Research on the Forecast of Grain Production in Henan Province from 2010 to 2015

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Abstract According to the latest amended agricultural economic statistical data from 1996 to 2009 in *Henan Statistical Yearbook*-2010, by selecting and establishing the optimized grey model of logarithmic new developed coefficient, we conduct the empirical analysis and forecast research on the grain output and the relevant main economic indices in Henan Province from 2010 to 2015. The results show that the grain output of Henan Province in 2010 will reach 54.896 9 million tons, and it will break through 60 million tons at 60.17 million tons in 2015. In years ahead, the grain output of Henan Province will develop to a new stage steadily, which guarantees the national grain supply and socio-economic sustainable development forcibly.

Key words Henan Province, Grain production, Grey model of LNDC, Forecast, China

China is a country with a population of 1.3 billion. Ensuring the food security is an important strategic problem. Henan Province is the biggest agricultural province in China and the biggest province of producing grain in China. It is famous as the granary of China, the grain output of which accounts for 10% of the total output of China and the wheat output of which accounts for 25% of the total output of China. From the year 2000, the total output of grain ranks first in China in continuous ten years. In 2010, the south of China firstly suffered from severe disaster of drought, and then continuous heavy rain, which imposed a severe impact on the production of grain. Under this circumstance, the summer grain in Henan Province had good harvests. The total output of summer grain increases in successive 8 years, and the total output of grain annually is expected to exceed 50 million tons in successive 5 years. This not only ensures the national food security effectively, but also can play the significant role of promoting the stable and rapid development of national economy, and arrest inflation[1]. The prediction research of grain production is the prerequisite of implementing the strategy of food security and agricultural sustainable development of China[2]. By selecting and establishing the optimization grey model of logarithm new development coefficient, this research conducts the prediction and analysis on the future grain output in Henan Province, in order to provide scientific evidence of production and management of food security.

1 Data source and research methods

1.1 Data source According to *The Statistical Yearbook in* 2010 *of Henan Province*[3], we get the total output of grain of Henan Province from 1996 to 2009 (Table 1) and the main economic index data related with grain output of Henan Province from 2001 to 2009 (Table 2).

Table 1 Total grain yield in Henan Province from 1996 to 2009

$\times 10^4$ t

Year	Yield	Year	Yield
1996	3 839.90	2003	3 569.49
1997	3 894.66	2004	4 260.00
1998	4 009.61	2005	4 582.00
1999	4 253.25	2006	5 112.30
2000	4 101.50	2007	5 245.22
2001	4 119.88	2008	5 365.48
2002	4 209.98	2009	5 389.00

1.2 Research methods The grey prediction is one of the basic contents of grey system theory, which explores the law of future development and changes by establishing GM (1,1) dynamic model. It deals the synthesis quantum that is difficult to describe as the grey quantum, extracts the useful information by interfering with the random factors of data generation and development infirmness, and realizes the precise cognition and effective control over the law of system running[4]. The grey model needs few data, and it is elastic and convenient to establish model. In addition, the model has high precision and strong practicability, so it is can be applied extensively in the fields of social science and natural science. The economic growth is the result of interaction, mutual restriction and balanced development of myriad complicated factors in socio-economic system, which is fit to adopt the grey model to research and explore the internal law of system. On the basis of new development coefficient grey of document[5], this research tries to establish a kind of new grey prediction with high precision and stability[6-7].

We assume that the original time sequence is $P^{(0)} = [p^{(0)}(1), p^{(0)}(2), \cdots, p^{(0)}(n)]$. The research does not establish prediction model directly from the grain output sequence in Table 1, but takes logarithm of the original sequence firstly, namely $x^{(0)}(k) = \log p^{(0)}(k)$, and conducts first-order accumulated generation of grain output sequence $x^{(0)}$ of logarithm, so we get generation sequence $x^{(1)}$ namely:

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

Received: November 15, 2010 Accepted: December 20, 2010
Supported by the Key Program of the Statistical Scientific Research of China (2008LZ022); the Scientific Research Foundation Program of Nanjing University of Information Science & Technology.
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Table 2 Data for the main economic indices related to the grain yield in Henan Province from 2001 to 2009

Year	Regional GDP $\times10^8$ yuan	Animal husbandry and fishery yield $\times10^4$ tons	Sown area $\times10^4$ hm^2	Wheat yield $\times10^4$ tons	Oilseed yield $\times10^4$ tons	Fruits yield $\times10^4$ tons
2001	5 533.01	540.65	1 312.77	2 299.71	362.49	399.12
2002	6 035.48	570.01	1 335.98	2 248.38	420.68	427.01
2003	6 867.70	603.55	1 368.44	2 292.50	309.91	430.38
2004	8 553.79	643.00	1 380.57	2 480.93	408.75	507.07
2005	10 587.42	689.90	1 392.26	2 577.67	449.67	555.69
2006	12 362.79	584.60	1 399.54	2 936.50	460.07	591.78
2007	15 012.46	542.90	1 408.78	2 980.21	483.98	663.49
2008	18 018.53	584.50	1 418.17	3 015.00	505.34	714.09
2009	19 480.46	610.73	1 419.66	3 056.00	532.98	755.90

We assume that the initial value $\alpha_0 = \ln\{\frac{1}{n-1}[\sum_{k=2}^{n}\frac{x^{(0)}(k-1)}{x^{(0)}(k)}$, $k=1, 2, \cdots, n)$, $\lambda_0 = \frac{1}{\alpha_0} - \frac{1}{e^{a_0}-1}$. $x^{(0)}(k) + a_1 z^{(1)}(k) = b_1$ is grey differential equation (a_1, b_1 are undetermined coefficients and the background value is as follows:

$$z^{(1)}(k) = \lambda_0 x^{(1)}(k-1) + (1-\lambda_0) x^{(1)}(k) \quad (2)$$

By applying the least squares, we can get:

$$\hat{a} = (a_1, b_1)^T = (B^T B)^{-1} B^T Y \quad (3)$$

$$B = \begin{pmatrix} -\lambda_0 x^{(1)}(1) - (1-\lambda_0) x^{(1)}(2) & 1 \\ -\lambda_0 x^{(1)}(2) - (1-\lambda_0) x^{(1)}(3) & 1 \\ \cdots & \cdots \\ -\lambda_0 x^{(1)}(n-1) - (1-\lambda_0) x^{(1)}(n) & 1 \end{pmatrix};$$

$$Y = (x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n))^T.$$

Select $\hat{x}^{(0)}(n) = x^{(0)}(n)$ get the bleaching responsiveness as follows:

$$\hat{x}^{(0)}(k) = x^{(0)}(n) \cdot e^{-a(k-n)}, (k=1,2,\cdots,n) \quad (4)$$

Finally by the form $p^{(0)}(k) = \exp(x^{(0)}(k))$ the gross is reverted. We call this prediction model logarithm new development coefficient optimization grey model (LNDCGM). This model ensures that the initial value is close to the practical value, and decreases greatly iteration number, which not only makes the calculation simple and effective, but also increase the fitting accuracy and prediction accuracy[4], so it has extensive space of application.

2 Results and analysis

2.1 The verifiable prediction of grain output of Henan Province in 2009 According to the practical situation of grain output in Henan Province, we select 5 – 8 dimension shortage sequence output data to establish logarithm new development coefficient model of different dimensions, and conduct the verifiable prediction on the total grain output in 2009. The results of calculation are listed in Table 3. From Table 3, the prediction accuracy of 5 dimensional model reaches 99.74%, and the results are satisfactory.

Table 3 Comparison of the inspected prediction of the LNDCGM model with different dimensions

Dimensions of model	Actual value $\times10^4$	Predicted value $\times10^4$	Absolute error $\times10^4$	Relative error %
5	5 389.00	5 403.98	14.98	0.28
6	5 389.00	5 431.44	42.44	0.79
7	5 389.00	5 459.87	70.87	1.32
8	5 389.00	5 359.71	29.29	0.54

In order to select appropriate model, according to the comparative results of prediction accuracy of different dimensions in Table 3, we select 5 dimensional short sequence grain output data of Henan Province and the principal input factors data to establish common GM(1,1) model, attenuation discrete grey incremental model, new development coefficient grey model and logarithm new development coefficient optimization model, so as to conduct verifiable prediction on the grain output of Henan Province in 2009. The calculated prediction value of various grey models can be seen in Table 4.

From Table 4, the logarithm new development coefficient grey optimization model has the relatively high accuracy. The prediction accuracy of grain output of Henan Province in 2009 reaches 99.74%, which is very satisfactory. Besides, this model is steadier and more reliable than the other models. So, we conduct the practical prediction on the total grain output of Henan Province from 2010 to 2015 by using 5 dimensional logarithm new development coefficient optimization grey model.

Table 4 Comparison of the inspected prediction of 2009 grain yield by each model

Model	Actual value $\times10^4$	Predicted value $\times10^4$	Absolute error $\times10^4$	Relative error // %
General GM (1,1) model	5 389.00	5 440.86	51.86	0.96
Weakening and discrete grey incremental model	5 389.00	5 415.19	26.19	0.49
New development coefficient grey model	5 389.00	5 115.79	273.21	5.07
Logarithmic new development coefficient optimization model	5 389.00	5 403.98	14.98	0.28

2.2 The prediction of grain production in Henan Province from 2010 to 2015 According to the comparative analysis in "**2.1**", we select the data from 2005 to 2009 to establish 5 dimensional logarithm new development coefficient optimization

model of the grain output in Henan Province as follows:

$$\hat{x}^{(0)}(k) = 8.592\,6e^{0.002\,73(k-5)} \quad (5)$$

By verification, the unbiased variance specific value of model parameter $C=0.003\,172$, the minimum-error probability $p=1$, the average fitting accuracy $\bar{q}=99.12\%$. The model passes the verification, and the accuracy is fittest. According to the data in Table 1 and Table 2, by using model(5),we get the prediction value of grain output in Henan Province from 2010 to 2015 after calculation (Table 5).

2.3 The main economic index prediction related with grain production in Henan Province from 2010 to 2015 Along with the good harvest of grain in successive years, Henan Province develops vigorously the processing industry of agricultural products and byproducts, transforms the advantage of grain into the advantage of industry, develops agricultural industrialization, promotes the comparative profit of rice-cropping, further reinforces the activity of farmers' growing grain, and ensures the goods harvest and increased output of grain. According to the data in Table 2, by using model (5), we get the main economic index prediction value related with grain production in Henan Province from 2010 to 2015 after calculation (Table 6).

Table 5 Predicted value of the grain yield in Henan Province from 2010 to 2015 $\times10^4$ t

Year	Predicted value	Year	Predicted value
2010	5 489.58	2013	5 799.58
2011	5 590.89	2014	5 907.18
2012	5 694.17	2015	6 017.01

Table 6 Predicted value of main economic indices related to the grain yield of Henan Province from 2010 to 2015

Yield	Regional GDP $\times10^8$ yuan	Animal husbandry and fishery yield $\times10^4$	Sown area $\times10^4$ hm^2	Wheat yield $\times10^4$	Oilseed yield $\times10^4$	Fruits yield $\times10^4$
2010	22 036.99	638.29	1 427.775	3 289.99	563.22	832.79
2011	25 118.16	667.34	1 435.121	3 381.49	592.73	908.58
2012	28 679.21	679.93	1 442.529	3 475.87	624.05	992.38
2013	32 801.97	730.14	1 449.979	3 573.21	657.29	1 085.16
2014	37 583.40	764.08	1 457.472	3 673.63	692.6	1 187.98
2015	43 138.55	799.85	1 465.008	3 777.21	730.11	1 302.06

3 Conclusion and discussion

(1) On the basis of new development coefficient grey model, this research poses and establishes the logarithm new development coefficient optimization model, which weakens greatly the interfering factors and explores the law of system running. This will make the model steadier and have higher prediction accuracy. The empirical analysis demonstrates that this new grey model is not restricted by the sample amount; it is easy and convenient to establish model with small quantity of calculation; it is easy to control, and it has better prediction effect as against general grey models as regards the time sequence which increases in a short time; it is the ideal instrument for specializing in economic prediction study. The prediction results show that the grain output of Henan Province will break through 54 million tons in 2010, reaching 54.896 9 million tons and it increases by 1.83% over the year 2009; while the total output value of Henan Province reaches 2 203.699 billion yuan, and it increases by 13.78% over the year 2009; the output of animal husbandry and fishery industry reaches 6.382 9 million tons, and it increases by 4.51% over the last years; the output of wheat is projected to reach 32.899 9 million tons, and it increases by 2.77% over the last years; the output of oil is projected to reach 5.632 2 million tons, increasing by 5.19% over the last years;the output of fruits will reach 8.327 9 million tons, increasing by 8.97% over the last years;meanwhile, the planting area of Henan Province tends to increase slowly on the premise of ensuring stability, which provides powerful guarantee for grain production, and it is expected to reach 14.650 08 million hm^2 in the year 2015.

(2) The total output of summer grain in Henan Province in 2010 reaches 30.907 million tons, increasing by 0.257 million tons and 0.8% over the last year; the average yield per mu is 388.3 kg, increasing by 0.5% over the last year. To people's surprise, the total output of summer grain increases in the successive 8 years, and hits an all-time high in the successive 7 years. In the process of propelling industrialization and urbanization, the Central Plains does not realize the continuous increase and farmers' continuous income increase at the expense of agriculture but by improving the basic farmland water conservancy increasingly and strengthening agricultural technological popularization and so on [1]. Under the big background of the increase of the total output value of Henan Province in successive years, the grain output of Henan Province increases steadily, the planting area also expands gradually at the same time, and the output of animal husbandry and fishery industry which is as the component element of the primary industry also increases steadily, while the output of wheat, oil and fruit, the component element of grain production, increases continuously, which provides the advantageous conditions for grain output increase.

(3) The good framework of grain production in Henan Province has taken form and developed steadily, but the reform still needs to be further propelled, for example, the output of cotton decreases year by year from 2007. So we should increasingly improve the basic farmland water conservancy under the former conditions, reinforce agricultural technological popularization and investment of fixed assets, and construct project of emergency irrigation and flood control and waterlogged elimination. The departments at all levels in whole province should plant profuse wheat and manage it well, cooperate close and make concerted efforts so as to form the great cohesion of grain production. Henan Province should develop vigorously the

(To page 47)

information about production technology, policy and regulation as well as business markets according to different demands and offer on-line services matching with agro-product logistics in Binhai new area, such as on-line order, dispatching and clearing. Regional, transportation and industrial advantages in Binhai new area are to be exerted and the service system of agro-product logistics is to be established with the developmental concept of modern logistics and the support of infrastructure and operation mode of modern logistics in Binhai new area. The agro-product safety inspection system is to be established in Binhai new area. Inspection facilities in regional agricultural departments and key production bases of healthy agro-products, dispatching center and leading enterprises should be perfected to form an integrated inspection network and improve the industry-oriented and social inspecting abilities.

3.3.2 Developing agriculture sightseeing tourism. Binhai new area is situated in the Jingjin City belt with burgeoning economy, growing residents' income, relatively high living qualities and great tourism demand, which provides abundant visitor source for developing the sightseeing agriculture. According to the characteristics of natural and humanity environment in the region and with the support of high and new technology, the construction of tourist attractions at the county and district level and agro-ecological sightseeing scenic spots should be quickened to build more distinctive tourist villages, such as improved variety cultivation techniques, soilless cultivation techniques, precious agriculture techniques and so on. Sightseeing vegetable parks and sightseeing fisheries should be constructed separately. Some relatively developed villages can also be developed into demonstration towns. For example, Huaming Town establishes a demonstration pavilion of its own developmental history and charges visiting fees, which can not only develop tourism in the town but decrease the reception pressure of the town caused by a large amount of foreign visitors.

3.3.3 Perfecting rural financial service system. Rural industrial upgrading requires financial assistance, so rural banking business should be developed energetically to provide capital guarantee for rural industrial development. The formulation of overall reform program is to be quickened. Micro-credit institutions should be developed and farmers' funds mutual aid organizations started to satisfy small but frequent financial demand of the vast farmers and provide low-interest business loan for agricultural development. Agricultural risk prevention mechanism is to be established and agricultural insurance developed vigorously. Agricultural policy insurance should be broadened to offer appropriate financial premium and subsidies to farmers participating agricultural insurance[6].

3.3.4 Stressing rural educational training system. The integration of industry, university and research in agriculture should be promoted and vocational technology training center for farmers in Binhai new area established to form rural educational training system in Binhai new area. Agricultural adult education and vocational education should be developed and combined with those frequent trainings, such as "351" farmers' qualification training and new farmers' technology training, to improve the skills and comprehensive qualities of vast farmers, educate a team of agricultural producers in Binhai new area with strong adaptability to the market economy, production capacity, management and operation abilities and promote the transference of rural labor forces in Binhai new area.

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(From page 16)

processing industry of agricultural products and byproducts, transform the advantage of grain into the advantage of industry, develop agricultural industrialization, promote the comparative profit of rice-cropping, further reinforce the activity of farmers' growing grain, and ensure the goods harvest and increased output of grain in order to provide powerful support for grain production.

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