

# Impact of COVID-19 on the Big Industrial Enterprises in Hebei, China: Grey Forecast Perspective

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**Abstract:** To analyze the impact of COVID-19 on the big industry enterprise in Hebei, a province of China, value added of the industrial enterprises 'above designated size' in Hebei Province is predicted by grey forecasting model GM (1,1). The difference between the predicted value and the actual value implied the influence. The study found that the impact of the epidemic is relatively serious in January-February 2020. The industrial value added has a difference of 27.6 billion Yuan. It is recommended that some tax reliefs should be given to the industries above designated size.

**Keywords:** COVID-19; grey forecast; grey model; industry; Hebei Province.

## 1. Introduction

The COVID-19 not only came up as a healthcare crisis it also brought havocs on national and regional economies. Caraka *et al.* (2020) studied the impact of the COVID-19 on Indonesian economy. Xu *et al.* (2021) studied its impact on performance of fourteen major Chinese ports. Setyoko and Kurniasih (2022) studied its impact on small and medium enterprises in Indonesia. The problem is today well-known however a major gap in the literature is finding solution. Gu *et al.* (2020) guided the industries in responding to the COVID-19 pandemic-induced disruptions. The role of industrial enterprises above designated size in driving the economy is quite obvious, and local governments attach great importance to these enterprises. An important question in this context is how much influence does the COVID-19 on industries above the designated size? Also, there are different methodologies that can be used in our quest to find answer to this solution however which one should be deemed fit?

Because of the COVID-19 induced-economic disruptions, the influence data of the epidemic on industries are limited. Traditional statistical methods cannot analyze the influence because the distribution of the influence data is unknown. Grey forecasting model can deal with the problem with the limited data (Wu *et al.*, 2022; Tian *et al.*, 2021; Ofosu-Adarkwa *et al.* 2020). Thus, grey forecasting model had been used to analyze the influence of the COVID-19 epidemic on industries (Şahin & Şahin, 2020; Liu *et al.*, 2020). If the COVID-19 epidemic does not have influence on industries, the value added of industries is supposed to continue the trend historically. This trend often follows the grey exponent law (Zeng *et al.*, 2015). Because of the COVID-19 epidemic-induced disruptions, one may argue that the actual data does not follow the grey exponent law. The

difference between the predictive value and the actual data indicates the influence of COVID-19 epidemic on industries. Therefore, there is a need to predict the value added of industries using a suitable grey model while studying the difference between the predictive value and the actual data. With the sudden outbreak of the COVID-19 epidemic in 2020, it has a certain impact on the regional economy and industry (Wu *et al.*, 2021). Also, its impact on economic development and production activities in Hebei Province was no small. Considering the insignificant amount work on studying the influence of the pandemic on the regional industrial enterprises, the current study will conduct quantitative assessment and analysis of the influence of the COVID-19 epidemic on industries above the designated size in Hebei Province.

The rest of the study is organized as. In the second section, the research methodology is presented. In this section firstly data is presented and then the grey forecasting model GM (1,1) and the assumptions are introduced. In the third section, the forecasting model is applied on real-world data. Firstly, the model GM (1,1) is established. Later, the value added of the Hebei industries is predicted followed by the comparison between actual and predicted values. In the last section, the study has been concluded.

## 2. Methodology

### 2.1 Data collection

The data was collected from Hebei Provincial Bureau of Statistics (<http://tjj.hebei.gov.cn/>). The statistical data of the value added of industries above designated size in Hebei Province from 2016 to 2020 are shown in Table 1.

### 2.2 Forecasting model and assumption

The current study used the grey forecasting model GM (1,1) for predicting the data. GM (1,1) is the most famous grey forecasting model and it has seen applications in various fields. The complete details of the model can be found in Liu *et al.* (2017). The following assumptions are given: It is assumed that during and after the epidemic of the COVID-19 in Hebei Province, the changes of data are only related to the impact of the COVID-19 epidemic, and the influence of other random factors is not considered.

### 2.3 Forecast error measurement

Absolute percentage error (Duan & Nie, 2022) will be used to compare predicted values with the actual values,

**Table 1.** The value added of industries above designated size in Hebei Province from 2016 to 2020 against twelve months (Unit: 100 million Yuan)

	2016	2017	2018	2019	2020
1-2	1641.8	1691.1	1721.5	1843.8	1670.5
3	1067.8	1123.3	1150.3	1283.7	1322.2
4	960.7	1015.5	1069.3	1126.0	1184.5
5	1017.1	1063.9	1100.1	1172.7	1253.6
6	1199.7	1269.3	1315.0	1451.8	1505.5
7	1095.7	1116.5	1137.7	1196.9	1263.9
8	1117.5	1135.4	1176.3	1222.1	1300.4
9	1221.5	1232.5	1327.4	1376.5	1477.0
10	1176.6	1180.1	1300.5	1273.2	1400.5
11	1157.8	1164.7	1271.9	1301.1	1414.3
12	1126.5	1176.1	1271.4	1340.0	1488.8
Total	12782.8	13168.4	13841.3	14587.7	15281.1

$$APE(\%) = \sum_{k=1}^n \left| \frac{x(k) - \hat{x}(k)}{x(k)} \right| \times 100$$

where,  $x(k)$  and  $\hat{x}(k)$  are actual and predicted values, respectively.

### 3. Results

In this section the grey forecasting model will be built firstly and the results will be analyzed later.

#### 3.1 Establishing the grey model GM(1,1)

- (1) Initialize the modeling original sequence:

$$1162.07, 1197.13, 1258.30, 1326.16$$

- (2) The 1-AGO generation of the original sequence is as follows:

$$1162.070, 2359.200, 3617.500, 4943.660$$

- (3) The immediate mean generation sequence of 1-AGO generation sequence is as follows:

$$1760.635, 2988.350, 4280.580$$

- (4) Calculate the grey model development coefficient  $a$  and the grey action quantity  $b$ :

$$a = -0.05; \quad b = 1106.38$$

- (5) Simulation value and simulation error are as follows:

Serial numbers	Actual data	Analog data	Residual	Relative simulation error
2	1197.13	1196.27	0.86	0.07%
3	1258.30	1259.13	-0.83	0.07%
4	1326.16	1325.30	0.86	0.07%

- (6) Calculate the average simulation relative error: 0.07%

- (7) Predict the value for the next 1 year: 1394.94.

#### 3.2 Forecasting results of industrial value added

According to the prediction of the grey data model, it can be concluded that the monthly average value of value added of industries above designated size in Hebei Province in 2020 is  $X_{2020} = 1394.94$ , and the annual total value is  $X_{2020} = 11 * X_{2020} = 15344.34$ .

According to the average method of the original data, the monthly ratio is

$$u = (0.1269, 0.0850, 0.0767, 0.0801, 0.0963, 0.0836, 0.0855, 0.0948, 0.0907, 0.0900, 0.0904)$$

Therefore, the predicted value added of the industry in 2020 is

$Y = u X_{2020} = (1946.5, 1305.0, 1177.1, 1228.5, 1477.4, 1283.0, 1312.5, 1455.4, 1391.2, 1381.3, 1386.6)$  (100 million Yuan).

#### 3.3 Comparison between predicted value and actual value

Comparison of the predicted value with the actual value is shown in Table 2. According to the prediction results of the model, The Absolute Percentage Error in January-February is the largest, as shown in Table 2. There is a large difference between the predicted value and the actual value in January-February 2020. It can be seen that the impact of the epidemic is relatively serious. Since

**Table 2.** Comparison between predicted and actual value of industrial growth above designated size in Hebei in 2020 (Unit: 100 million Yuan)

Month	Actual value	Predicted value	Absolute Percentage Error
1-2	1670.5	1946.5	16.52
3	1322.2	1305.0	1.301
4	1184.5	1177.1	0.625
5	1253.6	1228.5	2.002
6	1505.5	1477.4	1.866
7	1263.9	1283.0	1.511
8	1300.4	1312.5	0.930
9	1477.0	1455.4	1.462
10	1400.5	1391.2	0.664
11	1414.3	1381.3	2.333
12	1488.8	1386.6	6.865

March, with the epidemic gradually controlled and the full resumption of production and work, the impact on industries above designated size has been reduced. Compared with tourism and retail industry, the COVID-19 epidemic has little impact on industries above designated size.

#### 4. Conclusion

The study noted a large difference between the predicted and the actual value. It was observed that the impact of the epidemic is relatively serious in January-February 2020. The industrial value added has a difference of 27.6 billion Yuan. Since March, as the epidemic is gradually brought under control and the production and work activities fully resume, the impact of the epidemic on industries above designated size has been reduced. The policy-makers are suggested to bestow tax relief to the industries above designated size to some extent. Analysing the impact of the epidemic on other economic indicators is our future research directions.

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