

The Analysis of Agricultural Output in Port SD Province Based on System Dynamics

Jianliang Liu¹, Junhai Ma¹ and Yi Tian^{1,2}

¹College of Management Economic, Tianjin University, Tianjin 300072, China

²School of Economics, Tianjin normal university, Tianjin 300071, China

Email: lzqslyi@126.com, mjhtju@aliyun.com; ytian150413@126.com

Abstract

In order to know various factors affecting agricultural development in Shandong Province, this paper uses system dynamics model, modeling on agricultural output system in Shandong Province .It analyses how population growth, household consumption, the existing agricultural resources as well as GDP of Shandong Province affect the agricultural output, and uses Vensim software to make algorithm implemented. It analyses the effects of changed factors on agricultural output, and helps for government to make the agricultural development policy.

Keywords: *Agricultural Output in Shandong Province; Analysis of Agricultural Output; System Dynamics*

1. Introduction

Shandong Province is one of the granary provinces in China, producing enough food to meet its own needs and can export to other provinces. So, Shandong Province's stable food production plays an important role in national food security. In recent years, due to economic and social development ,all kinds of factors that affect the agricultural output in Shandong Province has gradually changed, which has an important impact on future agriculture development . For example, accelerating urbanization decreases agricultural land, resulting in the reduction of agricultural resources; water pollution seriously affects the quantity and quality of food.

In order to improve agricultural development, we must have a clear understanding that how the changing factors affect agriculture. This paper, based on System Dynamics method, modeling on agricultural production system in Shandong It analyses how population growth, household consumption, the existing agricultural resources as well as GDP of Shandong Province affect the agricultural output, and uses Vensim software to make algorithm implemented. It analyses the effects of changed factors on agricultural output, as well as the feedback of added agricultural output on these factors.

2. Review of the Literature

System Dynamics or SD, is proposed in 1956 by Professor Forrest in the Massachusetts Institute of Technology. It's a subject to study information feedback system, also a cross integrated discipline to discover and solve system problems. From a systemic point of view, System Dynamics is a unified method of structural, functional and historical method. It is based on the system theory, with absorption in the essence of cybernetics and information theory. It is a transverse science that integrates natural science and social science. System dynamics emphasized the overall system, the system composition and the interaction of each part. the system can be carried out on dynamic simulation experiment by SD. System dynamics model is a causal machine rational model, it is good at dealing with chronic and recurrent problems; When data is

insufficient and some parameters are difficult to quantify, we can still do some research on the basis of the feedback loop.

System dynamics have been applied in many fields. Hao Hai, *et al.*, analyzed the petroleum price based on the system dynamics. Since oil market was a complex nonlinear dynamic system, they found an orderly process from complex and changeable price, and then analyzed and forecasted the result of complicated and changeable market. Wu Haihua, *et al.*, regarded stock as a nonlinear system, studied system dynamic characteristics of the Shanghai stock market based on the complexity theory of fractal and chaos. Chen Hu *et al.* discussed and analyzed the system structure and operation mechanism of the VMI inventory management mode and the traditional inventory management model respectively, and then compared operation performance of the two modes.

The paper organized as follows. The System Dynamics model is presented in Section 3. In this section, the paper presents the positive and negative relationship between the factors such as population, consumption, GDP and so on. Then the paper presents the SD model with a Figure. The paper analyzes the influence of Economic Growth, Government's Investment Rate,

Farmers' Investment Rate to Shandong Province's agricultural machinery total power in Section 4. In Section 5, the paper gives some advices to increase agricultural machinery total power. Last we summarize the results of the paper.

3. System Dynamics Analysis of Shandong Province's Agricultural Development

Shandong province is one of the major grain production provinces in China, the production can not only meet the demand of residents of the province and the production output, but also be sold to other provinces. Therefore, the stability of the grain production of shandong province has been the important role in ensuring national food security. As the main producers of food, farmers vigorously promote the production of food. The food meets the needs of the masses of the people and the food market, at the same time, they also generate revenue through the selling of food, improve their standard of living. So farmers' income is closely related to food production.

As the growth of the population of Shandong province, the improvement of people's living level of production, people's demand of food will continue to increase, therefore, the most important thing is to ensure sustained increase in grain production in Shandong province, which is beneficial to social security and stability and economic sustainable development.

3.1 Causal Dependency Graph

In order to clearly understand the effects of population growth, the total consumption, the existing agricultural resources, as well as the gross domestic product (GDP) in Shandong, this paper established a causal dependency diagram as shown in Figure 1.

Population growth will increase the total consumption of Shandong Province, and in turn stimulate the rapid growth of the GDP in Shandong. Shandong Province's GDP increase will contribute to the consumption and population growth. Besides, population growth will increase the number of employed population as well as the labor force, so that increase agricultural output and GDP growth. However, in addition to the labor resources, agricultural output growth also depends on agricultural resources. Added population and GDP cause added consumption of agricultural resources in Shandong Province, which will cause a decline in agricultural output and GDP as well

3.2 System Dynamics Model

The agricultural machinery total power is integrated machinery power mainly used for agriculture, forestry, animal husbandry and fishery. Therefore, it is a major indicator to measure the extent of agricultural development. This article uses Shandong Province's agricultural machinery total power (hereinafter referred as AMTP) as an indicator to reflect agricultural output level, then makes a System Dynamics analysis.

According to the above analysis of various factors, this paper uses Vensim software to build corresponding System Dynamics model on Agricultural output in Shandong as shown in Figure 2.



Figure 1. The Causal Dependency Diagram On Agricultural Output In Shandong Province

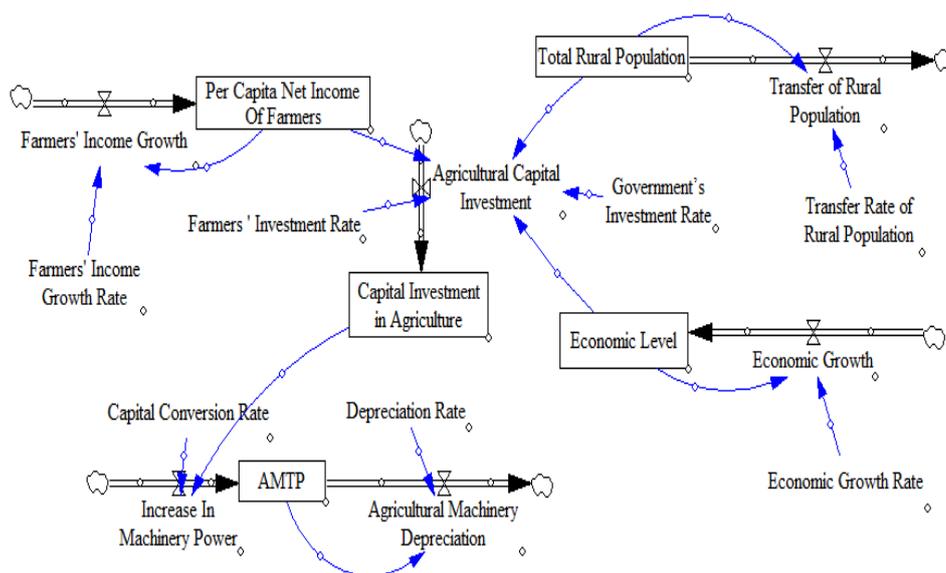


Figure 2. System Dynamics model of agricultural output value in Shandong Province

In this model, the initial values of the state variables are from national economy and society developed statistical bulletin 2002 in Shandong Province, as shown in the following Table.

According to the historical data released by the Bureau of Shandong Province, we use a linear fitting algorithm to determine some parameters. The Transfer Rate Of Rural Population in Shandong Province was 0.021. The Depreciation Rate of farm machinery is 2%. The correlation coefficient of the per capita net income of farmers and farmers' investment in agriculture, which is called Rate Of Famers' Capital Investment in agriculture, is 0.0245. The correlation coefficient of Capital Investment in Agriculture and AMTP, which is called Capital Conversion Rate, is 0.09.

Government departments and individual farmers can affect Economic Growth Rate, Government's Investment Rate and Farmers ' Investment Rate, so we take the three variables as decision variables, thus discuss that the government's decision-making has an influence on agricultural mechanization.

Table 1. State Variables And Their Values

State Variables	Values
Gross Domestic Product (GDP)	1055206 Million
Total Cultivated Area	653200 Million
Total Population	91.25 Million
Total Rural Population	67 Million
Agricultural Machinery Total Power	81.556 Million Kilowatts
Per Capita Net Income Of Farmers	2954 Yuan
Farmers' Income Growth	5.30%
Capital Investment in Agriculture	1589.19 Million Yuan
Rate of Government's Capital Investment in Agriculture	28.48%
Number Of Agricultural Labor	2370.91 Million
Land Scale Of Operation (Total Cultivated Area / Number Of Agricultural Labor)	2.755km2 /
Rate of Economic Growth	11.60%

4. Results

4.1 Changed Economic Growth Rate Impact AMTP

It can be seen from Figure 3 that a rising trend for AMTP has emerged in both cases as time goes on. When Economic Growth Rate decreases from 11.6% to 8%, the rise for AMTP is much lower. The Economic Growth Rate decreases by 3.6 percentage points, AMTP decreases more than half compared with the original one. Therefore, the economic growth is crucial for the development of agriculture, vigorous economic growth is a good driving force for agricultural development.

4.2 Changed Government's Investment Rate Impact AMTP

As seen from Figure 4, AMTP showing a rapid growth trend over time, when Government's Investment Rate increased to 50% from the previous 28.48%, AMTP shows a good momentum of development from 30th year, and almost the double of the former one in 50th year. Therefore, the national policy support and financial assistance of the government contribute to the rapid development of agricultural output.

Although government investment has a positive impact on agricultural production, it is the fact that the government investment in agricultural is not perfect. Investment system is not sound and volatile now, at the same time, the structure of investment for agricultural is unreasonable.

4.3 Changed Farmers' Investment Rate Impact AMTP

Investment is an important means for farmers to increase income, in the countryside, farmers have become the important main body of investment in agriculture.

It can be seen from Figure 5, AMTP showing an upward trend in the growth over time. When Farmers' Investment Rate increases to 4% from the previous 2.45%, the AMTP curve does not change much. Therefore, the method is not very practical to rely on the increase of farmers' income to buy state-of-the-art agricultural facilities to increase agricultural output.

Although the farmers' investment influence on agricultural output is not too significant, for the reason that the farmers' investment can increase the income of the farmers, the government should encourage this behavior. Therefore, the government needs to optimize the external environment of the farmers' investment; To transform government function in order to solve inequality problem of farmers market trading right; To perfect socialized service system and promote the farmer stable investment; And improve the mechanism of financing and investment and promote the farmers' enthusiasm for investment.

5. The stability of the Market of Agricultural Products

In our country, agriculture is a problem that can not be ignored, for the agriculture of our country is not as high efficient as USA large-scale scientific agriculture. Restricted by the terrain, the level of scientific development and various kinds of factors, the agriculture of our country is still at a relatively primitive and backward stage. So how to improve the level of agricultural science, improve farming personnel professional skills and qualities, is a worth pondering question.

Because of the information asymmetry, the farmer is used to determining the amount of crop planting and the category of crop planting according to the previous year's market conditions. Taking wheat for example, farmers tends to grow a great amount of wheat when the price of wheat rose quickly last year. This behavior leads to excessive supply in wheat market, so the price fell.

This planting pattern is due to the asymmetric information and time delay. This phenomenon not only do harm to market competition, but also seriously damage the interests of our farmers.

Some scholars have made some attempts to do research on agriculture. Paulo, *et al.*, [1] studied the effect of precipitation on agriculture, and then analyzed the tariff adjustment according to the goal of the domestic profit maximization. Stefan, *et al.*, [2] studies the relationship between agricultural production and the surrounding environment, and analyzed the influence of the cultivation of agricultural products produced CO₂ to cause the greenhouse gases. Ming-Che Hu, *et al.*, [3] proposed the agricultural sustainable development of the factory system, and this system can use less manpower cost, irrigation water and nutrients, *etc.*

Through the data we can see that the amount of grain production per year is growing, and food demand is fluctuated dramatically, however, it is a disadvantage for producers.

Figure 6 shows the relationship between the changes of production price index and the trend of grain production, we can see that they have an obvious trend, when the T phase of the production price index increased, production period of T-1 growth rate will increase. Correspondingly, the producer price index of T-1 period will decrease due to increased speed of current yield. So the two movements intuitively showed the opposite trend. By the same, there is the same trend of change between food sales and production.

The phenomena were simulated by the model, the growers can plant according to the trend of grain purchase price a year earlier, decision model for the current period:

Table 2. For Grain Yield and Sales Data of Shandong Province from 2004 to 2013.

Index	2013year	2012year	2011year	2010year	2009year	2008year	2007year	2006year	2005year	2004year
Population(million)	9733	9685	9637	9588	9470	9417	9367	9309	9248	9180
Consumption level(yuan)		15095	13524	11606	10494	9673	8142	7064	5916	4924
Food Yield(10 kilo-ton)	4528.2	4511.4	4426.29	4335.68	4316.3	4260.5	4148.76	4092.97	3917.38	3516.7
Food Consumer Price Index		102.5	108.7	113	104.4	106.3	108.1	102.8	100.2	124.3
Price Index Of Agricultural Production	105.9	102.5	109.7	118.8	101.2	112.5	114	103.4	102.9	112.3
Rural Residents Per Capita Sales Of Grain (kg)		632.95	547.88	563.16	568.82	535.16	461.53	478.06	424.47	360.11
Rural Population(10 thousand)		4607	4727	4823	4894	4935	4988	5018	5086	
Food Sales (10 kilo-ton)		2916	2589.83	2716.12	2783.81	2641.01	2302.11	2398.91	2158.85	

$Q_s(t) = Q_s(t-1) + \gamma_1[w(t-1) - w(t-2)] + \gamma_2[Q_d(t-1) - Q_d(t-2)]$ $Q_s(t)$: the amount of agricultural

products in T phase, $Q_s(t-1)$: the amount in T-1 phase,

$\gamma_1[w(t-1) - w(t-2)]$, $\gamma_2[Q_d(t-1) - Q_d(t-2)]$ means the change trend of grain purchase price and volume influenced by previous year, price increases in the previous period, the farmers will choose more planting, γ_1 , γ_2 means correlation coefficient.

Agricultural products dealers determined grain purchase price and sale price. The price associated with the current trend of changes of grain yield, specific model:

$$w(t) = w(t-1) - \mu_1[Q_s(t) - Q_s(t-1)] + \mu_2[Q_d(t-1) - Q_d(t-2)]$$

$w(t)$: grain purchase price, $w(t-1)$: purchase price for the T-1 period, $\mu_1[Q_s(t) - Q_s(t-1)]$,

$\mu_2[Q_d(t-1) - Q_d(t-2)]$ means the float price influenced by grain supply and demand changes; μ_1 , μ_2 : correlation coefficient.

Distributors' decisions on agricultural price is prior to the sales process, so designated sales price according to the demand of food should make reference to the demand of the previous period, According to the information above, specific model is given:

$$p(t) = p(t-1) + \lambda[Q_d(t-1) - Q_d(t-2)]$$

$p(t)$: food sales price, $p(t-1)$: food sales price for the period T-1; $\lambda[Q_d(t-1) - Q_d(t-2)]$ means floating price part, model represents the sales price increases with increasing food demand volume, and decreased with the decrease of grain demand, λ : correlation coefficient.

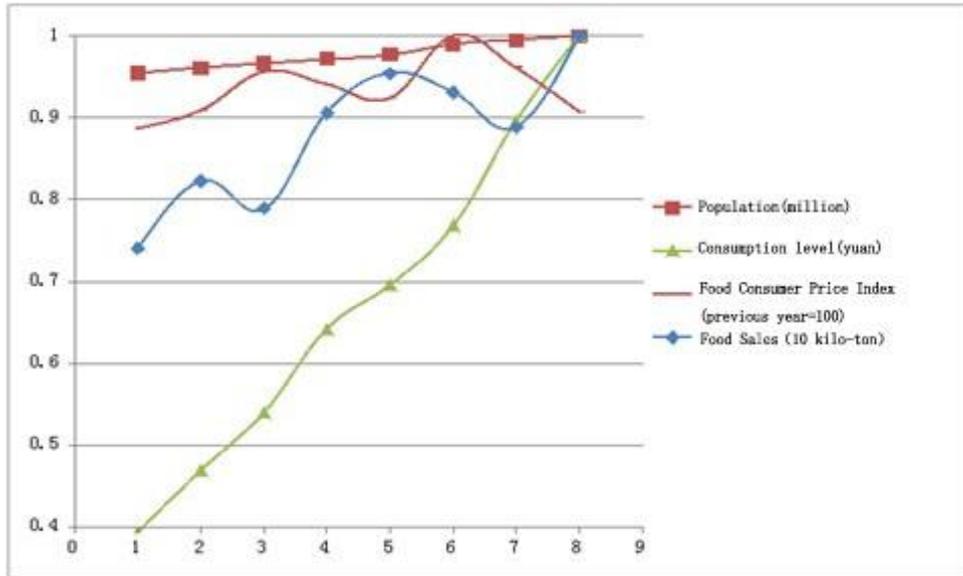


Figure 7. The Trend Graph of Resident Population, Consumption Level, Consumer Price Index and Food Sales

It can be seen that with the grain demand fluctuated, grain consumption price index has also been volatiling and the consumption level of residents showed a substantial rise. So it can be seen that food demand is negatively related to the price, and is associated with residents' consumption level and the number of population.

The model can be expressed as:

$$Q_d(t) = a - bp(t) + cL(t) + dH(t)$$

$H(t)$ respectively represents the price of agricultural products, consumption level and the population, b , c , d respectively represents the correlation coefficient.

The size of the market demand is affected by many factors such as the level of consumption, and the price of agricultural products. The model is expressed:

$$L(t) = \alpha + \beta L(t-1) \quad H(t) = \omega H(t-1)$$

The parameters of sales model, population growth model and consumption levels model are determined by fitting the model. The parameters of grain purchase and sales price are determined by the dealer. The food supply model parameters are determined by food manufacturers. So the trend of each variable and each square is obtained in Figure 8.

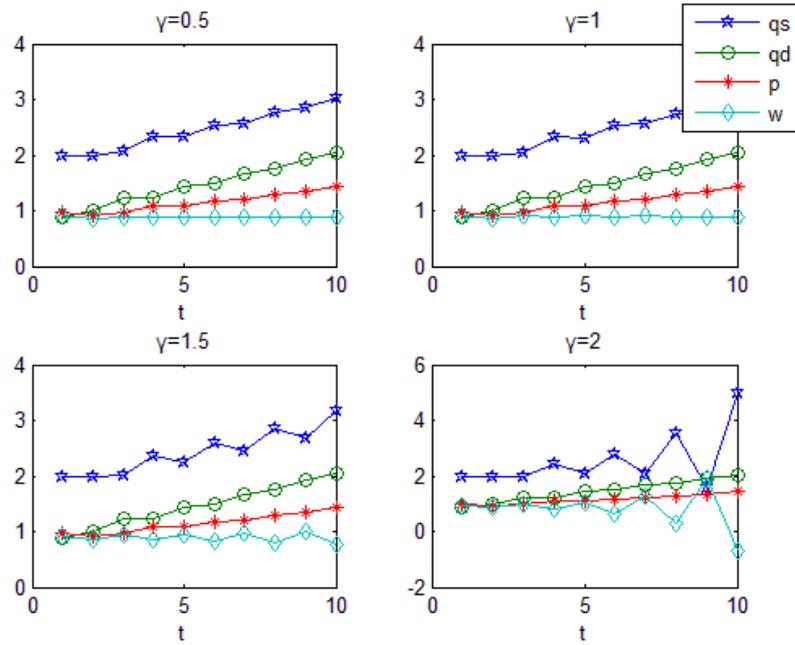


Figure 8. The Trend Graph of Variables in Different Adjustment Factor

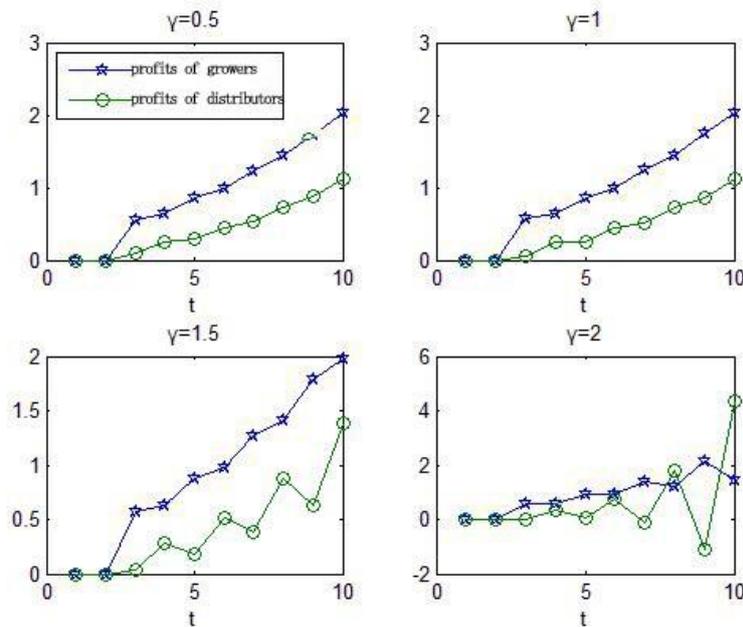


Figure 9. The Trend Graph of Profit Trend under Different Adjustment Coefficient

We can see that with the increase of adjusting parameters, each parameter will fluctuate gradually while the impact on profit increased with the adjustment of parameters, so the grower's profits will be damaged. As for growers, it is unwise that they change the amount of grain according to the acquisition price in previous year. Because the information obtained is lagging behind. The more dependent on information delay, the volatility of output is larger. At last it lead to the fluctuations of acquisition price, eventually making growers and dealers profit decrease. Therefore, growers need to

collect market information, and to develop the planting amount according to their own situation. The planting decision should be in his own hands. And the dealer can make the optimal decision according to growers' decision. The game has become a Nash game.

6. Development Proposals

Firstly, promote the coordinated development of industry, vigorously develop the processing industry of agricultural and sideline products

The coordinated development of the industry helps continued economy development, as well as helps to maintain a strong momentum of economic development. Economic growth can foster the development of agriculture, which can be seen from Figure 3. Therefore, we can draft a range of industrial policy to promote the coordinated development of industry. On the base, vigorously develop the processing industry of agricultural and sideline product, which can raise the added value of agricultural products, thereby enhancing agricultural output.

Secondly, increase agricultural funding

Central Document No. 2008 explicitly proposed to increase investment in agriculture, and that is, the incremental financial support for agriculture is significantly higher than that in 2007, the incremental fixed assets investment for the rural construction is significantly higher than that in 2007, incremental land transfer income for rural construction is significantly higher than that in 2007.

Increase fiscal revenue can not only improve agricultural infrastructure construction and maintenance, but also disseminate agricultural scientific and technological knowledge, thusly improve the quality of farmers. The increasing funds of agricultural research and development can transform the traditional agriculture into scientific agricultural. Compared to traditional agriculture, scientific agricultural can greatly improve the agricultural productivity, find the agricultural disasters timely, and solve it timely. As a result, it reduces disaster losses. All of these plays an active role in increasing agricultural output.

Thirdly, develop local characteristics of agriculture, build brand of agricultural products

Agricultural brand refers to agricultural producers and business operators create a significant mark in order to identify its products, to distinguish it from competitors, and to facilitate consumer awareness.

The establishment of agricultural brand can effectively reduce the degree of agricultural products alternative in similar products market, so it can make the agricultural industry competition even more inadequate among various market subjects. Relative market monopoly advantage of brand agricultural products makes it obtain strong ability of market penetration in the market competition, and enhances its market competitiveness relying on the brand strength.

Due to geographical differences, agricultural products in different areas have many differences. Shandong is in vast and fertile North China Plain, we should take full advantage of the inherent advantages and develop agriculture in local characteristics. In addition, we should increase brand awareness of agricultural products, vigorously taking agricultural brand strategy. Brand 'Shouguang' in Shandong Province is a model of success.

Fourthly, develop a recycling agricultural economy

With the ever-accelerating pace of urbanization, arable land is diminishing. Water pollution and other environmental issues make gradual shortage of agricultural resources. In order to ensure AMTP, we can develop a recycling agricultural economy. Make full use of agricultural resources, reduce the wastes of resources, and achieve the sustainable development of agriculture.

In order to establish circular agriculture, we must establish recycling agricultural legal system, establishing policy system of recycling agriculture, and promote the technology innovation system of recycling agricultural.

Now there are some mature recycling agricultural economy model, for example, after picked by the farmers, the corn stalk, can be used to feed livestock. The excrement of livestock can be used to produce biogas, the remaining waste can also continue to provide fertilizer for the next issue of crops.

7. Conclusion

In order to make systemic analysis and accurate prediction of agricultural output in Shandong Province, this paper builds a System Dynamics model, after showing the effects of population growth, the total consumption, the existing agricultural resources, the gross domestic product (GDP) to the AMTP in Shandong. The SD model analyses the effects of population growth, consumer spending, existing agricultural resources, GDP and several other variables on agricultural output in Shandong Province. This paper uses Vensim software to build System Dynamics model, and we get some figures about the agricultural development. Through the figure we can see that, when Economic Growth Rate decreases, the rise for AMTP is much lower; when Government's Investment Rate increased, AMTP developed a lot from 30th year; but, when Farmers' Investment Rate increases, the AMTP curve does not change much.

Based on these results, the paper gives some advices on Shandong's agricultural development. Firstly, the government should promote the coordinated development of industry and vigorously develop the processing industry of agricultural and sideline products. Secondly, the government should increase investment in agriculture. Increasing fiscal revenue can improve agricultural infrastructure construction and disseminate agricultural scientific and technological knowledge. Thirdly, the government should develop local characteristics of agriculture and build brand of agricultural products. Finally, the government should develop a recycling agricultural economy.

Agriculture is the foundation of the national economy. The rise and fall of agricultural is related to the global of the national economy. Application of system dynamics theory, this paper analyses the factors affecting the development of agriculture in Shandong province, and puts forward the reasonable suggestions on development of agriculture. In future research, some problems need to be improved. System dynamics model can be further refined. Some influence factors can be further considering such as national policy and competition between provinces. Agricultural development is complex and covers widely.

Anyhow, development of agriculture widely involved, also more complex. We have a lot of work to do to improve our study results, and contribute to the problem of "agriculture, rural areas and farmers".

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Author



Jianliang Liu, 1963.08, HuNan Lianyuan, PhD student of Tianjin university collage of management and economic department.

