International Journal of Social Science and Education Research Volume 5 Issue 8, 2022
ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

# Forecast of Rural E-commerce Scale Based on Grey Markov Model

Jia Luo, Liguang Chen

School of Economics and Management, Tianjin University of Technology and Education, Tianjin 300222, China

## Abstract

**The emergence of the concept of "Internet +" has enabled various industries from all over the world to take this express train. my country is a big agricultural country, and the emergence of "Internet +" provides a new development direction for my country's agricultural development. In this paper, the gray prediction model and the gray Markov prediction model are used to predict the scale of rural e-commerce in my country, and the results of the two are compared. After the experimental study, it is found that the model used in the prediction experiment is relatively accurate, and the final prediction result is basically in line with the expectation, so the predicted value corrected by the gray Markov model is closer to the actual value.**

## Keywords

**Rural E-commerce; Scale Forecas; Grey Markov Model.**

## 1. Introduction

With the wide application of Internet technology, the whole society has entered the Internet age, and the sharing of global information resources has provided a huge trading platform for the market. Modern society is a society of information sharing. The emergence of the concept of "Internet +" has enabled various industries in various countries to take this express train to promote their products and services to various fields more widely and deeply, which not only broadens their own market, and brought great profits. my country's rural e-commerce started relatively late, and there are relatively few studies on the application of scientific quantitative methods to rural e-commerce. With the development of rural e-commerce, a certain amount of transaction scale data has been accumulated. This paper uses the gray Markov model to analyze the rural e-commerce transaction scale. Carrying out short-term forecasting and better combining the grey system forecasting method with other fields not only enriches the grey system theory, but also provides a certain reference for rural e-commerce research [1].

## 2. An overview of the Relevant Theories

### 2.1. Rural E-Commerce

Rural e-commerce is the use of Internet information technology, focusing on the development of rural areas, so that rural areas can keep up with the pace of information of the times, and a variety of Internet information services can be implemented in rural areas with high timeliness, so that the advantages of the Internet can better serve the rural areas. To promote the development of rural economy well, it also closely links local counties, towns, and villages, so that the development and changes of the countryside can closely follow the development and changes of the general environment, so that the three rural areas can better serve the farmers and maximize the play its role and value [2].

The rural e-commerce platform uses digital and information technology to establish an orderly business model through centralized and market-oriented operation and management, systematic cross-regional and cross-industry cooperation, and collaboration with densely

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

populated rural chain outlets. Through this model, the cost of establishing a commercial scale in rural areas can be reduced, so that farmers can enjoy the benefits brought by the development of rural e-commerce to the greatest extent, so as to expand the value-added field of rural e-commerce [3].

### 2.2. Grey System Theory

Grey system theory is a research method that can effectively solve uncertainty problems such as small data, few samples, and poor information. Information, this method studies the system from the internal structure and parameters of the system, in order to emphasize the cognition of the laws of reality. Through the analysis of this series of uncertain, small sample and poor information data, useful value is extracted.

Grey system theory was first proposed by Professor Julong Deng, a famous scholar in my country in 1982. After the grey system theory was first proposed, it has attracted many scholars to continue to study and explore in the field of grey system theory, and has been received by scholars and scholars from all over the world. Close attention and strong support from academia; in the discussion of many disciplines and research fields, grey system theory has been repeatedly used and studied, so many excellent results have been achieved in this field[4] .

### 2.3. Markov

Markov is a discrete stochastic process that describes a sequence of states whose value depends on a finite number of preceding states. A Markov chain is a random, memoryless discrete process, and a Markov process whose time and state are both discrete is a Markov chain. A Markov chain is a sequence of random variables with Markov properties. Markov chains are widely used in mathematical modeling of chemical reactions, queuing theory, market behavior and grey system forecasting [5, 6].

The extensive application of Markov provides scholars with new research directions and methods, as well as new research ideas for other disciplines and research fields [7, 8].

## 3. Literature References

### 3.1. Principles of Grey Predictive Modeling

Let the original data be $x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)$ , the non-negative sequence $x(0) = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n))$ , and accumulate it once to get $x(1) = (x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n))$ , where the $x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1, 2, \ldots, n$ accumulation sequence overcomes the volatility and randomness of the original sequence, and converts it into an increasing sequence with strong regularity. Prepare the predictive model.

Differential equation

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b \tag{1}$$

Grey prediction model $GM(1,1)$ , where a, b are constants,

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

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

It can be obtained by least squares fitting: $\hat{a} = [a,b]^T = (B^T B)^{-1} B^T Y$ , where $Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}$,

The solution of differential equation (1) is

$$\hat{x}^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}, k = 1,2,\ldots,n \tag{3}$$

Equation (3) is the prediction formula of the sequence. Since Equation (3) is the predicted value of the sequence generated by one accumulation, the restored predicted value of the original sequence can be obtained by Equation (3)[9,10].

$$\hat{x}^{(1)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k), k = 1,2,\ldots,n \tag{4}$$

## 3.2. Grey Markov Prediction Model

Let the original data $x^{(0)}(k)(k=1,2,\cdots,n)$ be a non-stationary random sequence that conforms to the characteristics of Markov chain, and divide the value of $x^{(0)}(k)(k=1,2,\cdots,n)$ into s different states, and any state $\otimes_i$ is expressed as

$$\otimes_i = [b_{1i}, b_{2i}], i = 1,2,\cdots,s$$

where $b_{1i}, b_{2i}$, is a constant that needs to be set according to the state division [11].

here are $s$ states $\otimes_1, \otimes_2, \cdots, \otimes_s$, in the $M$ period of the observation record, and the state $\otimes_i \left(i = 1,2,\cdots,s\right)$ appears $M_i$ times, so

$$p_i = \frac{M_i}{M} \tag{5}$$

The probability is approximated in terms of frequency, then

$$p_{ij} = \frac{M_{ij}}{M_i}$$

Similarly, an approximation of the $m$-step state transition probability can be obtained

$$a_{ij}(m) = \frac{M_{ij}(m)}{M_i}, i = 1,2,\cdots,s \tag{6}$$

Select the state corresponding to the largest one in $(a_{i1}, a_{i2}, \cdots, a_{is})$ as the prediction result, that is,

$$\max\{a_{i1}, a_{i2}, \cdots, a_{is}\} = a_{ik} \tag{7}$$

it can be predicted that the next step the system will turn to state $\otimes_k$ [12,13].

Markov correction to the predicted value of GM(1,1).

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

Denote the relative error percentage between the predicted value and the actual value of GM(1,1) as $F$ , and divide it into i states according to the positive and negative and the magnitude of the relative error percentage value in the GM(1,1) model, corresponding to state $F_1, F_2, \cdots, F_S,$ respectively The value of each state interval is denoted as $[F_{s-}, F_{s+}]$[14,15].

In summary, the stateful transition matrix is:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1s} \\ a_{21} & a_{22} & \cdots & a_{2s} \\ \vdots & \vdots & \vdots & \vdots \\ a_{s1} & a_{s2} & \cdots & a_{ss} \end{bmatrix}$$

Then the correction formula is:

$$\hat{X}_{(k)}^{(0)} = x_{(k)}^{(0)} \times [1 - (F_{i-} + F_{i+}) / 2] \tag{8}$$

## 3.3. Application of The Model

### 3.3.1. Application of GM(1,1) Model

Select the rural e-commerce transaction scale data from 2014 to 2020 as shown in the figure below for GM(1,1) prediction and grey Markov prediction respectively.(Data sources:WJS)

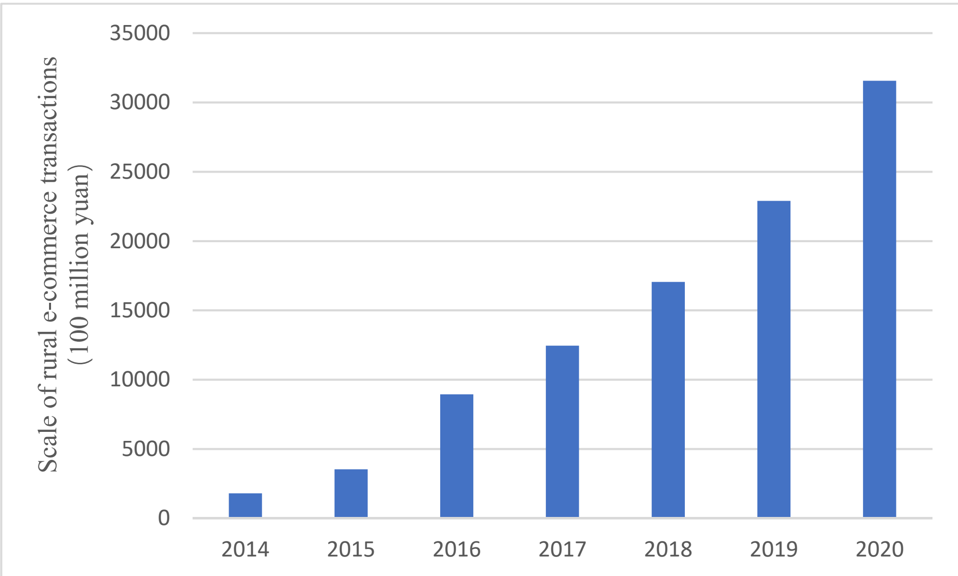


**Figure 1.** Scale of rural e-commerce transactions

According to the 2014-2020 rural e-commerce transaction scale data in Figure 1 and the principle of the grey forecast model, using the Matlab program to calculate, the calculation can be obtained:

$$a = -0.33 \quad b = 4568.25$$

$$\hat{a} = [a, b]^T = (B^T B)^{-1} B^T Y = \begin{bmatrix} -0.33 \\ 4568.25 \end{bmatrix}$$

$$\hat{x}^{(1)}(k+1) = \left(1800 - \frac{4568.25}{-0.33}\right) e^{0.33k} + \frac{4568.25}{-0.33}, k = 1, 2, \cdots, n$$

Through the above formula, the data can be substituted into the following Table 1GM(1,1) The predicted value of rural e-commerce transactions.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

**Table 1.** GM(1,1) predicted value

| Years | Actual value (100 million yuan) | GM (1,1) Predictive value (100 million yuan) | Relative simulation error |
|---|---|---|---|
| 2014 | 1800 | 0 | 0 |
| 2015 | 3530 | 6136.12 | 73.83% |
| 2016 | 8945.4 | 8567.23 | 4.23% |
| 2017 | 12448.8 | 11961.53 | 3.91% |
| 2018 | 17050 | 16700.65 | 2.05% |
| 2019 | 22898 | 23317.38 | 1.83% |
| 2020 | 31553.4 | 32555.64 | 3.18% |

### 3.3.2. Application of GM(1,1) Model

The predicted value of the gray system is revised by using Markov chain, in order to make the predicted value of the rural e-commerce transaction scale data closer to the real value. According to the results of the relative simulation error calculated in Table 1 above, the relative simulation error can be divided into 3 intervals, and the minimum interval is 1.83%, the maximum interval is 73.83%, and the upper and lower limits of the interval are closed intervals. The three intervals divided are respectively: , respectively denoted as: $M_1, M_2, M_3$.

The state interval is divided by the relative simulation error of the above predicted values, as shown in Table 2 below.

**Table 2.** Division of the status of rural e-commerce transaction scale

| Status | Interval | Year | Quantity |
|---|---|---|---|
| M1 | [1.83%,3.03%] | 2018,2019 | 2 |
| M2 | [3.04%,4.24%] | 2016,2017,2020 | 3 |
| M3 | [4.25%,73.83%] | 2015 | 1 |

From the state interval of the rural e-commerce transaction scale in Table 2 above, the Markov state transition matrix can be obtained as:

$$A = \begin{bmatrix} 1/2 & 1/2 & 0 \\ 1/2 & 1/2 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

The predicted value of gray rural e-commerce transaction scale data after using Markov chain correction is shown in Table 3 below.

**Table 3.** Comparison of GM(1,1) and Markov modified prediction results

| Years | Actual value (100 million yuan) | GM (1,1) Predictive value (100 million yuan) | Relative simulation error | Markov predictions value (100 million yuan) | Markov Prediction Relative Simulation Error |
|---|---|---|---|---|---|
| 2014 | 1800 | 0 | 0 | 0 | 0 |
| 2015 | 3530 | 6136.12 | 73.83% | 4413.2 | 25.02% |
| 2016 | 8945.4 | 8567.23 | 4.23% | 8890.86 | 0.61% |
| 2017 | 12448.8 | 11961.53 | 3.91% | 12413.38 | 0.28% |
| 2018 | 17050 | 16700.65 | 2.05% | 17116.58 | 0.39% |
| 2019 | 22898 | 23317.38 | 1.83% | 22764.21 | 0.58% |
| 2020 | 31553.4 | 32555.64 | 3.18% | 31412.23 | 0.45% |

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

From Figure 2 below, we can clearly see that the revised grey Markov prediction is closer to the true value.

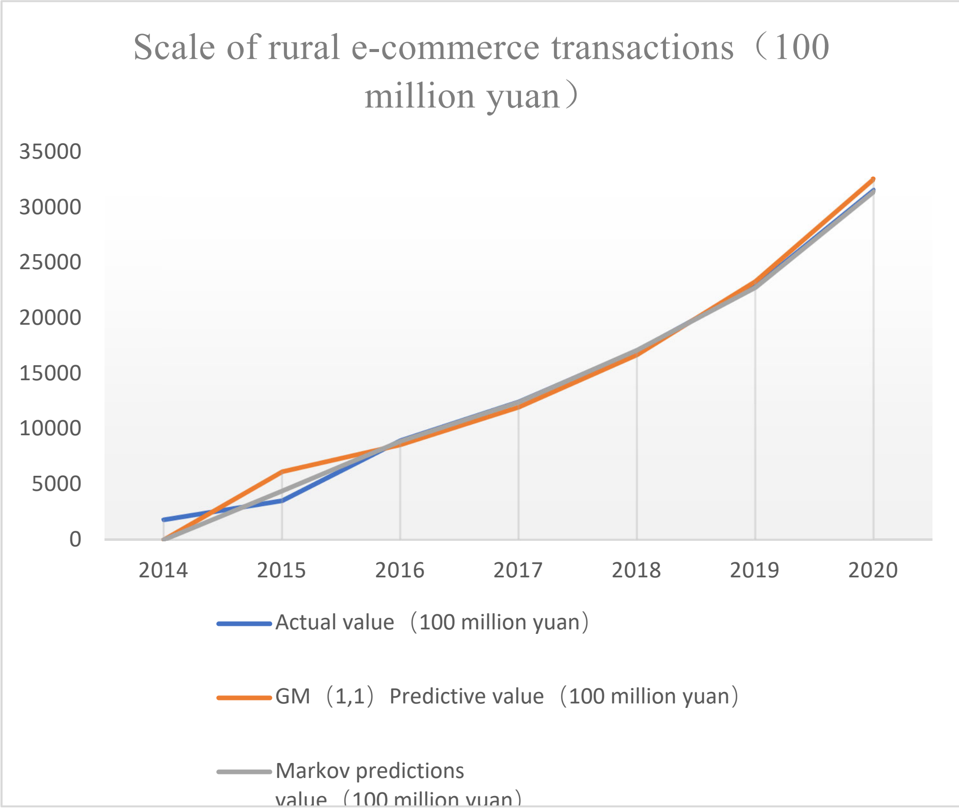


**Figure 2.** Comparison of GM(1,1) and Gray Markov

## 4. Conclusion

In order to compare and analyze the prediction accuracy of the grey Markov model and the traditional GM(1,1) model, based on the data of rural e-commerce transaction scale from 2014 to 2020, the actual measured values and the predicted values of the two models are shown in Table 3 above. According to statistics, the relative error of the predicted value of the traditional GM(1,1) model is between 1.83% and 73.83%, and the absolute value of the relative error is 14.84% on average; while the relative error of the predicted value of the gray Markov model is between 0.28% and 73.83%. Between 25.02%, the absolute value of the relative error is 4.56% on average, which is much better than the traditional GM(1,1) model. Therefore, the grey Markov model is more accurate for predicting data with volatility.

In this paper, the gray prediction model and the gray Markov model are used to predict the transaction scale of rural e-commerce in the short term. By comparing the results of the two, it can be seen that the gray prediction value corrected by the Markov chain is closer to the original actual value. , which reduces the prediction error and further improves the accuracy of the prediction, which has a little reference significance for the future rural e-commerce business.

## Acknowledgments

Natural Science Foundation (71871084).

Ministry of Education, Humanities and social science projects(20YJC630083).

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202208_5(8).0024

## References


[1] Y.Chen: Discussion on the mode of rural e-commerce live broadcast to help industrial development under the background of rural revitalization,Journal of Shanxi Agricultural Economy ,(2022) No.6, p.78-80.

[2] J.Bai: Exploration on the transformation and upgrading path of rural e-commerce under the background of "Internet + agriculture", Journal of Nuclear Agricultural Sciences,Vol. 36 (2022) No.5, p.1072-1073.

[3] Y.A.Wei: Big changes in rural e-commerce, Journal of Decision-Making,(2022) No.z1, p.70-73.

[4] F.H.Shu: Prediction of Flour Consuption and Thoughts on Grain Safety in China Based on the Grey-Markov Model, Journal of Modern Flour Milling Industry, Vol. 33 (2019) No.4, p.48-54.

[5] X.F.Yang: The Application of Grey Markov Model in Forecasting the Number of Tourists, Journal of Yibin University,Vol. 19 (2019) No.12, p.110-116.

[6] W.T.Mo: Application of grey-markov model for high slope deformation prediction ,Journal of Shanxi Architecture, Vol. 46 (2020) No.6, p.73-74.

[7] X.Y.Wang,C.Q.Yang: Prediction of Dangerous Weather Influence Range Based on Residual Grey Markov Model, Computer and Information Technology, Vol. 30 (2022) No.2, p.38-41.

[8] P.Y.Li,A.C.Cao and Y.H.Zhang: Free Cash Flow Forecast Based on Improved Grey Markov Model, Journal of Friends of Accounting, (2020) No.23, p.144-150.

[9] G.H.Yang,Y.Yan and H.Z.Yang: Application of improved GM(1,1) grey prediction model, Journal of Nanjing University of Science and Technology, Vol. 44 (2020) No.5, p.575-582.

[10] Y.Feng,M.D.Ye: Research on a Grey-Markov China Prediction Model Based on the Range Correction of State Intervals, Journal of Geomatics,Vol. 46 (2021) No.4, p.65-68.

[11] J.J.Li,W.M.Liu and H.M.Fei: Prediction of Farmers' Income in Jilin Province Based on Gray Markov Model ,Journal of Northeast Agricultural Sciences, Vol. 45 (2020) No.6, p.106-109+139.

[12] Y.Li,X.Bai: Forecast of wheat yield based on new dimensional unbiased grey Markov model ,Jiangsu Agricultural Sciences, Vol. 49 (2021) No.15, p.181-186.

[13] Q.You: The application of grey Markov prediction model in the trend of college students changing majors, Journal of Computer & Digital Engineering, Vol. 49 (2021) No.9, p.1878-1883.

[14] L.Zhang: Prediction of Coal Spontaneous Combustion Based on Improved Grey Markov Chain Model, Journal of Inner Mongolia Coal Economy, (2020) No.16, p.142-143.

[15] Q.Z.Wei,Y.Yang,L.Y.Li and H.Z.Wei: Predict Model for Foreign Exchange Based on Grey-Markov, Journal of Computer and Modernization, (2020) No.2, p.12-15.