qinghua. Pace of technological progress and contribution in Grain Production - Based on the Provincial Panel Data from 1985 to 2010[J].Agricultural Technological Economy,2012,10.
- [6] Tan feng、Zhang lin. Measurement and Analysis of the contribution rate of scientific and technological progress in Heilongjiang Reclamation [M].China Agriculture Press,2013,05: 35.
- [7] Winford Henderson Masanjala B.Sc. Empirical analysis of economic growth[D]. University of Malawi,2003,08.
- [8] Hao li、Han menghua、 Zhou lian. Calculation on the contribution rate agricultural technological Progress from 1990 to 2007 [J].Agricultural Technological Economy,2010,3.
- [9] Zhu xigang.The calculating results on the contribution rate agricultural technological Progress during the time of "eight five" [J].Economic Digest,1997,3.
- [10] Li qiang.The analysis of investment and return in agricultural technological research in China[J].China Science and Technology Forum,2012,05.
- [11] Chang jiayun、Wang yang.An empirical analysis of agricultural scientific research on the investment efficiency[J].Journal of Shanxi Finance University ,2010,04.
- [12] Xu jiaxian、Zheng yifang、Su shipeng.The expectations' analysis of the contribution rate of agricultural science and technological progress in "Eleventh Five-Year" in Fujian [J].Subtropical Resources and Environment Journal ,2008,12.

## Author

**Zhang lin** (1972-) ,Female, Daqing people,Associate Professor of economics and management college in Heilongjiang Bayi Agricultural University, Postdoctoral in economics and management college of Southwest University . Research direction: Agricultural Systems Engineering, Agricultural Economics.

