Prediction of the Productive Capacity of Grain in Henan Province

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Abstract Firstly, status of grain production in Henan Province is introduced. The rapid development of grain production has brought adequate food and clothing for Henan Province, has supported the development of industrial and agricultural production, has maintained the overall stability of the whole society, and has made grate contribution to the national food security. Secondly, considering the small sample of research object, the uncertain poor information and the few restrictions on data distribution, the gray forecast is usually conducted by using time series data based on GM (1,1) Model. In order to ensure the high accuracy and the application in practical prediction, residual test is used. Thirdly, according to the grain productive data in Henan Province in the years 1996 -2008, Gray Prediction Model of grain production in Henan Province is established. Simulation and prediction results are obtained by the calculation of Gray System Modeling Software, indicating that grain production of Henan Province still shows a steady rise in future, and reflecting the change law of grain production. Finally, predicted target is divided into three stages according to the planning. And analysis shows that the planning target is practical and feasible.

Key words Grain production; Gray forecast; Grain increase; China

Under a steady demand structure for grain, relationship between input and grain production is analyzed and the scientific prediction of future food production is carried out, which has important significance for the decision making of farmers and agricultural manufacturers, as well as the agricultural policy and other macroeconomic policies[1]. With the gradual transfer of grain production center from south to north, Henan Province becomes increasingly prominent in China's food supply. After entering the 21st century, capacity of grain production of Henan Province has been improved with more than 50 billion kilograms during the four consecutive years, accounting for 1/4 of the total grain output in China. Thus, Henan Province has become the " Chinese Granary" worthy of the name. However, food consumption demand shows a rigid growth trend. Therefore, maintaining the growth trend of grain is of vital importance to the protection of national food security in China.

1 Current situation of grain production in Henan Province

As a major agricultural province in China, grain output of Henan Province achieves the first place in China at the year 1997 and takes the first place steadily since the year 2000. In 2006, total grain output of Henan Province has reached 53 700 thousand tons in the year 2008, increasing by more than 7 times compared with 7 135 thousand tons in the year 1949. Its annual increase is 10.95%, which is higher than both the national and world average annual growth rates. According to the preliminary statistics, grain output of Henan Province is 53.9 billion kilograms, achieving the objective of the tenth consecutive group champion. Rapid development of grain production in Henan Province has made great contributions to the food and clothing problems in Henan Province, to the development of industrial and agricultural production, to the overall stability of the whole society, and even to the national grain security.

In general, since the foundation of new China, total grain output has increased in Henan Province. Although both grain unit yield and per capita grain fluctuate, total trends of the two are increasing. Growth speed of per capita grain is a little lower than that of total grain yield in different periods, but the difference is tiny, indicating that the per capita grain maintains the same development speed when the total grain output of Henan Province is increasing.

2 Forecast of grain output level in future in Henan Province

Grain output is determined mainly by the production input, the science and technology development and other social factors. At the same time, it is also affected by the climate, environment and natural conditions, adjustment of national policies and so on. Thus, grain output is the result of the comprehensive effect of many factors. And formation of grain output is a gray dynamic system of known information and unknown information, which can avoid the factors affecting the decrease and increase of grain output, so as to find out the useful information of time-series data of grain output. Based on this, we can search for the inherent laws of the development of grain output in order to establish a dynamic prediction model for abstract system development and to forecast the grain output accurately and scientifically.

2.1 Establishment of gray forecast model Research object of gray mathematics is the uncertain information of small sample and poor information, having little restrictions on data

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and their distribution. Generally, time-series data are used to carry out prediction by GM (1,1) model. This method has the advantages of high forecast accuracy and long-term forecast. Fitting equation is generated by accumulation, which accords with the change law of energy system.

First of all, gray system theory processes the raw data, and finds out the inner regularity from the disordered data series after generation processing[2]. GM (1,1) model is the most commonly used gray prediction model.

We assume that the original time series data $x^{(0)}$ is

$X^{(0)} = \{x_1^{(0)}, x_2^{(0)}, \cdots, x_n^{(0)}\}, x_i^{(0)} \geqslant 0$.

And its one-accumulate production series is

$X^{(1)} = \{x_1^{(1)}, x_2^{(1)}, \cdots\cdots, x_n^{(1)}\}$, where, $x_t^{(1)} = \sum_{i=1}^{t} x_i^{(0)} = x_{t-1}^{(1)} + x_t^{(0)}$, $t = 1, 2, \cdots, n$.

According to the one-accumulate production series, we have the differential equation $\frac{dx^{(1)}}{dt} ax^{(1)} = u$.

Coefficient vector can be obtained by the least squares method:

$\hat{a} = (a, u)^T = (B^T B)^{-1} B^T Y$,

where B and x are

$$B = \begin{bmatrix} -1/2[x_1^{(1)} + x_2^{(1)}] & 1 \\ -1/2[x_2^{(1)} + x_3^{(1)}] & 1 \\ \vdots & \vdots \\ -1/2[x_{n-1}^{(1)} + x_n^{(1)}] & 1 \end{bmatrix}, Y = \begin{bmatrix} x_2^{(0)} \\ x_3^{(0)} \\ \vdots \\ x_n^{(0)} \end{bmatrix}.$$

Hence, we have the time response sequence according to the differential equation:

$$\hat{x}_{(t+1)}^{(1)} = [x^{(0)}(1) - \frac{u}{a}] e^{-at} + \frac{u}{a}.$$

And its discrete form is

$$\hat{x}_{(t+1)}^{(1)} = [x_{(1)}^{(1)} - \frac{u}{a}] e^{-at} + \frac{u}{a}.$$

Since $x^{(1)}$ is the first-order accumulative sequence of $x^{(0)}$, estimated value of $x^{(0)}$ is obtained by accumulative reduction according to $\hat{x}_{(t+1)}^{(1)}$:

$$\hat{x}_{(t+1)}^{(0)} = \hat{x}_{(t+1)}^{(1)} - \hat{x}^{(1)},$$

where $t = 1, 2, \cdots, n$.

In order to ensure the high accuracy and application of the established gray model, three test methods are usually adopted, such as residual test, correlation test and posterior-variance-test.

Generally, residual test index is commonly used. Moreover, according to the gray system theory, GM(1,1) model has certain scope of application. When development coefficient is greater than −0.3, the established GM(1,1) model can be used for medium and long-term prediction. When development coefficient is between −0.5 and −0.3, GM(1,1) model can be used for short-term prediction, and for long-term prediction with caution. When the development coefficient is between −0.8 and −0.5, we should be very cautious with the short-term forecast by GM (1,1). When development coefficient is between −1 and −0.8, residual modification GM(1,1) model should be adopted. And when the development coefficient is smaller than −1, it is inappropriate to use GM(1,1) model.

Table 1 Historical evolution of grain output in Henan Province

Year	Total grain yield//10^4 t	Per capita grain output//kg	Year	Total grain yield//10^4 t	Per capita grain output//kg
1949	713.5	171	2000	4 101.5	435
1969	1 321.5	229	2001	4 119.9	433
1983	2 904.0	383	2002	4 210.0	439
1990	3 303.7	386	2003	3 569.5	370
1995	3 466.5	383	2004	4 260.0	440
1996	3 839.9	420	2005	4 582.0	490
1997	3 894.7	423	2006	5 010.0	534
1998	4 009.6	432	2007	5 245.0	559
1999	4 253.3	455	2008	5 370.0	572

Note: Data are from the *China Statistical Yearbook*, and the *Henan Rural Statistical Yearbook*.

2.2 Forecast of grain output Grain output in Henan Province since the year 1995 is selected. Gray prediction model of grain output in Henan Province is established. Predicting result can be calculated by gray system modeling software (Table 2).

Table 2 Predicting value, residual error and relative error of grain output in Henan Province 10^4 t

Year	Actual value of grain output	Predicting value	Residual error	Relative error
1996	3 839.9	3 718.890 781	−121.009 219	−3.151 364
1997	3 894.7	3 808.951 821	−85.748 179	−2.201 663
1998	4 009.6	3 901.193 885	−108.406 115	−2.703 664
1999	4 253.3	3 995.669 792	−257.630 208	−6.057 184
2000	4 101.5	4 092.433 640	−9.066 360	−0.221 050
2001	4 119.9	4 191.540 833	71.640 833	1.738 897
2002	4 210.0	4 293.048 124	83.048 124	1.972 640
2003	3 569.5	4 397.013 635	827.513 635	23.182 901
2004	4 260.0	4 503.496 898	243.496 898	5.715 890
2005	4 582.0	4 612.558 883	30.558 883	0.666 933
2006	5 010.0	4 724.262 043	−285.737 957	−5.703 352
2007	5 245.0	4 838.670 339	−406.329 661	−7.746 991
2008	5 370.0	4 955.849 279	−414.150 721	−7.712 304
2009		5 075.865 965		
2010		5 198.789 114		
2011		5 324.689 115		
2012		5 453.638 061		
2013		5 585.709 784		
2014		5 720.979 912		
2015		5 859.525 902		
2016		6 001.427 085		
2017		6 146.764 712		
2018		6 295.622 008		
2019		6 448.084 207		
2020		6 604.238 611		

Time response function of the model is

$$X_{(t+1)} = 153\,564.167\,155 \exp(0.023\,929\,t) - 150\,097.667155,$$

where development coefficient is −0.023 929, which is bigger than −0.3. Thus, the established GM(1,1) model can be used for medium and long – term prediction. Average relative error is relatively small, which is 5.088 544%. Table 2 indicates that grain output of Henan Province will continue to show a steady rising trend in the future, showing that the model can reflect the change law of grain yield to some extent. In theory, gray model can extend from the initial value to any time in future and provides basis for the long – term planning of food output. However, as time goes on, future factors will access to the system and affect the prediction results. Therefore, it is impossible to achieve the degree of complete whitening due to the impact of climate national policy and other uncertainties. We can only obtain a level within a certain range, that is, the level within gray boundary.

3 Conclusion and discussion

The *Construction of Henan Grain Production Core Region of National Grain Strategic Project*, put forward by Henan Province at August, 2008, pointed out that grain output will be improved from 50 billion kilograms at present to 65 billion kilograms in the year 2020. Thus, Henan Province becomes an important core area of food production in China and has made greater contribution to ensure the national grain security[3]. The expected target can be divided into three stages. Firstly, grain output reaches 55 billion kilograms in the year 2010 and the added value of primary industry achieves 250 billion yuan according to the price in the year 2007. Per capita net income of farmers reaches 5 000 yuan and the Engel coefficient in rural areas becomes 35%. Secondly, until the year 2015, grain output reaches 60 billion kilograms and the added value of primary industry grows to 300 billion yuan. Per capita net income of farmers reaches 7 000 yuan and the Engel coefficient in rural areas becomes 32%. Thirdly, grain output reaches 130 billion kilograms in the year 2010 and the added value of primary industry achieves 370 billion yuan. Per capita net income of farmers reaches 10 000 yuan and the Engel coefficient in rural areas becomes 30%.

According to the forecast result of gray model, grain output in Henan Province will reach 51 988 thousand tons in the year 2010 (about 52.00 billion kilograms). In the year 2015, annual output will reach 58 595 thousand tons (about 58.60 billion kilograms). In the year 2020, it is forecasted that the grain output of Henan Province will achieve 66 042 thousand tons (about 66.05 billion kilograms). Therefore, it can be concluded that the planning target is feasible. And it can be realized if there is no major accidents (natural disasters, etc.) during this period.

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河南省粮食生产能力预测

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摘要 首先，介绍了河南省粮食生产现状，指出河南省粮食生产的飞速发展既解决了河南省人民的温饱问题，支持了工农业生产发展，保持了全社会大局稳定，又为保障国家的粮食安全作出了巨大贡献。其次，考虑到研究对象为小样本、贫信息的不确定信息，对数据及其分布的限制要求少，一般利用时间序列数据，通过 GM(1,1)模型进行灰色预测。为确保所建立的灰色模型有较高的精度并应用于实践预测，该研究采用残差检验法。再次，选用 1996 ~2008 年河南省粮食产量数据，建立河南省粮食产量灰色预测模型，经灰色系统建模软件运算得到模拟及预测结果，表明河南省粮食产量在今后的发展中仍将呈现平稳攀升的态势，反映了粮食产量变化的规律。最后，规划将预测目标分为 3 个阶段，通过分析指出，规划目标切合实际，具有可行性。

关键词 粮食生产；灰色预测；粮食增产

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基于生态特征驱动的品牌延伸规模模型实证分析

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摘要 首先，建立了品牌延伸规模模型，采用边际分析法分析品牌延伸规模模型的最优解。其次，采用问卷调查法对 G 品牌的品牌延伸情况进行调研，调查共发放问卷 240 份，收回 211 份，其中有效问卷 187 份，以此来检验品牌延伸规模模型中各因素的影响程度；同时采用层次分析法分析品牌延伸规模的大小，采用主成分分析找出影响 G 品牌进行品牌延伸的主要因素。最后，进行了基于生态特征的品牌延伸规模模型实证分析，结果表明，通过主成分分析方法得出的各主成分反映出的全部信息的顺序与采用层次分析法分析得出的顺序有所不同；随着消费者生活水平的不断提高，人们对购买产品的方便性和购物环境的舒适程度的关注度日渐提高，为此品牌企业要加强品牌种群的环境建设，满足消费者日益提高的物质文化需求；企业品牌延伸的成功率很大程度上与产品本身及产品渠道关系紧密，与国外品牌相比，消费者对企业产品品牌的传播、品牌联想相对较弱。

关键词 模型；规模；实证；品牌延伸；生态特征