Price Forecast of Building Materials Based on GM (1,1) Model

Chunfeng Wu, Zhuai Zhang*, Sheng Zhang

School of Civil Engineering and Architecture, Wuhan University of Technology, Wuhan 430070, China

*Corresponding author e-mail: 947114929@qq.com

Abstract. With the development of the national building materials industry, people's energy consumption of building materials production and its own performance have also been paid more and more attention. The prediction of building material prices is a very important part of the building price management system. Based on the gray model theory, the main analysis is based on the gray prediction model to predict the price of the main building energy-saving materials required in the project, and the actual engineering case is used to verify the prediction accuracy of the gray model. The effect is hoped to provide some reference and thinking for related building energy conservation research.

1. Introduction

In the construction process of related projects in various industries, a variety of building materials are used. Relatively speaking, the various industries involved in building energy-saving materials are very extensive, and the prices of building materials are subject to change at any time. Risks such as inflation in the economy are very sensitive. Faced with the increasingly competitive environment in the construction market, it is an important premise for bidders to conduct material price surveys and forecasts before engineering bidding to ensure reasonable bids and ensure the success of construction companies. Moreover, engineering projects often have long operating cycles, ranging from a few months to as many as several years. Therefore, the construction project should correctly estimate the price of the building materials during the relevant construction, and give a reasonable judgment on the bid price of the project and the price of the main materials in the later construction process, which has very important practical significance. In this paper, the GM (1,1) model is used to analyze the model and make a corresponding conclusion on the short-term price forecast of building materials.

2. GM (1,1) gray prediction model

The grey system was introduced by Mr. Deng in early 1982 [1]. It has also been rapidly developed and widely used in the fields of forecasting science such as industry, economy, and natural phenomena [2], [3], [4]. By requiring a small amount of data, four observation points, and comprehensively dealing with the uncertainty of the raw data to reduce the error of modeling fit, this is an important task for each study [5]. In recent years, scholars have been working hard to propose new models that combine grey prediction theory with theories or discourses of other algorithm domains to improve prediction accuracy. These new models focus on improving the predictive power of grey theory to achieve higher
prediction accuracy. Researchers have proposed new high-precision prediction models, such as hybrid gray models [6].

Grey system theory is a new method to study the problem of less data and poor information uncertainty. The gray system theory takes "small sample" and "poor information" uncertainty system with "partial information is known, some information is unknown" as the research object, mainly through the generation and development of "partial" known information, extracting valuable value. Information, to achieve a correct description of the system's operating behavior, evolutionary rules and effective monitoring [7].

"Extremely explicit, unclear connotation" is the main object of grey system theory research. Because the main characteristics of the grey system theory research object are "some information is already known, some information is unknown" and there are uncertain factors, so mainly through the "partial the formation, research, and extraction of knowing information are studied and analyzed to achieve accurate control and description of the overall operating law of the system [8]. The framework of the grey dynamic model is the key to the grey theory. Its main feature is to use the gray differential function and the function based on the gray function and the differential fitting as the core of the modeling, so that the model can be constructed based on a small amount of information and accurately predicted [9].

2.1. Preprocessing raw data methods

Since GM (1,1) belongs to the exponential model, when the dynamic data is used for correlation prediction, the original data should be pre-processed accordingly, so that the marketing of the extreme value of the data column can be reduced, thereby reducing the data. Randomness, and can greatly enhance the general trend of the original data column, which is conducive to improve the accuracy and credibility of the overall prediction [10]. The methods we use to process data on a daily basis mainly include the moving average method, the exponential weighting method, the logarithm method, the method of adding policy factors, and the method of opening the data. After research, it is found that the method of sliding average is better in predicting the accuracy of building material price prediction. The main steps are as follows:

Assuming the original data column is, for the two endpoints of the series, the following formula can be used for related processing:

\[ X^{(0)}(1) = \frac{3X^{(0)}(1) + X^{(0)}(2)}{4} \]  \hspace{1cm} (1)

\[ X^{(0)}(n) = \frac{X^{(0)}(n-1) + 3X^{(0)}(n)}{4} \]  \hspace{1cm} (2)

For each data point in the middle, the sliding average can be calculated according to the following formula:

\[ X^{(0)}(t) = \frac{X^{(0)}(t-1) + 2X^{(0)}(t) + X^{(0)}(t+1)}{4} \]  \hspace{1cm} (3)

2.2. The main steps in building a GM (1,1) gray model

Grey system modeling is a method for estimating the subsequent data by establishing an approximate differential equation model that basically satisfies the conditions of the differential equation. In the existing research, GM (1,1) is commonly used. The following are the main steps in model building.

Assume the time series are as follows:
\[ X^{(0)} = \{ X^{(0)}(1), X^{(0)}(2), \ldots, X^{(0)}(n) \} \]  
\hspace{1cm} (4)

By accumulating, a new time series can be generated, as follows:
\[ X^{(1)} = \{ X^{(1)}(1), X^{(1)}(2), \ldots, X^{(1)}(n) \} \]  
\hspace{1cm} (5)

From this, the differential equation corresponding to the GM (1,1) model can be obtained as follows:
\[ \frac{dX^{(1)}}{dt} + \alpha X^{(1)} = \mu \]  
\hspace{1cm} (6)

In the above formula, \( \alpha \) represents the development gray number, and \( \mu \) represents the endogenous control gray number.

Assuming that \( \hat{\alpha} \) represents the parameter vector to be estimated, it can be solved by our commonly used least squares method, which can be obtained:
\[ \hat{\alpha} = (B^T B)^{-1} B^T Y_n \]  
\hspace{1cm} (7)

\( B \) and \( Y_n \) in the above formula can be obtained by the following formula:
\[ B = \begin{bmatrix} -\frac{X^{(1)}(1) + X^{(1)}(2)}{2} & 1 \\ -\frac{X^{(1)}(2) + X^{(1)}(3)}{2} & 1 \\ \vdots & \vdots \\ -\frac{X^{(1)}(n-1) + X^{(1)}(n)}{2} & 1 \end{bmatrix} \quad Y_n = \begin{bmatrix} X^{(0)}(2) \\ X^{(0)}(3) \\ \vdots \\ X^{(0)}(n) \end{bmatrix} \]  
\hspace{1cm} (8)

A specific predicted value can be obtained according to the following formula.
\[ \hat{X}^{(0)}(t+1) = \hat{X}^{(1)}(t+1) - \hat{X}^{(1)}(t) \]  
\hspace{1cm} (9)

3. **Actual price forecast**

The bidding for a large overpass project on a certain road in China was completed in July 2018. During the half-year period of the construction period, the construction materials were specially marked in the bidding documents to be separately purchased by the construction unit and required to bear the risk of price fluctuations during the construction period. The size shows that the project requires about 900 tons of steel. The price of steel in 2018 is relatively stable, so some predictions should be made when making quotations. Based on the market steel prices from January to July in 2018, the GM (1,1) gray dynamic model was used to predict the price of steel in 2019.
3.1. Using grey dynamic model to predict steel prices during project construction

Table 1 Steel prices for January-July 2018 are shown in Table 1.

| month | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
|-------|-----|-----|-----|-----|-----|-----|-----|
| Price / (yuan / ton) | 4130 | 4110 | 4450 | 4460 | 4280 | 4276 | 4212 |

According to the statistics in the above table, the original data can be obtained as:

\[ X^{(0)} = \{4130, 4110, 4450, 4460, 4280, 4276, 4212\} \]  \hfill (10)

According to the model process, according to the formula, we can get the predicted steel price for the 6-12 months of 2018:

\[ X(0) = \{3946, 3961, 3933, 3904, 3887, 3859, 3842\} \]  \hfill (11)

3.2. Using grey dynamic model to predict steel price during construction period

According to the above table 1, it can be seen that the price is relatively low in January and February, and the price suddenly increases in March and April, and the price is relatively stable between May and July, according to the stable period. The price uses a grey dynamic model to predict the price between June and December:

\[ X'(0) = \{4278, 4096, 3892, 3876, 3884, 3681, 3678\} \]  \hfill (12)

3.3. Verify the predicted accuracy value

(1) In order to effectively improve the accuracy value of the prediction and minimize the error existing in the prediction, we can use the method of comparing the actual value with the predicted value to test the prediction model we constructed. The relative error can be obtained using the formula as follows:

\[ q = \frac{e^{(0)}(t)}{X^{(0)}(t)} \times 100\% \] \hfill (13)

\[ q' = \frac{e'^{(0)}(t)}{X'(0)(t)} \times 100\% \]

(2) According to the January-July price analysis, the price from June to December and the corresponding residual and relative error values are shown in Table 2 below.

Table 2 Table of steel price and relative error forecast value for June-December

| Serial number | Month | Actual value | Predictive value 1 | Predictive value 2 | Relative error 1 | Relative error 2 |
|---------------|-------|--------------|--------------------|--------------------|-----------------|-----------------|
| 1             | 06    | 4276         | 3946               | 4278               | 7.71%           | -0.04%          |
| 2             | 07    | 4212         | 3961               | 4096               | 5.95%           | 2.75%           |
| 3             | 08    | 3880         | 3933               | 3892               | -1.36%          | -0.03%          |
| 4             | 09    | 3616         | 3904               | 3876               | -7.96%          | -7.19%          |
| 5             | 10    | 3820         | 3887               | 3884               | -1.75%          | -1.67%          |
| 6             | 11    | 3800         | 3859               | 3681               | -1.55%          | 3.13%           |
| 7             | 12    | 3660         | 3842               | 3722               | -4.97%          | -1.69%          |
According to the analysis in Table 2 and Figure 1, according to the steel price forecast from January to July, the steel price in June-December is relatively stable. The maximum relative error is -7.96%, which is mainly due to the steel in September. The price is suddenly reduced, so the relative error is relatively large. The accuracy of the domestic steel price analysis and release forecast after June is slightly biased, and the price fluctuations from August to October lead to higher prediction values, and the maximum relative error suddenly decreases. In May to July, the market price is relatively stable, so the predicted value and the actual value are relatively close. Therefore, under the premise that the market price is relatively stable, the prediction accuracy value through the gray model is relatively high.

4. Summary
Through the model verification analysis, the following conclusions can be drawn: Grey system theory is an effective method to study the forecast of building material price growth.

In the construction process of the project, the cost of building energy-saving materials often occupies a very large proportion of the project cost, and it is also an important component, which will directly affect the cost accounting of the project and the later benefits. How to effectively and accurately predict the price of building energy-saving materials at the time of bidding will be a very important part for the construction unit. In this paper, the gray model is established, and the sliding average method is used to preprocess the original data to complete the price prediction analysis of building materials. The example engineering is used to verify that the prediction accuracy and effect of the method are ideal. The development of the building energy-saving materials industry must conform to the theme of green energy conservation, environmental protection and sustainable development, and will have a broad application market and development prospects.
References

[1] J.L. Deng. Control problems of Grey system [J]. Systems and Control Letters, 5 (1982), pp. 288-294

[2] J.L. Deng. Introduction to Grey system theory [J]. Journal of Grey System, 1 (1) (1989), pp. 1-24

[3] S. Liu, Y. Dang, Z. Fang. Grey Systems Theory and its Applications (third ed.) [J]. Science Press, Beijing (2004)

[4] S. Liu, Y. Lin. Grey Information Theory, and Practical Applications. Springer-Verlag, London (2006)

[5] S.F. Liu. The current developing status on Grey system theory. Journal of Grey System, 19 (2) (2007), pp. 111-123

[6] F.M. Tseng, H.C. Yu, G.H. Tzeng. Applied hybrid grey model to forecast seasonal time series. Technology Forecast Social Change, 67 (2001), pp. 291-302

[7] Yulan Zhang, Yiqing Lu, Yufei Sun. Prediction of Cross-border E-commerce Growth Scale in China Based on Grey System Theory [J]. Commercial Economic Research, 2019(03):136-139.

[8] Weijie Zheng. Construction of Grey System Prediction Model and Its Application in Virtual Reality [D]. Ningbo University, 2014.

[9] Yanxia Wang. The bid price is based on the GM (1,1) gray dynamic model of the main material price forecast [J]. Railway Engineering Cost Management, 2013, 28 (05): 39-43.

[10] Zhuohong Yao. Research on dynamic bidding quotation based on price forecast [D]. Changsha University of Science and Technology, 2012.

[11] Yi Liu, Jiawen Peng, and Zhihao Yu. 2018. Big Data Platform Architecture under The Background of Financial Technology: In The Insurance Industry As An Example. In Proceedings of the 2018 International Conference on Big Data Engineering and Technology (BDET 2018). ACM, New York, NY, USA, 31-35.