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A Forecast of the Number of Labor Force in Chinese Construction Industry under the Influence of the COVID-19

Lian Li, Wenfang Sun, Qifa Jiang

International Business School, Yunnan University of Finance and Economics, Kunming, 650221, China

Abstract

In 2020, the Coronavirus Disease 2019 (COVID-19) swept the world, causing a significant negative impact on the global economy, and affecting the development of China's construction industry as well. Scientific prediction of labor demand in China's construction industry is conducive to the implementation of the "Fourteenth Five-Year Plan" and the formulation of corresponding supporting policies. Using the grey system theory, the G,M(1,1) prediction model is applied to forecast the total output and its labor productivity of construction from 2021 to 2025 based on the corresponding data in China from 2011 to 2020, and estimate the demand value of construction industry employees from 2021 to 2025. The forecast results show that the demand for construction workers is rising steadily in the following years. After testifying the model, the accuracy is up to 99.9% when using the G,M(1,1) prediction model to predict the number of employees in the construction industry, and the prediction level of the model is reliable as being Excellent. Finally, two hypotheses are set that, due to the national economic stimulus policies such as New Infrastructure and Double Cycles, the total output of construction industry will increase by 5% and 10% on the basis of the original forecast results, and the demand for construction industry employees will reach 79,962,000 and 83,769,700 in 2025, respectively. The construction industry demands a large number of labors. In order to promote the development of the construction industry, smart policies should be implemented such as strengthening the epidemic prevention measures, improving the quality of construction workers, accelerating the reform of social security and economic security, etc.

Keywords

Construction Industry; Labor Force; Grey System Theory; G,M (1,1) Prediction Model.

1. Introduction

As a pillar industry of China's national economy, the construction industry accounts for a high proportion of its economic added value, with a large number of employees and a large contribution to employment. According to the data of the National Bureau of Statistics , the added value of the construction industry in 2020 was 7.29957 trillion yuan, accounting for 7.18% of the total GDP; the total output value was 24.844327 trillion yuan; the number of employees in construction enterprises reached 53.6692 million, accounting for the proportion of national employment. 7.15%. The huge scale and benefits of the construction industry provide strong support for China's urban and rural economic development.

The coronavirus pandemic (COVID-19), which has ravaged the world in 2020 , has devastated the global economy. The Chinese economy is no exception. According to data from the National Bureau of Statistics, preliminary calculations show that the gross domestic product (GDP) in 2020 will be 101.6 trillion yuan , an increase of 2.3% over the previous year at comparable prices . This economic growth rate is the lowest since China's reform and opening up in 1978 .

Under the influence of the epidemic, the demand for employment was suppressed, the resumption of employment was hindered, and career risks increased; although the epidemic mainly occurred in cities, the impact on rural employees was more prominent, especially migrant workers [1] .

Among the large-scale migrant workers, the construction industry accounts for a large proportion . From 2011 to 2014, the proportion of migrant workers engaged in the construction industry in the total number of migrant workers increased year by year, reaching a peak of 22.3% in 2014; 18.3%, as shown in Table 1.

Table 1. Proportion of construction workers among migrant workers

Years	2011	2 012	2 013	2 014	2 015	2 016	2 017	2 018	2 019	2020
Construction industry share /%	1.77	1.84	2 2.2	2 2.3	2 1.1	1 9.7	1 8.9	1 8.6	1 8.7	18.3

Source: Compiled from the "China Migrant Workers Monitoring and Investigation Report" from 20011 to 2020.

Given the important role of the construction industry in the national economy, investment in recessions, especially in public projects, once again played an important leverage role. In the spring of 2020 , China launched the "New Infrastructure Construction (New Infrastructure)" plan [2] , and decided to build a new development pattern of "domestic and international dual circulation promoting each other and domestic circulation as the main". According to the fact that the economic and social development of western China lags behind that of the central and eastern regions, the Chinese government has also decided to promote the development of the western region in the new era to form a new pattern. There are various indications that the Chinese government intends to make large-scale infrastructure investment in China, especially in the western region of China, to promote employment, stimulate economic growth, bridge the economic development gap between regions, and at the same time lay a solid foundation for China's future development.

In this case, it is very important to predict the overall development trend of China's construction industry, especially the demand for construction workers. The forecast of labor demand in the construction industry can provide decision-making basis for the flow, distribution and migration of employees, provide reference for industrial development forecast, and provide ideas for the next step of industrial upgrading and transformation. implement.

However, predicting the number of construction workers in the years ahead is not easy. The main reasons are the lack of relevant data and the rapid economic and social changes. On the one hand, the number of labor force in China's construction industry has not been continuously counted for a long time. On the other hand, China's economic and social development is too rapid, which makes factors such as labor productivity and resource prices rise rapidly, thus magnifying the difficulty of forecasting.

by scholars at home and abroad since it was put forward, and it has been applied to solve specific problems . The grey system is distinguished from the traditional white system (completely known information) and black system (completely unknown information), and considers that there are both white parts and black parts in the system (that is, the existence of information is partially known and partially unknown) . When studying real economic and social problems , it is difficult for us to collect all the information, but it is not completely unknown . Usually, we can only collect part of the information, according to which the socio-economic system can be regarded as a gray system. The gray system is mainly used in evaluation, decision-making, control, prediction, etc. Among them, the gray prediction model is the most widely used . The biggest advantage of using the gray system for forecasting is that the data requirements are low. The gray model of "small sample and poor data" is a very good application model for the research that is difficult to collect data in reality [3] . This kind of prediction model is based on the function of sequence operators, which can be predicted with very little data, and the prediction accuracy is high, which is favored by scholars.

Grey system theory is a mathematical method used to solve the incompleteness of system information. It applies cybernetics and research methods to complex systems, and combines the relevant knowledge of operations research with its unique effective methods and means to study It solves the gray problems that are difficult to solve in real life [4] . Grey prediction can make more accurate scientific predictions on the basis of small samples and less data, and solves the defect of insufficient data collection. When forecasting the building economic system, due to the lack of data and the lack of samples, it is very consistent with the characteristics of the gray system. Therefore, the grey forecasting model can be used to forecast the demand of migrant workers in the construction industry.

The creation of the grey system was published in 1982 by Chinese scholar Professor Deng Julong in " Control Problems of grey systems " published in the journal " Systems & Control Letters "published by North Holland Publishing Company and published in "Journal of Huazhong University of Technology" Start [5][6] on the "Gray Control System" . The basic research on gray system mainly includes gray number operation, sequence operator and gray sequence generation, and the applied research includes gray prediction model, gray correlation analysis, gray cluster evaluation model, gray decision model and gray combination model [7] . Among them, the gray prediction model is one of the most studied and widely used gray system models. Xie Naiming et al first proposed the discrete GM(1,1) model and studied its properties [4] . Liu Sifeng et al. used simulation experiments to determine four basic models of GM (1,1) , namely the mean GM (1,1) model (EGM), the discrete GM (1,1) model (DGM), and the mean difference GM (1 ,1) model (EDGM) and original differential GM (1,1) model (ODGM), and clarified the sequence types applicable to different models [8] .

Regarding the application of the grey forecasting model in population forecasting, Yang Binfeng used the grey system GM(1,1) model to forecast the population of Shangluo [9] ; Wu Qiong et al. forecasted the population of Shaanxi Province [10] ; Yang Qingsheng predicted the population of Guangzhou The population of Suzhou City was predicted [11] ; Gao Fengwei et al. predicted the population of Suzhou City [12] . It can be seen that the gray forecasting model is widely used in population forecasting, and its forecasting accuracy is also high.

2. G, M(1, 1)Basic Principles and Steps of Grey Forecasting Model

2.1. Fundamental

G, M(1,1)The model is the most widely used type of gray prediction model. The model adopts the form of differential and difference equations, and its parameters and structure can be predicted according to a small amount of known data [13] . G, M(1,1)The gray prediction model is composed of a single-variable first-order differential equation. It generates the original sequence data, finds the law in the complex and disordered data, and then establishes the differential equation to predict the data [14] .

2.2. Step

2.2.1. Determine if Modeling is Feasible

(1) given raw data

$$X^{(0)} = \left(x^{(0)}(1),\ x^{(0)}(2),\ x^{(0)}(3), \dots, x^{(0)}(n)\right) \tag{1}$$

(2) Calculate the order ratio of the sequence

$$\lambda^{(0)}(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, \mathrm{k} = 2,3, \dots, \mathrm{n}. \quad (2)$$

get the sequence

$$\lambda^{(0)}(k) = \left(\lambda^{(0)}(2),\ \lambda^{(0)}(3),\ \dots, \lambda^{(0)}(n)\right) \quad (3)$$

(3) judged $\lambda^{(0)}(k)$whether it is within the interval $\left(e^{-\frac{2}{n+1}},\ e^{\frac{2}{n+1}}\right)$. If most of the ratios are within the interval, the G, M(1,1)model can be used for the sequence. Otherwise, the original data needs to be preprocessed.

2.2.2. Select Original Array

$$X^{(0)}(k) = \left(x^{(0)}(1),\ x^{(0)}(2),\ x^{(0)}(3), \dots, x^{(0)}(n)\right) \quad (4)$$

2.2.3. Generate New Series

Generate a sequence by one accumulation $X^{(1)}(k)$, where

$$X^{(1)}(1) = X^{(0)}(1)$$
$$X^{(1)}(k) = \sum_{t=1}^{k} x^{(0)}(t) \quad (5)$$

2.2.4. Build G, M(1, 1)Predictive Models

(1) established $X^{(1)}(k)$next-to-average mean generation sequence

$$Z^{(1)}(k) = \left(z^{(1)}(2),\ z^{(1)}(3), \dots, z^{(1)}(n)\right) \quad (6)$$

in,

$$Z^{(1)}(k) = \frac{1}{2}\left(x^{(1)}(k) + x^{(1)}(k-1)\right), \mathrm{k} = 2,3, \dots, \mathrm{n}. \quad (7)$$

(2) established G, M(1,1), and its differential equation is:

$$\frac{dx^{(1)}}{dt} + \mathrm{a}x^{(1)} = b \quad (8)$$

Among them, a is the development gray number, and b is the endogenous control gray number. make

$$Y_n = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{pmatrix} \quad (9)$$

$\hat{u}$vector $\hat{u} = \binom{a}{b}$to be estimated,

make

$$B = \begin{bmatrix} -z^{(1)}(2), & 1 \\ -z^{(1)}(3), & 1 \\ \vdots & \vdots \\ -z^{(1)}(n), & 1 \end{bmatrix} \quad (10)$$

Therefore, the model can be expressed as:

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$$Y_n = B\hat{u} \tag{11}$$

Solve using the least squares method $\hat{u}$,

$$\hat{u} = (B^T B)^{-1} B^T Y_n \tag{12}$$

Solving differential equation (8) , we get:

$$\hat{x}^{(1)}(t+1) = \left(x^{(0)}(1) - \frac{b}{a}\right) e^{-at} + \frac{b}{a}, t = 0,1,2, \ldots n - \tag{13}$$

Among them, $\hat{x}^{(1)}(t+1)$is the accumulated predicted value obtained, which can be restored by one accumulation:

$$\hat{x}^{(0)}(t+1) = \hat{x}^{(1)}(t+1) - \hat{x}^{(1)}(t) \tag{14}$$

It should be noted that if the data has been preprocessed, it needs to be restored by corresponding transformation.

2.2.5. Model Checking

The test of gray prediction model generally includes residual test and posterior difference test .
(1) residual test
residual $\Delta^{(0)}(t)$is the absolute difference between the predicted value and the actual value, expressed as:

$$\Delta^{(0)}(t) = \left|\hat{x}^{(0)}(t) - x^{(0)}(t)\right| \tag{15}$$

relative error $\varepsilon(t)$is the ratio of the residual to the actual value, expressed as:

$$\varepsilon(t) = \frac{\Delta^{(0)}(t)}{x^{(0)}(t)} \tag{16}$$

Modeling accuracy is required $p^* > 80\%$, optimal $p^* > 90\%$, where $p^* = \left(1 - \varepsilon(avg)\right) * 100\%$.
(2) Posterior difference test
Calculate the standard deviation of the original series and the standard deviation $S_1$of the residual series S_2, where,

$$S_1 = \sqrt{\frac{\sum\left[x^{(0)}(t) - \bar{x}^{(0)}\right]^2}{n-1}}, S_2 = \sqrt{\frac{\sum\left[\Delta^{(0)}(t) - \bar{\Delta}^{(0)}\right]^2}{n-1}} \tag{17}$$

Calculate the posterior difference ratio $C = \frac{S_2}{S_1}$. The Csmaller the ratio, the better the model. The small error probability $P = P\left\{\left|\Delta^{(0)}(t) - \Delta^{(0)}\right| < 0.6745 S_1\right\}$, the posterior difference ratio Cand the small error probability Paccuracy test grade standard are shown in Table 2.

Table 2. Standard table of precision test grades for the ratio of small error probability and posterior difference ratio

Inspection index	Excellent	Good	Middle	Difference
p	> 0.9	> 0.8	> 0.7	≤ 0.7
c	< 0.35	< 0.5	< 0.65	≥ 0.65

2.2.6. Data Forecast

Data prediction can only be carried out after the model passes the test, otherwise, model correction is required.

3. Based G, M(1, 1) Forecasting Analysis of the Number of Employees in the Construction Industry

3.1. Prediction of the Gross Output Value of the Construction Industry

3.1.1. Data Selection

According to the total output value of the construction industry released by the National Bureau of Statistics, the data for the ten years from 2011 to 2020 are selected, as shown in Table 3. The data meets the characteristics of "small sample" and "poor data" of the gray prediction model, so the G, M(1,1) gray prediction model is used to predict the number of employees in the construction industry.

Table 3. 2011-2020 The total output value of the construction industry

Years	Gross output value of construction industry/100 million yuan
2011	116463.32
2012	137217.86
2013	160366.06
2014	176713.42
2015	180757.47
2016	193566.78
2017	213943.56
2018	225816.86
2019	248443.27
2020	263947.04

Source: Based on the total output value of the construction industry released by the National Bureau of Statistics from 2011 to 2020 .

3.1.2. Predictive Analytics

The prediction data obtained by one-time accumulation prediction equation is calculated, and the prediction data obtained by one-time accumulation and subtraction are shown in Table 4.

Table 4. 2021-2025 forecast construction industry output value forecast (100 million yuan)

Years	2021	2022	2023	2024	2025
Number	286006.6 3	308369.2 2	332480.31	358476.63	386505.5 8

3.2. Labour Productivity Forecast

3.2.1. Data Selection

According to the labor productivity calculated by the total output value of the construction industry released by the National Bureau of Statistics, the specific data from 2011 to 2020 was selected as the sample data, as shown in Table 5. The data meet the characteristics of "small

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sample" and "poor data" of the grey forecasting model. Therefore, the G, M(1,1)grey forecasting model is used to forecast the quantity of labor demand.

Table 5. Labor Productivity by Gross Output Value of Construction Industry, 2011-2020

Years	Labor productivity calculated by gross output value /(yuan /person)
2011	233104
2012	296424
2013	324842
2014	317633
2015	324026
2016	336991
2017	347963
2018	373193
2019	399674
2020	422906

3.2.2. Predictive Analytics

The prediction data obtained by one-time accumulation prediction equation is calculated, and the prediction data obtained by one-time accumulation and subtraction are shown in Table 6.

Table 6. Forecasts of labor productivity by gross construction output, 2021-2025(yuan/person)

Years	2021	2022	2023	2024	2025
Number	428654.08	447142.0 8	466427.46	486544.63	507529.46

3.2.3. Forecast of the Number of Employees in the Construction Industry

According to the forecast of the total output value of the construction industry in Table 4 and Table 6 and the forecast of labor productivity calculated by the total output value of the construction industry, the forecast value of the number of employees in the construction industry can be calculated. As shown in Table 7. It can be seen from the table that the number of employees in the construction industry is increasing year by year, and the demand will reach 76.1543 million by 2025.

Table 7. Forecast of the number of employees in the construction industry

Years	2021	2022	2023	2024	2025
Number	6672.20	6896.45	7128.23	736 7.80	7615 43

4. Discuss

In 2020, as the novel coronavirus swept the world, the Chinese government adopted a strict quarantine policy and restricted the movement of people to protect the personal safety of its citizens, resulting in a slowdown in economic growth. In order to overcome the slowdown in economic growth, in 2020, the Chinese government proposed to expand effective investment and focus on supporting "two new and one heavy" . The main tasks include strengthening the construction of new infrastructure , strengthening the construction of new urbanization , and vigorously improving the public facilities and service capabilities of county towns to adapt to The increasing demand of farmers to find jobs and settle down in the county towns, newly started the renovation of 39,000 old urban communities, and increased the national railway construction capital by 100 billion yuan and other measures [15] . Under the background of new infrastructure and dual circulation pattern , the state's investment in the construction industry has increased, which has a positive role in promoting the development of the construction industry. Therefore, in the next five years, in order to overcome the adverse impact of the new crown epidemic on economic growth , based on the multiple advantages of new infrastructure , dual-cycle pattern and the development of the western region in the new era , it is assumed that the total output value of the construction industry from 2021 to 2025 will be based on the original forecast. Predict the number of demand for the number of construction workers in the case of an increase of 5%. Based on the original forecast of the total output value of the construction industry (Table 4), let:

Assumption H1: The total output value of the construction industry will increase by 5%.

Table 8. Prediction of the number of employees in the construction industry under assumption 1

Years	The total output value / billion	Employees/10,000people
2021	300306.96	7005.81
2022	323787.68	7241.27
2023	349104.33	7484.64
2024	376400.46	7736.20
2025	405830.86	7996.20

5. Conclusion and Suggestion

Using the gray system G,M(1,1) prediction model to predict the number of employees in the construction industry, in the case of "small sample" and "poor data", it can achieve a high-precision prediction effect. It can be seen from the predicted results that the demand for construction workers is steadily increasing, and the construction industry is still and will continue to be a pillar industry for the employment of rural migrant workers. Affected by the new crown epidemic in 2020 , China's economy has been greatly affected by the economy. The state adopts economic stimulus policies such as " new infrastructure " and " dual circulation " to promote economic recovery. With the support of these economic policies, the construction industry will have good development prospects in the next five years. Therefore, this paper assumes that the total output value of the construction industry increases by 5% and 10% on the basis of the original forecast value , and then calculates the number of employees in the construction industry, which provides a certain reference for the future development of the construction industry.

It can be seen from the forecast results that the demand for construction workers is increasing year by year. By 2025, the demand for construction workers will reach 76.1543 million. Taking into account a series of economic stimulus policies launched by the state, assuming that the total output value of the construction industry will increase by 5% and 10% respectively on the basis of the original forecast value , the demand for employees in the construction industry is even more considerable. Under Assumption 1, the demand for construction employees will reach 79.962 million, and under Assumption 2, the demand for construction employees will reach 83.7697 million. Compared with the number of employees in the construction industry in 2020, these three situations increased by 13.7416 million, 17.5493 million and 21.3570 million respectively . In the next five years, the demand for employees in the construction industry will continue to increase, providing a large number of jobs for job seekers, and the development of the construction industry will make a greater contribution to the employment of the whole society .

The above forecast data already takes into account the increase in labor productivity caused by technological progress. It can be seen that in order to better promote the development of the construction industry, it is necessary to solve the key problem of the increasing demand for construction employees during the "14th Five-Year Plan" period. Based on this, the following recommendations are made:

First, strengthen epidemic prevention and control measures to minimize the negative impact of the epidemic on life and production.

Second, improve the professional quality of employees in the construction industry. Carry out production training for construction employees, and accelerate the professionalization process so that construction employees, especially construction migrant workers, can be transformed into real industrial workers as soon as possible, so as to improve production safety awareness and accelerate the improvement of labor productivity in the construction industry.

Third, speed up the reform of the social security and economic security system, strengthen the social security level of construction workers to attract more talents to engage in the construction industry, and at the same time implement policies to protect migrant workers and protect their legitimate rights and interests.

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References

[1] X. B. Qu, J. Cheng: The Impact of the New Crown Pneumonia Epidemic on the Labor Market and Policy Responses, Journal of Hebei Normal University (Philosophy and Social Sciences Edition), Vol. 04(2020) No.43, p.126-133. (In Chinese).

[2] L. D. Qin: New Infrastructure is Coming, Oriental Outlook Weekly, Vol. 09(2020), p.01-04. (In Chinese).

[3] S. F. Liu, Y.G. Yang and L.F. Wu: Grey System Theory and Its Application 7th (Science Press, China 2014).

[4] S. F. Liu, Y.G. Yang: Research Progress of Grey Systems (2004-2014), Journal of Nanjing University of Aeronautics and Astronautics, Vol. 01(2015) No.47, p.1-18. (In Chinese).

[5] H. M. Liu, S.H. Fan: Prediction and Analysis of Tourism Reception Number in Guangzhou Based on Grey System Theory, Statistics and Decision-Making, Vol. 17(2010), p.64-66. (In Chinese).

[6] J. L. Deng: Control Problems of Grey Systems, Systems & Control Letters, Vol. 05(1982) No.01, p.288-294. (In Chinese).

[7] J. L. Deng: Grey Control System, Journal of Huazhong University of Science and Technology, Vol. 03(1982), p.9-18. (In Chinese).

[8] S.F. Liu: Modeling Mechanism of Discrete GM (1,1) Model and Grey Prediction Model, Systems Engineering Theory and Practice, Vol. 01(2005) No.25, p.93-99. (In Chinese).

[9] S.F. Liu, B. Zeng, J.F. Liu: Research on Several Basic Forms of GM (1,1) Model and Its Scope of Application, Systems Engineering and Electronic Technology, Vol. 03(2014) No.36, p.501-508. (In Chinese).

[10] B. F. Yang: Population Prediction of Shangluo City Based on Grey System Prediction GM (1,1) Model, Journal of Shangluo University, Vol. 02(2018) No.32, p.23-26. (In Chinese).

[11] Q. Wu, Y.D. Chen, L.Y. Qin: GM (1,1) Model and Its Application in Population Forecasting in Shaanxi Province, China Management Information, Vol. 03(2015) No18, p.156-158. (In Chinese).

[12] F.g. Gao, Y.H. Li: Suzhou Population Forecast Based on Grey GM (1,1) Mode, Journal of Jiamusi University (Natural Science Edition), Vol. 04(2016) No.34, p.614-616. (In Chinese).

ISSN: 2688-9323

[13] J. L. Deng: Grey System Theory and Its Application, (Science and Technology Literature Publishing House, China 1992).

[14] J. L. Deng: Grey Prediction and Grey Decision Making, (Huazhong Science and Technology Press, China 2002).

[15] http://www.xinhuanet.com.