

Research and Prediction of Agricultural Mechanization Development in China based on GM (1,1) Model

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Abstract:

Agricultural mechanization is an important material basis for the development of China's modern agriculture. Agricultural mechanization will gradually drive the standardization, scale and industrialization of China's agricultural products, and is an important factor to promote the transformation of China's traditional agriculture to modern agriculture. This paper will predict the total impetus of agricultural machinery in China through the GM (1,1) model, grasp and understand the development trend of the general agricultural impetus, analyze the problems facing the development of agricultural mechanization, put forward the countermeasures to promote the development of agricultural mechanization, and promote the development of agricultural modernization.

Keywords:

Agricultural Modernization, Agricultural Mechanization, Gray System Prediction, GM (1,1) Model

1. Introduction

Agricultural modernization is a way to change from traditional agriculture to modern agriculture. The 17th National Congress of the Communist Party of China in view of the objective fact that China's agricultural foundation is weak and the rural development lags behind, the problem we must solve at present is how to find a road of agricultural modernization with Chinese characteristics. Agricultural mechanization plays a decisive role in the development of modern agriculture in China, which will gradually promote the standardization, scale and industrialization of China's agricultural products.

Since the "13th Five-Year Plan", the development of agricultural mechanization in China has shown a trend of acceleration, the level of agricultural mechanization production has been continuously improved, and the service capacity of agricultural mechanization operation has been significantly enhanced, which has played an important role in promoting agricultural production increase, farmers' income and rural prosperity. China's total power force of agricultural machinery has increased by

17 percent compared with the end of the 12th Five-Year Plan period, reaching 1.056 billion kilowatts. The overall mechanization rate of crop cultivation and harvest was further increased to 71.25 percent, an increase of 7.4 percentage points. Through demonstration and guidance, 614 demonstration counties for the full mechanization of major agricultural products have been established, and the mechanized production of animal husbandry and aquaculture, facility agriculture, primary processing of agricultural products, fruit and vegetable tea and other industries has been continuously promoted. In addition, intelligent agricultural machinery has come to the first line of production, agricultural mechanization industrial group industrial chain has also been very well developed. So far, 19,000 new agricultural machinery cooperatives have been added, and 195,000 agricultural machinery service organizations.

The gray system was founded by Professor Deng Julong from Huazhong University of Science and Technology in the early 1980s. In just 20 years, this new interdisciplinary subject has made great progress. Now, the system has become a method that can predict society, economy, science, science and technology and many other fields, and is an important means of decision-making, evaluation, planning, control, system analysis and modeling. Especially in the case of short timing, less statistical data, incomplete information system, modeling and analysis, has a very significant effect. Gray prediction is a means of making predictions for systems with uncertainty. Gray prediction through the degree of differences between the factors of development on the basis of correlation analysis, and process the original data, find out its change law, with strong law of data sequence, in order to build the corresponding differential equation model, to predict the future development trend and status of related things. This method uses a set of numerical values observed in a certain period, which has the characteristics of predicted targets, to build a gray prediction model for predicting specific time points in the future.

This paper will predict the total driving force of China's agricultural machinery through GM (1,1) model, grasp and understand the development trend of the total agricultural driving force, analyze the problems facing the development of agricultural mechanization, put forward the countermeasures to promote the development of agricultural mechanization, and promote the development of agricultural modernization.

2. Literature Review

2.1. Agricultural mechanization

Zhao Yan analyzed the current situation of modern agricultural construction in Liaoning Province, and put forward some suggestions on the development of agricultural mechanization at three levels: increasing support funds, introducing suitable machinery and improving the promotion system, so as to implement the development strategy of agricultural modernization in Liaoning Province and promote the growth of agricultural economy in the region.

Yong-chun zhang thinks, in the new period to better promote agricultural efficiency, farmers' income and sustainable and healthy development of rural economy, agricultural mechanization work must focus on the bottleneck problem in the agricultural production link, based on the research and development of new machines,

to realize the improvement of agricultural production efficiency, to promote agricultural rural economy development, high quality, play its leading role.

Agricultural mechanization is the only way for the development of modern agriculture. In order to develop modern agriculture, we must develop agricultural mechanization. Agricultural mechanization combines modern science and technology closely with agriculture, which is of great significance to promote the rural revitalization strategy. To this end, Qin Qiomei and Wei Zhiqiang analyzed the development status of agricultural mechanization in China under the background of rural revitalization, and made a series of explanations on the level of agricultural mechanization during the “13th Five-Year Plan” period, and put forward targeted strategies for the current problems existing in the current development of agricultural mechanization.

Ma Zhanlian elaborated the importance of establishing the grass-roots agricultural machinery extension system, analyzed the problems in the current development of agricultural mechanization, and finally put forward suggestions on how to strengthen the grass-roots agricultural mechanization extension system.

2.2. Gray prediction model and its application

Liu Shifeng et al. defined the four basic forms of GM (1,1) models, and further analyzed the characteristics of these models, proving that these models are equivalent to each other. Through model analysis of the aligned exponential sequence and non-exponential growth sequence, the applicability of the different models is clarified.

The change of the total power of agricultural machinery is limited and constrained by the fixed gray related factors. Fan Miao used the theory of gray system in the calculation of agricultural machinery power and made a quantitative analysis. It is found that the grain output per unit area and per capita arable land area have a very important impact on the total power of agricultural machinery. The use of a variety of agricultural machinery can increase agricultural output and improve the application level and efficiency of agricultural machinery in the field of agricultural production.

Zhang Chaofeng et al. took the data of the national agricultural output value from 2002 to 2012 as an example, applied the gray system theory, conducted the gray correlation analysis, and on this basis established the gray GM (1,1) model of the national agricultural output value. The prediction results show that the prediction of the national agricultural economy is less different from the reality, and the model has strong prediction ability.

Lei Lei et al. selected the grain output statistics of Sichuan province from 2010 to 2020 and predicted the grain output from GM (1,1) model from 2021 to 2025. The forecast results show that the grain output in Sichuan shows a growing trend, and the development situation and opportunities are good. We should take the initiative to grasp the initiative of food security, and improve the comprehensive grain production capacity and output guarantee capacity.

Jian-hua wang points out the problems existing in the traditional agricultural supply chain, and from the application of information technology, benefit distribution between members, preservation technology application, quality traceability system this several aspects, dynamic research of agricultural supply chain integration, then use GM (1,1) model, using the existing data of vegetables the future production forecast, through the forecast results, the necessity of the integrating agricultural

supply chain data basis and theoretical basis at the same time, also for the enterprises in agricultural products supply chain advance work plan provides an important reference basis.

3. The Development of Agricultural Mechanization Under the Background of Agricultural Modernization

3.1. Function

Agricultural mechanization is the prerequisite to promote agricultural development, but also a necessary condition to realize agricultural modernization. First of all, promote agricultural mechanization process, promote agricultural productivity to increase. At present, China is facing the transformation from traditional agriculture to modern agriculture, the application of agricultural machinery in agricultural production is increasingly extensive, and some areas have even basically realized agricultural mechanization, which has greatly improved agricultural labor productivity. According to the calculation, the use of agricultural machinery in the field for production operations, its work efficiency is dozens of times higher than the traditional farming methods. For example, a combine harvester can do far more work in a day than the labor efficiency of dozens of farmers. At the same time, agricultural machinery can achieve precision planting, improve grain output, and enhance the disaster resistance of grain.

Secondly, with the improvement of agricultural mechanization degree, the ecological environment has also been further improved. With the development of science and technology, agricultural machinery from design to production, have given full attention to the needs of environmental protection, a large number of agricultural machinery has the prominent characteristics of low emission, low noise, in agricultural production, its environmental performance has been fully played. Because of its low emission characteristics, it can save energy, alleviate air pollution, achieve environmental protection and reduce the use cost of agricultural machinery. In addition, in the palace using agricultural machinery to harvest crops, harvest, threshing, straw crushing and other operations can be completed at one time, to avoid reuse, eliminate the air pollution of straw burning, so as to improve the soil structure.

Improved the economic benefit of the farmers. Because it consumes a lot of manpower, it not only increases the labor intensity of farmers, but also increases the labor cost, and reduces the production efficiency of farmers. But now, the operation of agricultural machinery has greatly improved its labor productivity, and then achieved the purpose of standardized cultivation, so that the sowing, fertilization, irrigation and other operation procedures are more accurate and balanced, and thus improve the quality of the operation, reduce the waste. At present, with the increase of the ownership and application rate of agricultural machinery, it greatly alleviates the labor intensity of farmers and also increases the source of income. Moreover, in the process of agricultural modernization, the new operators have become the main force of the development of modern agriculture, and agricultural mechanization provides equipment support for the new operators to carry out large-scale and intensive agricultural operation.

The improvement of agricultural mechanization degree has played a positive role in promoting the improvement of agricultural technology level. With the continuous development of agricultural science and technology, it is necessary to popularize and

transform some scientific and technological achievements to be reasonably applied to agricultural production, and agricultural machinery is the best tool to realize its popularization and transformation. Agricultural machinery has played an extremely important role in the whole growth process of crops, and the achievements of agricultural science and technology can become a reality in agricultural production along with the application of agricultural machinery. For example, fine sowing technology, soil moisture conservation technology, seedling technology and other scientific research achievements, through the use of agricultural machinery, in order to be popularized, transformation, so that it really play its due value.

3.2. Development status and problems

Agricultural mechanization is not only a necessary means to realize agricultural modernization, but also of great significance to promote the rapid development of agricultural economy. The high efficiency of agricultural machinery can replace the traditional manual work and improve the efficiency and quality of farmland operation. During the “13th Five-Year Plan” period, China’s agricultural mechanization process has made significant progress, the total amount of agricultural machinery and equipment has been increasing, the operation level has been continuously improved, and the level of socialized service has been significantly enhanced. So what problems does the development of agricultural mechanization in China still face?

First of all, the agricultural mechanization promotion mechanism is not sound. The traditional way of agricultural machinery promotion refers to the agricultural machinery extension units in accordance with the state promulgated, prescribed policies and requirements, a promotion mode consistent with the development trend of The Times. At present, the system of agricultural mechanization promotion in China is not perfect enough, resulting in the business level of agricultural mechanization promotion personnel is not high enough, and the promotion work is still more difficult.

Secondly, the structural problem of agricultural mechanization development in our country. From the current situation of agricultural mechanization in China, it is mainly small machinery, the number of supporting machinery is small, the number of mechanical equipment is too much, resulting in the low supporting rate of farm tools. In addition, the current Chinese agricultural mechanization industry product technology level is still low, the new technology, new equipment promotion strength is not enough, the equipment level is not high, the scale is small, the technical level is relatively backward.

Third, agricultural machinery and equipment is unreasonable. Traditional agricultural machinery accounts for a large proportion in agricultural production activities, while the application of intelligent agricultural machinery such as unmanned driving and multi-machine coordination is still in its infancy. In addition, the reasons that restrict the development of agricultural mechanization in China are that the operation service of China’s agricultural machinery system and the demand of production and operation do not match. The level of agricultural machinery management service in different regions varies greatly, especially in the areas with unbalanced economic development and different terrain, the research and development of agricultural machinery lags behind.

4. Gray System GM (1,1) Model Construction

In 1982, Chinese scholars Deng Julong professor proposed the gray system theory, the theory is “part of the information is known, part of the information is unknown” “poor information” uncertainty system as the research object, it is through the existing known information generation and transformation, reveal its internal law, so as to better describe the real world. In order to weaken the randomness in the original time series, the gray prediction method processes the original data before constructing the gray prediction model. Then the time series after data processing is called the generation column, so that the model and prediction established by the generation column with strong regularity become more accurate. In grey prediction, additive generation and subtraction generation are usually used as change methods. The essence of GM (1,1) model is to establish the first-order linear differential equation by analyzing the rules of the original sequence, and the fitted curve can be obtained by processing the existing data to calculate the estimated parameters, and finally the fitted curve can be used to predict. The grey GM (1,1) model is constructed as follows:

Set the original column:

$$X^{(0)} = (X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n))$$

One series of X (0):

$$X^{(1)}(k) = \sum_{i=1}^k X^{(0)}(i), k = 1, 2, \dots, n,$$

$$X^{(1)} = (X^{(1)}(1), X^{(1)}(2), \dots, X^{(1)}(n))$$

The gray derivative defining X (1) is:

$$d(k) = X^{(0)}(k) = X^{(1)}(k) - X^{(1)}(k-1)$$

Make Z (1) generate the series for the X (1) neighbor value of the series, namely:

$$Z^{(1)}(k) = aX^{(1)}(k) + (1-a)X^{(1)}(k-1)$$

The grey differential equation model defining the GM (1,1) is:

$$d(k) + aZ^{(1)}(k) = b$$

$$X^{(0)}(k) + aZ^{(1)}(k) = b$$

This is called gray derivative, a is called development coefficient, called whitening background value, and b is called ash action amount. Take $k=2, 3, \dots, n$, obtained from the grey differential equation:

$$\begin{cases} d(2) + aZ^{(1)}(2) = b \\ d(3) + aZ^{(1)}(3) = b \\ \dots \\ d(n) + aZ^{(1)}(n) = b \end{cases}$$

Introducing matrix:

$$\mathbf{u} = \begin{pmatrix} a \\ b \end{pmatrix}$$

$$Y = \begin{pmatrix} X^{(0)}(2) \\ X^{(0)}(3) \\ \vdots \\ X^{(0)}(n) \end{pmatrix}$$

$$B = \begin{pmatrix} -Z^{(1)} & 1 \\ -Z^{(2)} & 1 \\ \vdots & \vdots \\ -Z^{(n)} & 1 \end{pmatrix}$$

The GM (1,1) model can then be expressed as follows:

$$Y = Bu$$

$$\hat{u} = \begin{pmatrix} \hat{a} \\ \hat{b} \end{pmatrix} = (B^T B)^{-1} B^T Y$$

For the grey differential equation of GM (1,1), if $x^{(0)}(k)$ time k , is changed to a continuous variable, the corresponding white differential equation is:

$$\frac{dX^{(1)}(t)}{dt} + aX^{(1)}(t) = b$$

$$\int_{k-1}^k d(X^{(1)} / dt)dt + \int_{k-1}^k aX^{(1)} dt = \int_{k-1}^k bdt$$

The albino equation is:

$$X^{(0)} + aZ^{(1)} = b$$

Therefore, the steps of gray prediction are: the first step, the level ratio test, set the original number column as:

$$X^{(0)} = (X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n))$$

Calculate the level ratio of the sequence:

$$\lambda(k) = \frac{X^{(0)}(k-1)}{X^{(0)}(k)}$$

If all the level ratios fall within the overlay interval, the original sequence $X^{(0)}$ can build a GM (1,1) model and make grey prediction, otherwise the data needs to be changed.

$$X = \begin{pmatrix} \frac{-2}{e^{\frac{2}{n+1}}}, e^{\frac{2}{n+1}} \end{pmatrix}$$

The second step is to establish the GM (1,1) model: the original sequence is:

$$X^{(0)} = (X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n))$$

Build a GM (1,1) model for it:

$$X^{(0)}(k) + aZ^{(1)}(k) = b$$

The corresponding whitening model is:

$$\frac{dX^{(1)}(t)}{dt} + aZ^{(1)}(t) = b$$

The solution of this equation is given as follows:

$$X^{(1)}(t) = (X^{(0)}(1) - \frac{b}{a})e^{-a(t-1)} + \frac{b}{a}$$

So you can get the prediction value:

$$\hat{X}^{(1)}(k+1) = (X^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}, k = 1, 2, \dots, n-1$$

$$\hat{X}^{(0)}(k+1) = \hat{X}^{(1)}(k+1) - \hat{X}^{(1)}(k), k = 1, 2, \dots, n-1$$

The third step is to test the predicted value, and the residual test says:

$$\varepsilon(k) = \frac{X^{(0)}(k) - \hat{X}^{(0)}(k)}{X^{(0)}(k)}, k = 1, 2, \dots, n$$

For the relative residual, if vs

$$\forall k = 1, 2, \dots, n, |\varepsilon(k)| < 0.1$$

It is considered to meet the higher requirements. Otherwise, the general requirements are considered to be met.

5. Forecast and Analysis of the Total Dynamics of Agricultural Machinery

The total power of agricultural machinery refers to the sum of various power machinery of agriculture, forestry, animal husbandry and fishing. Including tillage, drainage and irrigation, harvesting, agricultural transportation and other machinery, according to the power conversion into tile calculation. This paper will reflect the development of agricultural mechanization in China by predicting the total power of agricultural machinery from 2022 to 2026. Agricultural machinery total dynamic data itself has certain objective volatility, and agricultural machinery total power will be affected by natural conditions, national policy, political, economic, cultural, under the influence of multiple factors, the change law has a lot of uncertainty, so through the establishment of gray forecast GM (1,1) model to predict agricultural machinery total power, provide reference for agricultural mechanization development in the future. The total power data of agricultural machinery in China from 2017 to 2020 are shown in Table 1:

Table 1. Total dynamic data of agricultural machinery in China from 2017 to 2020.

Age	2017	2018	2019	2020	2021
Farm machinery production	98783	100372	102758	105622	107764

The total dynamic GM (1,1) model of agricultural machinery is obtained by Matlab software. After the total dynamic data of agricultural machinery from 2017 to 2021, the new data is obtained. Then, the cumulative data is calculated. The smooth threshold is set at 0.7, and $b1 = (1.0161, 0.5160, 0.3498, 0.2644)$, so the data is smooth. Secondly, the background value of the model is calculated to obtain $b2 = (148969, 250534, 354724, 461417)$. According to the principle of the least squares method, the calculation.

$$A = \begin{bmatrix} -148969 & 1 \\ -250534 & 1 \\ -354724 & 1 \\ -461417 & 1 \end{bmatrix}$$

$$Y = \begin{bmatrix} 100372 \\ 102758 \\ 105622 \\ 107764 \end{bmatrix}$$

The estimated value of parameter a, b is $(-0.024, 96825.132)$, approximate instead of a, b can obtain the prediction model of GM (1,1) in the whitening form is:

$$\hat{x}(n) = (x_0(1) - \hat{b}/\hat{a})e^{-a(n-1)} - \hat{b}/\hat{a}$$

The original predicted value was calculated and reduced (98783, 100400.8, 102843, 105344.5, 107906.9, 110531.6, 113220.2, 115974.2, 118795.2, 121684.7). The predicted data and raw data from 2016 to 2027, and the values of relative residual test Q and variance ratio test C were respectively (0.0010, 0.0441). Through the residual test and variance ratio test, it can be seen that GM (1,1) model has a good effect on predicting the total dynamic value of agricultural machinery, while the total power of agricultural machinery in China shows a trend of increasing year by year.

The general dynamic prediction curve diagram of Chinese agricultural machinery is shown in Figure 1:

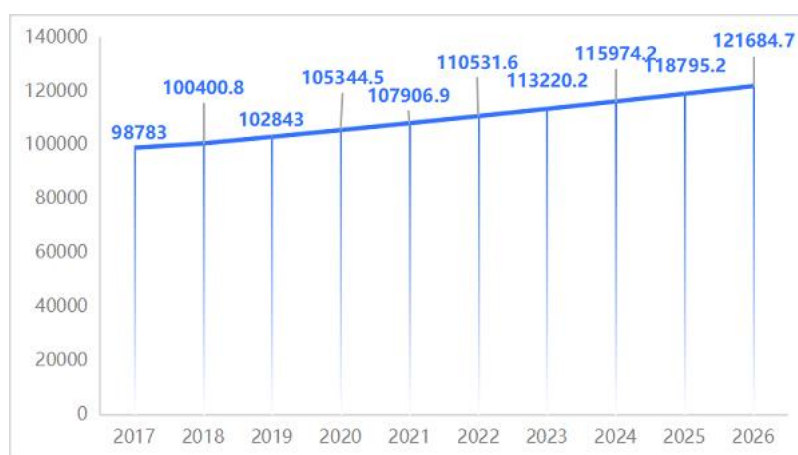


Figure 1. General dynamic prediction curve diagram of Chinese agricultural machinery.

Data source: Matlab calculation based on statistical Yearbook data

6. Revelations and Suggestions

6.1. Increase the promotion and publicity of agricultural machinery

We should give full play to the important role of new technology in the process of agricultural production, and the application of new technology is respectively reflected in the two aspects of system and management, and the application of new technology should be supported according to these two aspects. In addition, the relationship between farmers and agricultural science and technology personnel is clear, so that the two become mutual restriction and mutual cooperation. Therefore, farmers must be required to adjust their traditional awareness of farming and the way they work in agricultural work. How to change its way, it is necessary to strengthen the propaganda of agricultural mechanization, give guidance in the thought, give tilt in the reward, so that farmers have a deeper understanding of agricultural mechanization, and then break the traditional backward concept. First of all, improve the agricultural machinery promotion system, and formulate the relevant supervision mechanism, urge the relevant departments to conscientiously perform the promotion responsibilities. Secondly, the implementation of different, targeted agricultural technology extension, further improve the promotion efficiency. In some areas with harsh natural conditions, support should be given to characteristic industries and grain production. On this basis, according to the regional characteristics and actual situation of different regions, the agricultural mechanization promotion program suitable for the local. The purpose of agricultural machinery promotion is to serve the local economic development, in the process of regional construction and management, into the scientific planning and design, to realize the application and mode innovation.

6.2. Optimize the agricultural machinery system

Strengthen the combination of industry, education and research, and promote the improvement of industrial research and development level. Strengthen the cooperation between universities and enterprises, transfer the needs of enterprises to universities, and colleges and universities develop new technologies according to the needs of enterprises, and construct multiple types of agricultural machinery. Strengthen the combination of industry, university and research, and improve the level of industrial research. Strengthen the cooperation between universities and enterprises, and transfer the needs for new technologies, new products and new equipment to universities in a timely manner. Based on the needs of enterprises, colleges and universities have developed high-tech enterprises with industry characteristics, independent intellectual property rights and practical application value, so as to build various types of agricultural machinery and appliances.

Increase the cultivation of leading enterprises, in the process of agricultural mechanization, leading enterprises play a leading role, to a faster integration resource advantage, by cultivating a batch of leading enterprises, speed up the process of overall development of agricultural machinery, enable it to adapt to all kinds of demand, so as to improve the efficiency of agricultural production, promote the development of agricultural development. We will increase investment attraction, actively introduce foreign capital, and promote the construction of the agricultural mechanization industry system. The demand for agricultural machinery in our country is relatively large, and it has a broad market. Therefore, China can actively use foreign capital, from the technology, capital, mechanism and other aspects to absorb external forces, so that foreign capital to promote the development of China's agricultural

machinery industry system, and obtain benefits from the development of China's agricultural machinery.

6.3. Increase capital input

According to the current actual situation, under the existing financial conditions, as much as possible to increase the investment in agricultural machinery. Increase the investment in agricultural machinery research, improve the infrastructure construction of agricultural machinery research, and enhance the technical innovation ability of agricultural machinery research. Formulate and introduce more preferential purchase policies and encourage the development of agricultural mechanization policies as soon as possible, and guarantee the development, test and promotion costs of new agricultural machinery products and new technologies of agricultural machinery, so that the team of agricultural machinery science, teaching, management and promotion will become stable, so that their innovation and service ability can be improved.

7. Conclusions

Agricultural mechanization is a key link to promote the development of agricultural and rural modernization, but also a basic guarantee. At present, China's agricultural mechanization has been greatly developed. In the new period of agricultural production and mechanization, how to solve the problems of regional imbalance of agricultural mechanization development, slow research and development and manufacturing of agricultural machinery products, and still backward infrastructure? It is necessary to comprehensively promote rural revitalization and accelerate agricultural and rural modernization as a major strategic deployment, correctly understand the position of agricultural mechanization in the new historical period, actively face all challenges, accelerate the process of agricultural mechanization, and achieve all-round and high-quality development.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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