19

The Volatility and Growth Trend of Field Production Mechanization Level in China - A Positive Analysis Based on Hodrick-Prescott Method

Huang Y. X., Yang X. H., Huang S., Zhu R. and Zhang Z.
Northwest A&F University
China

1. Introduction

Agricultural machinery is the important material base for developing modern agriculture, and agricultural mechanization is a symbol of agricultural modernization. It is an urgent demand for improving agricultural productivity, increasing farmers' income, ensuring agricultural production ability and promoting rural development to promote agricultural mechanization level increasing sustainably, stablely and high-speedily(Yang, 2005; Zhang and Gao, 2009; Ju and Wang, 2009). During the 1940s to 1960s, Most of the developed countries had realized the mechanization of field production and, around the 1960s, had realized all-sided mechanization successively. Usually, mechanization of field production is used instead of agricultural mechanization (similarly hereinafter). During the developing history in the past 60 years, the Chinese agricultural mechanization has experienced the following process: start-up stage, preliminary development stage and fall, recovery and steady development stage. In 2008, the level of mechanical planting, mechanical sowing and mechanical harvesting are respectively 62.9%, 37.4% and 31.2%. This shows that Chinese agricultural production mode is changing constantly and the mechanization production methods are gradually playing a leading and dominant role in agricultural production mode. However, compared with the national economic and social development needs, the level of Chinese agricultural mechanization is still low and this is becoming the main sticking point to construct and develop modern agriculture. Especially, the low level of mechanical sowing and mechanical harvesting restricted the whole level of Chinese agricultural mechanization to develop rapidly. Due to the influence of social and economic development level, technical conditions, market environment, policy system and natural conditions, the development of field production mechanization has both the growth feature over time and certain volatility feature. The development of field production mechanization has experienced several downturn periods and these periods have adverse impact on improving agricultural labor productivity, guaranteeing the agricultural production ability and promoting rural development. Along with the agricultural mechanization and the sustainable development of national economic, ensuring that field production mechanization develops continuously, stably and rapidly plays an important role in safeguarding the national food security, promoting farmers' income, improving labor productivity and promoting rural development(Yang, 2005; Zhang and Gao, 2009).

Seeking an optimal path for Chinese agricultural mechanization to develop continuously and steadily, we have to consider the volatility of field production mechanization development as well as the potential ability to grow in the future. At present, there are few researches on the volatility of field production mechanization development. The level of mechanical sowing and mechanical harvesting reflect the characteristics of field production mechanization in China from different aspects. Considering that the low level of mechanical sowing and mechanical harvesting as the main factor that leads to the low overall level of Chinese agricultural mechanization, this article uses Hodrick-Prescott (HP) technique and GM (1, 1) model to analyse the volatility and growth trend of field production mechanization in China from 1973 to 2008 aiming to get the volatility feature and development potential and provide theoretical basis for promoting agricultural mechanization and developing modern agriculture.

2. The analysis of volatility of field production mechanization level based on HP technique

2.1 Research methods and data

As shown in Fig 1, the development of mechanical sowing and mechanical harvesting can be summarized as "growth in volatility" or "reduction in volatility". They are the interact results of two factors: long-term trends and short-term volatility. At present, the main methodologies that used to analyse the volatility measurement of economic problems are velocity method, residual method and HP technique. Compared with velocity method and residual method, HP technique possesses the characteristics of perfect theory, using flexible use and better fitting effect. Considering the complexity of field production mechanization in China (the coexistence of growth and volatility), this article selected HP technique to measure the volatility.

Since Hodrick and Prescott (1981) used HP technique to analyse the economic cycle, this method has been used in other fields. The basic principle of HP technique is: assuming that time series Y_t is combined by trend components Y_t^T and volatility components Y_t^C and then the time series is:

$$Y_t = Y_t^T + Y_t^C \quad (t=1, 2, 3, \cdots, T) \tag{1}$$

where t is the sample size.

HP filter method is to estimate the least value of the following formula:

$$\sum_{t=1}^{T}(Y_t - Y_t^T)^2 + \lambda\sum_{t=1}^{T}[(Y_{t+1}^T - Y_t^T) - (Y_t^T - Y_{t-1}^T)]^2 \tag{2}$$

where the parameter λ is the penalty factor controlling the smoothness. And this parameter requires to be given in advance. The greater the parameter λ is, the smoother the estimate trend line is, whereas the bender. For annual data, the parameter λ mainly has two kinds of value, 100 and 6.25. When using 6.25 to filter, the trend line reflects the volatility more meticulously, and it can reflect the large scale change, as well as smaller annual ups and downs. Here, λ=6.25 is used in HP filtering analysis.

Short-term volatility, described by mutation rate RV and its computation formula is:

$$RV = Y_t^C / Y_t^T \tag{3}$$

where RV reflects the deviation amplitude of economic variables to long-term trend in a specific time.

In order to analyze the China field production mechanization level volatility and growth trend between 1973 and 2008, it is necessary to get the data of mechanical sowing and mechanical harvesting. Here, data from 1973 to 1999 is from website of China Agricultural Mechanization Information Network (which is managed by Agricultural Mechanization Management of China's Ministry of Agriculture). Data between 2000 and 2008 is from China Agricultural Yearbook. Mechanical sowing and mechanical harvesting calculating methods are as follows:

$$Mechanical\ Sowing\ Level(\%) = \frac{Mechanical\ Sowing\ Area}{The\ Actural\ Total\ Sown\ Area} \tag{4}$$

$$Mechanical\ Harvesting\ Level(\%) = \frac{Mechanical\ Harvesting\ Area}{The\ Actural\ Total\ Sown\ Area} \tag{5}$$

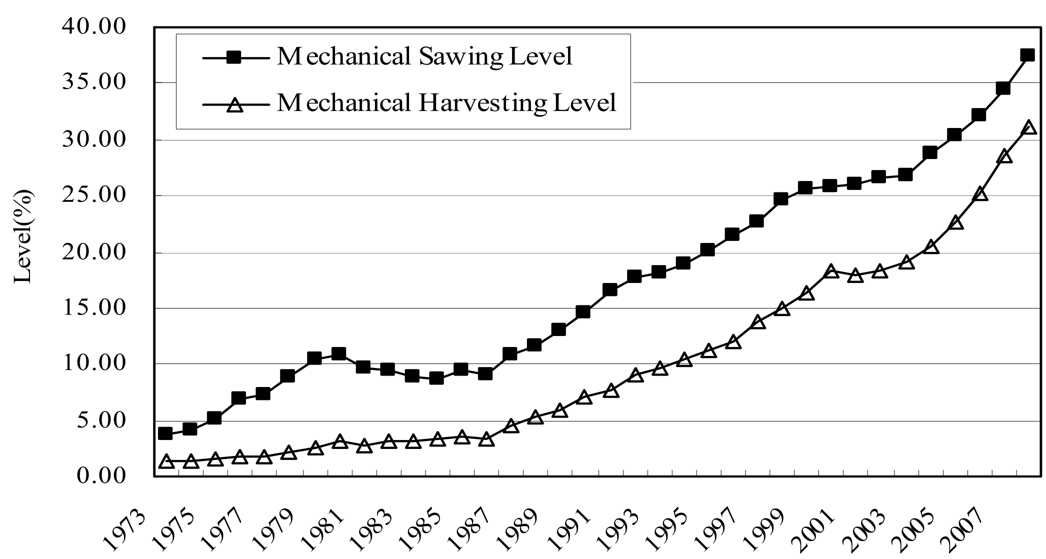


Fig. 1. The development of mechanical sowing and mechanical harvesting from 1973 to 2008 in China

2.2 The volatility analysis of mechanical sowing and mechanical harvesting

To investigate the fluctuating features of the mechanical sowing level and mechanical harvesting level, the long-term trends and short-term volatilities of the mechanical sowing level and mechanical harvesting level should be separated by HP filter. Therefore, this paper uses the software of Eviews6.0 to calculate both of the filtering results.

Table 1 shows the HP trend value of the mechanical sowing level and mechanical harvesting level in China from 1973 to 2008, which is the trend components of mechanical sowing level and mechanical harvesting level, reflecting the endogenous, stable aspects that could be used in economic forecasting.

Fig 2 and Fig 3 show the smooth trend of the long-trend volatility of mechanical sowing level and mechanical harvesting level. From tendency sequence we know that the mechanical sowing level and mechanical harvesting level are overall on the rise from 1973 to 2008. Among them, the average annual growth of the mechanical sowing level is 0.96% while the mechanical harvesting level is 0.85%. Those figures show that the feature of volatility of the mechanical sowing level and mechanical harvesting level are obvious.

Using formula (3), we could compute the mutation rate of the mechanical sowing level and mechanical harvesting level in China from 1973 to 2008. According to periodic wave theory and the feature of "peak - valley - peak" , when the difference of wave amplitude of a cycle is bigger than 5% and the interval time is more than 3 years, we regard this cycle as an integrated cycle. It should be noted that according to different standards to define an integrated cycle the results will vary. According to this, we get the cycle of the mechanical sowing level and mechanical harvesting level in China from 1973 to 2008 and the results are shown in table 3 and table 4.

Judging from the mechanical sowing level, there were six fluctuation cycles from 1973 to 2008 and the average interval time is 6 years while the longest one is 10 years and the shortest one is 4 years. The interval time is growing from short to long. The average amplitude is 10.44% while the largest one is 17.87% and the smallest one is 5.55%. The amplitude is becoming smaller and this means that the stability of fluctuation of mechanical sowing level is becoming strengthened.

Judging from mechanical harvesting level, there were five fluctuation cycles from 1973 to 2008 and the average interval time is 7.2 years while the longest one is 8 years. Except the period from 1989 to 1992, the interval time of the other cycles is 8 years and the fluctuation frequency is stable. The average amplitude is 13.228% while the largest one is 22.90%. The amplitude is becoming smaller and this means that the stability of fluctuation of mechanical harvesting level is also becoming strengthened.

Years	Sowing level	Harvesting level	Years	Sowing level	Harvesting level	Years	Sowing level	Harvesting level
1973	3.45	1.29	1985	9.35	3.57	1997	22.82	13.76
1974	4.51	1.42	1986	9.85	3.96	1998	23.92	14.94
1975	5.61	1.56	1987	10.70	4.52	1999	24.82	16.04
1976	6.74	1.74	1988	11.80	5.23	2000	25.51	17.00
1977	7.82	1.96	1989	13.09	6.03	2001	26.10	17.80
1978	8.78	2.21	1990	14.48	6.91	2002	26.77	18.63
1979	9.49	2.47	1991	15.85	7.81	2003	27.66	19.69
1980	9.80	2.70	1992	17.10	8.72	2004	28.91	21.16
1981	9.73	2.87	1993	18.23	9.61	2005	30.49	23.09
1982	9.48	3.01	1994	19.32	10.52	2006	32.36	25.43
1983	9.22	3.15	1995	20.45	11.49	2007	34.46	28.02
1984	9.14	3.31	1996	21.63	12.58	2008	36.68	30.69

Table 1. Trend value of agricultural mechanization operation level from 1973 to 2008 in China (%)

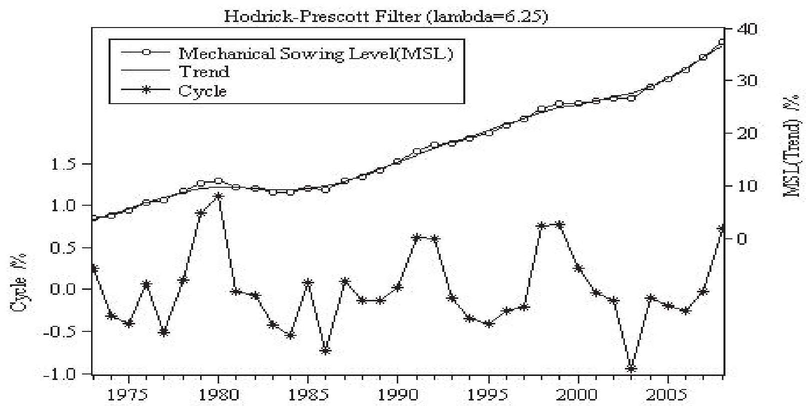


Fig. 2. Trend value of mechanical sowing from 1973 to 2008

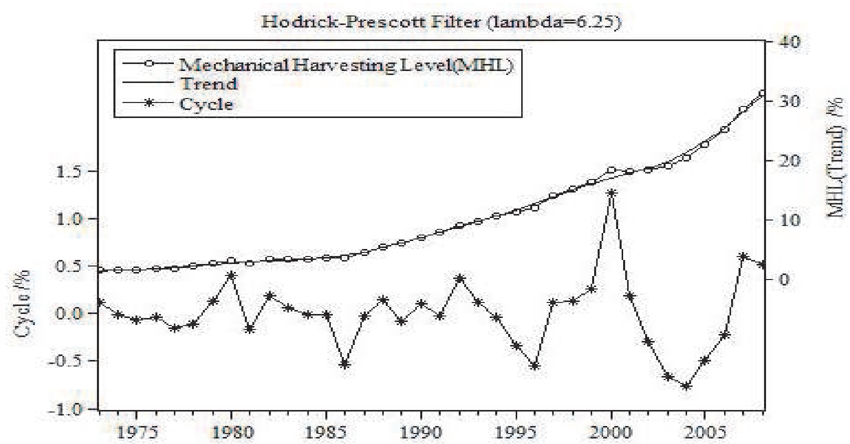


Fig. 3. Trend value of mechanical harvesting from 1973 to 2008

Years	Sowing level	Harve-sting level	Years	Sowing level	Harvesting level	Years	Sowing level	Harvesting level
1973	7.14	8.64	1985	0.90	-0.49	1997	-0.95	0.82
1974	-6.92	-1.20	1986	-7.45	-13.79	1998	3.13	0.89
1975	-7.32	-4.03	1987	0.93	-0.75	1999	3.11	1.57
1976	0.92	-2.41	1988	-1.19	2.63	2000	0.96	7.43
1977	-6.62	-8.11	1989	-0.99	-1.39	2001	-0.17	1.07
1978	1.32	-5.06	1990	0.17	1.37	2002	-0.49	-1.59
1979	9.62	5.09	1991	3.92	-0.36	2003	-3.45	-3.41
1980	11.25	14.79	1992	3.55	4.25	2004	-0.38	-3.59
1981	-0.30	-5.80	1993	-0.56	1.21	2005	-0.62	-2.13
1982	-0.79	6.29	1994	-1.82	-0.39	2006	-0.81	-0.89
1983	-4.56	1.73	1995	-2.00	-3.00	2007	-0.09	2.15
1984	-5.93	-0.42	1996	-1.16	-4.35	2008	1.97	1.66

Table 2. RV value of agricultural mechanization operation level from 1973 to 2008 in China (%)

Cycle serial number	Sowing level			Harvesting level		
	start-stop year	annual range	Amplitude(%)	start-stop year	annual range	Amplitude (%)
1	1973-1976	4	14.46	1973-1980	8	22.90
2	1977-1980	4	17.87	1981-1988	8	20.08
3	1981-1985	5	6.83	1989-1992	4	5.64
4	1986-1991	6	11.37	1993-2000	8	11.78
5	1992-1998	7	5.55	2001-2008	8	5.74
6	1999-2008	10	6.56			

Table 3. The results of Volatility features analysis of agricultural mechanization operation level from 1973 to 2008 in China

	cycle number	average annual range	Average amplitude (%)
Sowing level	6	6	10.44
Harvesting level	5	7.2	13.228

Table 4. The cycle of agricultural mechanization operation level

2.3 Consideration on promoting field mechanization level developing fast and perfectly

2.3.1 Paying attention to factors that affect field mechanization level during different periods

Through Table 3 and Table 4, the development cycle of China Mechanical Sowing Level and Mechanical Harvesting Level during the year 1973 and 2008 exists the largest difference; this is mainly because there are different development factors in different periods affecting field mechanization level. Existing researches show that the main factors that affect the field mechanization development are farm machinery management modes, rural economic development conditions, rural residents' per capita income, policy system and so on. For example, Lu etc (2008) applied the DEMATEL method to identify the factors that influence the agricultural mechanization development and finally found out six factors as key ones, namely, the farmer's income, farm machinery industry development level, farm machinery products use cost, the transfer of rural surplus labor force, the labor price, and scale of cultivated land management. Liu and Tian (2008) analyzed key factors that influenced China farm machinery equipment level. Through this analysis, the most important factor is the level of economic development level because it contributes the biggest share, and the second is the land business scale, thus expanding land management scale moderately plays an important role in promoting the level of agricultural equipment. The third is the planting structure. The factors mentioned above are those causing the volatility of agricultural mechanization, also the breakthrough of developing the agricultural mechanization.

2.3.2 Mobilizing farmers' enthusiasm of purchasing and using agricultural machinery

Mobilizing farmers' enthusiasm of purchasing and using agricultural machinery plays the most fundamental role in the development of agricultural mechanization. From 1949 to

1978, the main operation modes of agricultural machine were state-owned operation, collective ownership and collective operation. During 1970s, the operation of agricultural machine was mainly collective operation. Therefore, the improvement of the mechanical sowing level and mechanical harvesting level was the result of the inputs for agricultural mechanization from the state. To achieve the goal of 75% of agriculture, forestry, animal husbandry, sideline production and fishing mechanization till 1980, the country hand invested a lot of money. From 1971 to 1979(not including 1974) the money used to aid the agricultural mechanization was2.38 billion Yuan and the annual investment was about 0.3 billion Yuan. There was also a greater input all over the country. In addition, the price of agricultural machine had reduced 4 times from 1971 to 1978 and the reductions were respectively 15.50%, 5.4%, 10% and 13%. With the increase of the investment and the reduction of the agricultural machine price, the agricultural mechanization level had developed Greatly (Liu and Ren, 1997; Agricultural mechanization management department, 2009). The mechanical sowing level had increased from 3.7% in 1973 to 10.9% in 1980 with an annual growth rate of 1.03%; the mechanical harvesting level had increased from 1.4% in 1973 to 3.1% in 1980 with an annual growth rate of 0.24%. Overall, the mechanical sowing level and mechanical harvesting level had improved rapidly.

In the 1980s, with the system reform of rural economic, the farm machinery management mode came to a new period of the unit of family. The original farm machinery management pattern already could not adapt to the development of agricultural machinery, especially when the household contract responsibility system got popular. Farmers increased the enthusiasm to own and buy agricultural machinery when they came to know that the agricultural machinery could help them to lighten physical labor, to improve the operation quality and to enhance the work efficiency. Through this, to enhance the level of field mechanization, it is necessary to do from two aspects, namely, requirements and probabilities. Requirements emphasize whether agricultural and rural economic development require agricultural equipment, and in this point, it has reached a consensus. Probabilities emphasize whether farmers have the ability to buy agricultural equipments. When it came to the period of the unit of family, the improvement of field mechanization level mainly depended on whether farmers had ability to buy agricultural implements.

On July 1, 1994, the country cancelled the preferential policy of agricultural parity diesel. So far, the country has cancelled all the preferential policies for agricultural machine, which were implemented during the planned economy period. The development of agricultural mechanization entered the market-oriented stage. Farmers obtained the independent right of management of agricultural machinery, so they could buy agricultural machine and operate legal business independently. These policies greatly aroused the enthusiasm of the farmers for the development of agricultural mechanization and also solved the basic dynamic problems of agricultural mechanization. This promoted the development of agricultural mechanization at a high speed.

Table 5 shows the economic system and investment behavior of Chinese agricultural mechanization development in different periods. At present, it is in a mixed economy stage, and in this stage, the investment subjects include the farmers, collective and government finance. It presents the diversified structure. In the whole, the farmers' input takes the proportion of total investment in 70%, and this shows that the farmers are the most important part. Therefore, fully mobilizing farmers' enthusiasm to purchase and use agricultural machinery is the basic method to increase the level of field mechanization.

Economic System	Main Investors	Motivation	Investment Mechanism
Planned Economy	Country, Collective	State strategic goals	Administrative means, government order
Market Economy	Peasant(Peasant Household)	To meet some needs, pursue the economic benefits	Economic means, free trade
Mixed Economy	Peasant is the main body, government macro-control	Economic benefits and social benefits	Market mechanism and government functions

Table 5. Economic system and investment behavior

2.3.3 Being market-oriented, developing the agricultural machinery cooperative

Scientific and reasonable mode of agricultural machinery management is a supporting condition in developing agricultural mechanization, and also the intrinsic request to develop the modern agricultural productivity. Since the rural reform, agricultural machinery entered the market as commodity, forming resource allocation mechanism leaded by the market and the developing mechanism to pursue the economic benefit maximization, and these effectively promote the agricultural socialization and marketization. Different forms of agricultural machinery professional services firms, joint stock partnership, farm machinery professional cooperatives and farm machinery association, farm machinery users association and so on developed well in the whole country, and maintained a good momentum of development. Till now, they have become the market's main body and they are in the process of independent operation and financial self-sufficiency, self-accumulation, and self-development, fully displaying the strong vitality of farm machinery service socialization and marketization and outstanding development prospect.

Agricultural Machinery Cooperative (AMC) is the main development direction of Chinese Agricultural machinery socialization service. This is beneficial to the integrated application, large-scale promotion, moderate scale operation and industrialization (Li, 2009; Biser, 1983; Russo, 2000). 'Chinese State Council's opinion on promoting development of agricultural mechanization and farm machinery industry nicely aand rapidly' and the 'Chinese agriculture ministry's opinion on accelerating the development of agricultural machinery cooperatives have been issued Successively', which clearly require to promote the development of AMC. Table 6 shows that the number of AMC in 2007 and 2008 is respectively 4435 and 7860 and the number in 2008 is 77.23% larger than that in 2007. During this period, Agricultural machinery cooperatives in China developed at a high speed and the quantity increased substantially. This was due to the promulgation of the law on farmers' professional cooperatives and the implementation of various supporting policies. Table 7 shows statistics of the development of Chinese agricultural machinery cooperatives in 2007and 2008.

Item	2007	2008	Rate of Increase (%)
Total number of AMC	4435	7860	77.23

Data Source: The agricultural mechanization management department of Ministry of Agriculture, investigation of AMC development in 2007 and 2008.

Table 6. AMC development situation in 2008

Item	Unit	Quantity	item	Unit	Quantity
1.Total number of AMC	unit	7860	7. Machine number Where: Large and Medium Tractors Mini-Tractors Combines Rice transplanters Auxiliary farm tools	10,000 unit Individual Individual Individual Individual Individual	38.4353 54179 77902 44712 15530 217950
2. Cooperator	unit(household)	293327	8. General assets Where: Net value of fixed assets Facilities area	10,000 RMB 10,000 RMB khm²	1026050.09 866294.28 13284.7
3. Number of serving households	household	7537310	9. Funds supported by finance	10,000 RMB	108141.12
4. employee Where: perennial hire professional and technical personnel	Individual individual individual	267662 60695 41666	10. Quantities of AMC supported by finance	unit	3797
5. Homework service area Where: Mechanical farming Mechanical planting Mechanical harvesting Plant protecting Other	khm² khm² khm² khm² khm² khm²	11920.8 4678.4 2571.4 3364.7 836.4 1411.5	11. New AMC expected for year 2009	Individual	5466
6.Total Service revenue Where: operation services income Repair service revenue Other income	10,000 RMB 10,000 RMB 10,000 RMB 10,000 RMB	564734.59 495783.77 23657.07 42624.33	Appendix: Quantity of other farm machinery service organizations Where: Farm machinery professional associations Farm operating companies Farm machinery service (combination)	 Individual Individual Individual Individual	 76178 4813 1549 6447

Attach: Homework service area, Total Service revenue are the total number of 2008, others are the number of the end of year 2008.
Data Sources: The agricultural mechanization management department of Ministry of Agriculture,, investigation of farm machinery professional cooperatives development, 2007~2008.

Table 7. Statistics of China farm machinery professional cooperatives development situation in 2008(continued)

2.3.4 Improving the management efficiency of agricultural mechanization production continuously

Only when the management benefits rise, will farmers obtain economic strength and confidence to invest more money on buying agricultural machines and field production mechanization level be improved. Before 1980, China put forward slogans that we would realize the agricultural mechanization in 1980 which resulted in the bland blind development of Chinese agricultural mechanization. Such development had exceeded the development level of rural productivity during that time and could not be accepted by farmers, thus leaded to large quantities of wastes. One reason to explain this is that the government putting more focus on service other than efficiency which betrayed the economic law. Under the commodity economy conditions, profits are the major objective for farmers to purchase and use of agricultural machinery and the power for the development of agricultural mechanization (Hill, 2005; Georgeanne etc, 2009).

Many districts explored a lot to find the way to improve farm machinery management benefit. From them, improving agricultural socialization service quality and benefit continuously is an effective way to promote farmers' management benefit. Agricultural machinery cooperatives had a rapid development and service quality and benefits were improved significantly especially after the publishment of 'opinions on accelerating the development of agricultural machinery professional co-operatives'. They played even a more important role in increasing agricultural income and farmers' income. The farm machinery management service organizations must accumulate by themselves in order to increase the input of mechanization, make mechanization develop to a higher level. Therefore, it is necessary to forward the farm machinery service to the market, practising enterprise management and socialized service, improving mechanical utilization ratio and the economic efficiency, improving the level of agricultural industrialization service.

The necessary condition of increasing agricultural mechanization level is to increase the farmers' income. Under the current circumstance that the farmers' income level is low, it is possible to increase farmers' income, government subsidies and so on to solve problems of agricultural mechanization upfront input. Zhu etc (2007) studied the interdependency between agricultural mechanization development and financial input, and the results showed that the interdependency degree is related to financial investment and there is positive correlation to per capita net income of farmers. At present, China has entered the period in which the government needs to strength financial support for agricultural mechanization development and in which the dependence to finance is growing rapidly. Take '11th five-year plan' period of agricultural mechanization development as an example, the national comprehensive mechanization level came to an unprecedented increasing rate which was more than 3% from the year 2007 to year 2009. And this created a history record of rapid development. One of the most important reasons is agricultural machinery purchase subsidies increased fast year by year, and the central finance agricultural machinery purchase subsidies increased from 0.07 billion Yuan in 2004 to 15.5 billion Yuan in the year 2010, and this promoted the rapid development of operation level of agricultural mechanization.

2.3.5 Completing supporting system construction of agricultural mechanization development

Operation laws of agricultural mechanization include their own system coordination and external environment coordination. Since the publishment of People's Republic of China agricultural mechanization promotion law, through the development of 'tenth-five' plan and '11th five-year plan' this law became perfect and improved, forming the best legal, policies and the development environment during the whole history of China. Instead of developing agricultural mechanization in isolation, China developed agricultural mechanization together with developing the agricultural machinery industry, developed advanced agricultural socialization service together with developing modern circulation technology, and developed the agricultural machinery together with establishing information construction.

Completing agricultural mechanization promotion system mainly include: agricultural machinery production, study and research, spreading and coordination system, national macro regulation and policy system, land scale management system, agricultural mechanization investment, agricultural mechanization service team construction system, financing system, agricultural machinery development of information network system, agricultural machinery service of industrialization and marketization and socialized service system, and so on. Thus, it is important to complete supporting system construction of agricultural mechanization development in order to provide system guarantee for the development of agricultural machinery (Yang etc, 2005).

3. The long-term trends and growth capacity prediction of the growth of field production mechanization level

3.1 Research method

Using HP filter method, the field production mechanization level can be separated into two parts: the value of trend and the value of fluctuation. Between them, the value of fluctuation can be used as the basis for understanding mechanization development level and the value of trend can be used as the basis for estimating and judging development of field production mechanization level in the future. At present, in the area of forecasting the field production mechanization level, the main methods we used including gray forecast method, exponential smoothing, least-square method, comperz curve method and artificial neural network technology, etc (Biondi etc, 1998; Zhang and Gao, 2009). When using the methods mentioned above, most of the data was the value of time series about field production mechanization level and it did not separate field production mechanization level into two parts of the value of fluctuation and the value of trend. Because China field production mechanization develops over time and also contains the characteristic of volatility, considering the trend components and wave components, it is difficult to forecast. In this article, the value of fluctuation was eliminated when forecasting long-term growth trend of Chinese field production mechanization level; the value of trend was used and Grey Forecasting Model was applied to predict the growth trend of Chinese field production mechanization level.

Grey System Theory was developed by Professor Deng in the 1980s (Deng, 1989). This theory focuses on studying uncertainty problems with a small number of samples or a system with poor information. Grey forecasting model refers to the GM(1,1) based on the prediction. It is not suitable for approximation complex nonlinear function, but can reflect overall development trend very well. Grey prediction model is mainly used in prediction problems with short time span, small data quantity and little fluctuation. Under the circumstances that the data quantity is small, it can make the result much more accurate. The principle and procedure of grey prediction model is shown as Follows (Deng, 1989; Wang etc, 2010):

Giving the original data sequence vectors $x^{(0)}$

$$x^{(0)} = \{x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)\} \tag{6}$$

Where n is the number of data in the original sequence.
Firstly, accumulate the original data sequence in order to weaken the randomness and volatility of the original data.

$$x^{(1)} = \{x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)\} \tag{7}$$

In the equation above,

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) \qquad (k = 1, 2, \cdots, n)$$

Step 1 Establishment of Grey Model (1, 1)

$$x^{(0)}(k) + az^{(1)}(k) = u \tag{8}$$

Here, $z^{(1)}(k)$ is generated relating to $x^{(1)}(k)$, and $z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1)$. a is the model development coefficient. u is the gray input.
Step 2 Establishment of structural matrixes B and data vector Y_n

$$\hat{a} = [a, u]^T = (B^T B)^{-1} B^T Y_n \tag{9}$$

$$Y_n = [x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n)]^T$$

$$B = \begin{bmatrix} -0.5(x^{(1)}(1) + x^{(1)}(2)) & 1 \\ -0.5(x^{(1)}(2) + x^{(1)}(3)) & 1 \\ \vdots & \\ -0.5(x^{(1)}(n-1) + x^{(1)}(n)) & 1 \end{bmatrix}$$

Here, $\hat{a}$ is a parameter that needs to be identified.
Step 3 Calculation of a and u

$$\begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix} = \begin{bmatrix} -(z^{(1)}(2)) & 1 \\ -(z^{(1)}(3)) & 1 \\ \vdots & \\ -(z^{(1)}(n)) & 1 \end{bmatrix} \times \begin{bmatrix} a \\ u \end{bmatrix} \tag{10}$$

Step 4 Accumulation of the model and predication results
The analytical solution for equation (8) is:

$$\hat{x}^{(1)}(k+1) = (x^{(0)}(1) - u/a)^{-ak} + u/a \tag{11}$$

Here, $\hat{x}^{(1)}(k)$ is the K^{th} analytical solution.

Step 5 Predicted results

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) \tag{12}$$

In the equation (12), $\hat{x}^{(0)}(k)$ is the K^{th} predicted result by reduction.

Then, it is to get the following predicted data sequences

$$\hat{x}^{(0)} = \{\hat{x}^{(0)}(1), \hat{x}^{(0)}(2), \cdots, \hat{x}^{(0)}(n), \hat{x}^{(0)}(n+1)\} \tag{13}$$

Step 6 checking the error size, analyzing the accuracy of predicted results

GM(1,1) group includes four, five, six data and multiple data GM(1,1). In the prediction process, researchers could choose corresponding GM (1, 1) model according to the actual situation of the forecasted object (Deng, 1989).

3.2 Results and discussions

According to the formula (8) ~ (13), we established the GM(1,1) prediction model of mechanical harvesting level and mechanical sowing level based on data four, data five and data six. The main purpose is to choose the best GM (1, 1) forecasting model as the final prediction model through comparison. Among them, the GM(1,1) of data four uses the trend value of mechanical harvesting level and mechanical sowing level from 2002 to 2005, the GM (1, 1) model of data five uses the trend value of mechanical harvesting level and mechanical sowing level from 2001 to 2005 and the GM(1,1) of data six uses the trend value of mechanical harvesting level and mechanical sowing level from 2000 to 2005. The actual trend value of mechanical harvesting level and mechanical sowing level from 2006 to 2008 is used as inspection samples. Calculation results are showed in table 8 and table 9.

Table 8 shows that the average prediction error of the trend value of mechanical sowing based on data four dimension is 2.56%, obviously less than that based on data five and data six. This demonstrates that the result of GM (1, 1) model based on data four is more precise and this model can be used to forecast the trend value of mechanical sowing. The calculation equation is:

$$x(k+1) = 551.5702\exp(0.0488k) - 524.8002 \tag{14}$$

Using the equation (14), we can predict the trend value of Chinese mechanical sowing level from 2009 to 2015 and the results are shown in table 10.

Similarly, table 9 shows that GM(1,1) based on data four is the most precise one, thus we choose this model as the final model. The calculating equation is:

$$x(k+1) = 235.5554\exp(0.0800k) - 216.9254 \tag{15}$$

Using the equation (15), the trend value of mechanical harvesting level from 2009 to 2015 can be predicted, the results are also shown in table 10.

Year	Actual trend Value/%	Four dimension GM(1,1)		Five dimension GM(1,1)		Six dimension GM(1,1)	
		Predicted Value /%	Error (%)	Predicted Value /%	Error (%)	Predicted Value /%	Error (%)
2006	32.36	31.97	1.21	31.71	2.01	31.43	2.87
2007	34.46	33.57	2.58	33.13	3.86	32.69	5.14
2008	36.68	35.25	3.90	34.61	5.64	34.01	7.28

Table 8. Predicted mechanical sowing value and analysis of errors

Year	Actual trend Value /%	Four dimension GM(1,1)		Five dimension GM(1,1)		Six dimension GM(1,1)	
		Predicted Value /%	Error (%)	Predicted Value /%	Error (%)	Predicted Value /%	Error (%)
2006	25.43	24.94	1.42	24.65	3.07	24.35	4.25
2007	28.02	27.02	3.57	26.50	5.42	26.02	7.14
2008	30.69	29.27	4.63	28.49	7.17	27.80	9.42

Table 9. Predicted Mechanical Harvesting Value and Analysis of Errors

Year	Mechanical Sowing Trend Value /%	Mechanical Harvesting Trend Value /%
2009	36.97	31.71
2010	38.82	34.35
2011	40.76	37.21
2012	42.80	40.31
2013	44.94	43.66
2014	47.18	47.30
2015	49.54	51.24

Table 10. Predicted Trend Value of Mechanical Sowing and Mechanical Harvesting

4. Conclusions

Mechanical sowing level and mechanical harvesting level are important indexes that reflect development level of China's field production mechanization. It is important to research on its volatility and growth trend for promoting the development of mechanical sowing level and mechanical harvesting level in a stable and high-speed way. HP filtering method is adapted to analyse the fluctuations problems of mechanical sowing level and mechanical harvesting level and based on this, GM(1,1) is used to predict the growth trend of Mechanical sowing level and mechanical harvesting level. Results show that the mechanical sowing level and mechanical harvesting level from 1973 to 2008 China was overall rising; mechanical sowing level includes six fluctuation cycles and the average fluctuating interval is 6 years, average amplitude is 10.44%; Mechanical harvesting level contains five fluctuation cycles and the average fluctuating interval is 7.2 years, average amplitude is

13.228%; The amplitude of mechanical sowing level and mechanical harvesting level is reduced, and the growth stability of both is gradually strengthened; The factors that affect the development of field production mechanization level include farm machinery management modes, rural economic development condition, rural residents' per capita income, policy system, etc. In order to prevent mechanical sowing level and mechanical harvesting level from fluctuate greatly and promote both development at a high speed, this article put forward: attention should be focused on factors that affect production field mechanization development during different periods; enthusiasm of the farmers to purchase and use agricultural machinery should be mobilized; guided by the market, agricultural professional cooperatives should be developed quickly; management benefits of agricultural mechanization production should be improved continuously; the construction of supporting system for agricultural mechanization development should be promoted constantly. In addition,GM(1,1) is used to predict the growth trend of mechanical sowing level and mechanical harvesting level and the predicted results show that by 2015, trend value of Chinese mechanical sowing level and mechanical harvesting level will be 49.54% and 51.24% respectively.

5. References

Agricultural mechanization management department. (2009). Technology development report of agricultural mechanization in China from 1949 to 2009. China's agricultural science and technology press, pp: 3-30.

Arnon, I. (1981). Modernization of agriculture in developing countries: resources, potentials and problems. New York, John Wiley & Sons, pp: 565.

Andrea Harris; Murray Fulton. (2000). Farm machinery co-operatives in Saskatchewan and Quebec. Center for the study of Cooperatives, University of Saskatchewan.

Bagheri, N and Moazzen, S. A. (2009). Optimum strategy for agricultural mechanization development in Iran. Journal of Agricultural Technology, Vol.6, No.1, pp: 225-237.

Biser, L C. (1983). Cooperative Farm Machinery Operation, 1970~1980. Performer: Agricultural Cooperative Service, Washington.

Carlo Russo; Dave Weatherspoon; Christopher Peterson; Massimo Sabbatini. (2000). Effects of Managers' Power on Capital Structure: A Study of Italian Agricultural Cooperatives. The international Food and Agribusiness Management Review, Vol.3, No.1, pp: 27-39.

Deng, J. L. (1989). Introduction to grey system theory. The Journal of Grey System, Vol.1, No.1, pp: 1-24.

Deng, J. L. (2005). Grey system basic method. Wuhan, China: Huazhong University of Blank Science and Technology Press.

Erchao Li; Minli Yang; Michael L. Cook. (2009). Agricultural Machinery Cooperatives in China: Origin, Development, and Innovation. 2009 American Society of Agricultural and Biological Engineers Annual International Meeting, Reno, Nevada, USA.

Georgeanne M. Artz; Gregory J. Colson; Roger Ginder. (2009). A Return of the Threshing Ring-Motivations, Benefits and Challenges of Machinery and Labor Sharing Arrangements. IOWA STATE UNIVERSITY, pp: 1-24.

Hodrick, R.J; Prescott, E. C. (1981). Post-war U.S. business cycles: An empirical investigation. Carnegie-Mellon University, pp: 451.

Ju, J.Y; Wang J.W. (2009). Prediction method for the operation level of agricultural mechanization in Heilongjiang Province. Transactions of CSAE, Vol.25, No.5, pp: 83-88.

Jin, Xiuman; Ma, Chenglin. (1995). Research on critical value of purchasing power for farm machinery. Transactions of the Chinese Society for Agricultural Machinery, Vol.26, No.1, pp: 5-10.

Jian Fu Zhang; Zhi Jun Wu; Ping Fa Feng; Ding Wen Yu. (2011). Evaluation systems and methods of enterprise information and its application. Expert Systems with Applications, No.38, pp: 8938-8948.

Li, F. X; Xu, Z; Zhao, J. (2008). Analysis of factors influencing flue-cures tobacco production in Henan province. ACTA TABACARIA SINICA, Vol.14, No.2, pp: 39-43.

Liu, F.J; Ren,A.S. (1997). Historical Evolution and Features of Farm Machinery Market[J]. Transactions of the CSAE, No.4, pp: 13-18.

Liu, Y.M; Tian, Z.H. (2008). Research on determinant factor of farm machinery equipment level in China. Journal of Agrotechnical Economics, No.6, pp: 73-78.

Lu, B. F; Zhang, Z. L; Zhu, M. et al. (2008). Discrimination and analysis of key influencing factors for agricultural mechanization development. Transactions of the CSAE, Vol.24, No.11, pp: 114-117.

M. Marrit Van den Berg; Huib Hengsdijk; Joost Wolf. (2007). The impact of increasing farm size and mechanization on rural income and rice production in Zhejiang province, China. AGRICULTURAL SYSTEMS, No.94, pp: 841-850.

Paolo Biondi; Danilo Monarca; Arduino Panaro. (1998). Simple Forecasting Models for Farm Trantor Demand in Italy, France and the United States. J. agric. Engng Res, No.71, pp: 25-35.

Peter Hill. (2005). Partnering for profit from machinery. Machinery, No.3, pp: 136-138.

Unakitan, G; Akdemir, B. (2007). Tractor demand projection in Turkey. BIOSYSTEMS ENGINEERING, No.97, pp: 19-25.

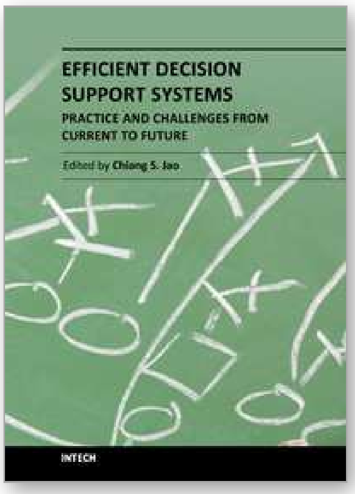
Wang, X. L; Ji, C. Y; Zhou, J; Jiang, L; Gu, B. X. (2010). Design and experiment of fruit and vegetable grasping system based on grey prediction control. Transactions of the CSAE, Vol. 26, No. 3, pp: 112-117.

Yang, M.L; Bai, R.P; Liu, M. (2005). Development of Agricultural Mechanization and Construction of Modern Agriculture. Transactions of Chinese Society for Agricultural Machinery, Vol.36, No.7, pp: 68-72.

Yang, Y. S; Liu, Z. Y; Sheng, G. H. (2005). Research on the promotion system of Chinese agricultural mechanization. Transactions of Chinese Society for Agricultural Machinery, Vol. 36, No.11, pp: 79-82.

Zhang, R; Gao H.W. (2009). Prediction Model of Agricultural Mechanization Level in China Based on GM(1,1). Transactions of Chinese Society for Agricultural Machinery, Vol.40, No.2, pp: 91-94.

Zhu, H. J; Tian, Z. H; Han L. J. (2007). Dependence of agricultural mechanization on financial investment. Transactions of the CSAE, Vol.23, No.3, pp: 273-278.



Efficient Decision Support Systems - Practice and Challenges From Current to Future
Edited by Prof. Chiang Jao

ISBN 978-953-307-326-2
Hard cover, 542 pages
Publisher InTech
Published online 09, September, 2011
Published in print edition September, 2011

This series is directed to diverse managerial professionals who are leading the transformation of individual domains by using expert information and domain knowledge to drive decision support systems (DSSs). The series offers a broad range of subjects addressed in specific areas such as health care, business management, banking, agriculture, environmental improvement, natural resource and spatial management, aviation administration, and hybrid applications of information technology aimed to interdisciplinary issues. This book series is composed of three volumes: Volume 1 consists of general concepts and methodology of DSSs; Volume 2 consists of applications of DSSs in the biomedical domain; Volume 3 consists of hybrid applications of DSSs in multidisciplinary domains. The book is shaped upon decision support strategies in the new infrastructure that assists the readers in full use of the creative technology to manipulate input data and to transform information into useful decisions for decision makers.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821