Impact of the covid-19 on China's economy

Yubo Wang

Shandong University of China

Abstract. What is the impact of the COVID-19 on China's economy? After using the linear regression to analyze the data of GDP, national fiscal revenue and the added value of nine major industries, we find that the COVID-19 had a great impact on China's economy in 2020 but not in 2021. Then, we use the principal component analysis to reduce the dimension of data and define a new variable to represent China's economy, which is called "Chinese economic quantity". It can well describe China's economy, which has the same function as GDP. By comparing its changes in different years, it can verify the influence on China's economy. Finally, some suggestions and advices will be given.

Key words: Mathematical statistics, linear regression.

1. Introduction

In 2020, the COVID-19 epidemic has impacted the economies of all countries in the world, and China has not been spared. On the evening of January 30, 2020, the World Health Organization (WHO) announced the COVID-19 epidemic as a Public Health Emergency of International Concern. Some countries evacuated their nationals from Wuhan, and some suspended flights with China. The COVID-19 epidemic disaster has caused widespread concern among governments and people around the world. Nowadays, COVID-19 patients have appeared in more than 200 countries and regions. By 7 p.m. on July 24, 2022(Beijing time), in China, there were 4,939,904 con-firmed cases nationwide, and 23,072 deaths; and in the world, there were 566,984,025 confirmed cases and 6,375,438 deaths. [1]

Novel coronavirus has the characteristics of strong camouflage, long incubation period, high variability and diverse transmission routes. Although vaccination works have been completed in China, it is still impossible to contain its outbreak in China in many cases. Since the whole population of China started vaccination in early 2021, there have been many large and small outbreaks all over the country, including a most serious Shanghai outbreak at the beginning of 2022. It can be seen that the COVID-19 epidemic still has a huge negative impact on China.

How big is the impact of the COVID-19 on Chinese economy? With the active role of the Chinese government, what is the degree of economic recovery in China? In this article, with curiosity about Chinese economy, we will explore the changes of Chinese economy under the influence of the COVID-19.

By analyzing the data of Chinese economy these years, this paper comprehensively considers the impact of the COVID-19 on Chinese economy including GDP, added value of nine industries, national revenue and so on, obtains the conclusion of the impact of the COVID-19 on them, and forecasts Chinese economic situation in the near future.

The following part will focus on literature review, methodology, data analysis, conclusion, and reference.

2. Literature Review

According to the National Economic Industry Classification issued by the National Bureau of Statistics, the industry is divided into five major industrial sectors, including agriculture, industry, construction, transportation and service industries (wholesale and retail, accommodation and catering, finance, real estate, etc.). The influence of COVID-19 on various industries has been studied by predecessors [2]. They use CGE model to analyze the disaster scenario, evaluate the comprehensive economic losses caused by COVID-19 in China according to the existing data, calculate the direct impact, comprehensive economic loss rate and absolute economic losses of various industries, and predict the GDP growth rate in 2020. It is not unique that another paper [3] mainly studies the impact of the COVID-19 on GDP and trade.

In addition, an article also focuses on the relevant policies of the Chinese government [4]. There is also an article [5] that similarly expounds the impact of the epidemic on the global economy and some policies and measures. The two papers pay more attention to the policies and measures of different countries but little data processing.

Some articles study the indirect impact of the epidemic on China's economy from more specific aspects, such as oil

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

prices and Urbanization Pattern. In the first paper **[6]**, the CEEEA/CGE model is used to analyze the impact of two major events: the COVID-19 epidemic and the international oil price plunge. It analyzes the influence of COVID-19 from two aspects: the consumption side and the supply side, and studies the influence of epidemic situation and price slump on China's economy and carbon emissions. In another paper **[7]**, It analyzed the indirect impact of the epidemic on China's economy by studying the urbanization mode of Wuhan, Hubei Province, combined with the data evaluation of the epidemic at that time, and put forward some valuable suggestions in this aspect. They both attach importance to the indirect impact of COVID-19 on Chinese economy.

To sum up, different from the above papers, this article will explore the direct impact of the epidemic on China's GDP, China's fiscal revenue and the added value of nine major industries, and put forward valuable suggestions to the Chinese government.

3. Methodology

3.1 Overview of methods

Principal component analysis (PCA) was put forward by Hotelling in 1933. It is a multivariate statistical analysis method that transforms multiple indexes into several comprehensive indexes by means of dimension reduction. Its main purpose is to explain most of the information of the original data with fewer variables.

Let X_1,..., X_m, be random variables of the observed values of the samples. If c_1,..., c_n can be found, the value of the following formula will reach the maximum, indicating the maximum difference of these m variables. Set F_i as the ith principal component, and F_i=$c_{i1}x_1$+...+$c_{im}x_m$, and find the vertical vector c_i to get all m principal components. In the research, in order to reduce the dimension, we usually select a small number of principal components, as long as the cumulative contribution rate reaches more than 85%.

Linear regression is a statistical analysis method that uses regression analysis in mathematical statistics to determine the quantitative relationship between two or more variables, and it is widely used. Regression analysis only includes one independent variable and one dependent variable, and the relationship between them can be approximated by a straight line, which is called univariate linear regression analysis.

The correlation coefficient is a coefficient that can judge the correlation degree of data, and it is usually taken as r. r>0 is positive correlation; r<0 is negative correlation.

a) If |r|≥0.8, it can be considered that the two variables are highly correlated;
b) If 0.5≤|r|<0.8, it can be considered that the two variables are moderately correlated;
c) If 0.3≤|r|<0.5, it can be considered that the two variables have low correlation;
d) If |r|<0.3, it can be considered that the two variables are basically irrelevant.

After applying linear regression analysis, the function of independent variable y about x will be obtained, so as to predict the data which are unknow.

3.2 The concrete process of the method

We will use linear regression analysis to deal with China's GDP, national fiscal revenue and the added value of various industries from 2012 to 2019 to predict the value in 2020 that would not be affected by the COVID-19. The influence coefficient is defined as follow:

$$Influence\ coefficient = \frac{(predictive\ value - actual\ value)}{actual\ value}$$

It aims to indicate the degree to which an index is affected by the COVID-19.

After that, we use principal component analysis to reduce the dimension of the data, and get first principal component and its nine-element expression. We set first principal component as Chinese economic quantity, and then we get the expressions of Chinese economic quantity about the added value of nine industries. Analyze and calculate the predictive data and actual data of Chinese economy in 2020, and compare them. If the second principal component needs to be analyzed, it is the same as the above method, and the following principal components are analogized.

4. Data Analysis

Looking at the GDP data from 2012 to 2021, we can easily find that the growth rate of other years is almost the same as that of the previous year, except that the growth rate in 2020 is slightly slower than that in 2019. After removing the points after 2020, through linear fitting, we get the expression of GDP about the year as follows:

y=64167.75238t+518936.84167

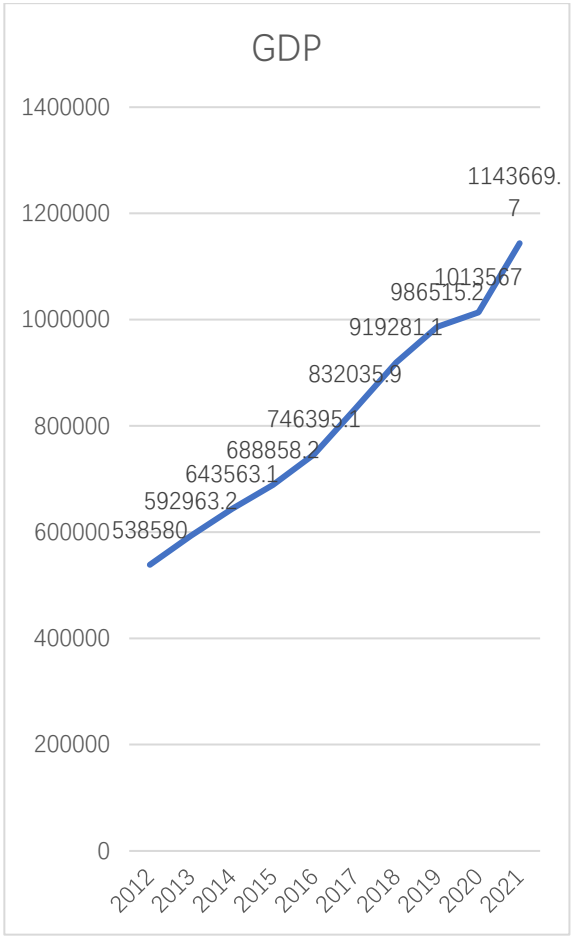

Fig.1 Looking at the GDP data from 2012 to 2021

The parameter y represents the predicted value of GDP, and the parameter t represents the year (t=0 in 2012 and so on). Therefore, we can predict that the GDP of 2020 without COVID-19 is 1,032,278.86, and the affected coefficient of China's GDP in 2020 is 1.812%. Although the figure seems to be small, it has actually changed a lot under the support of such a large base data as GDP. It can be seen that the impact of the epidemic on China's GDP cannot be underestimated.

Tab.1 The fitting function, influence coefficient and correlation coefficient of other indicators are as follows:

Index	Fitting function	Actual value **[8]**	Predictive value	Influence coefficient	correlation coefficient
GDP	y=64167.752t+518936.842	1013567	1032278.86	1.846 %	0.929
national revenue	y=10556.082t+118684.973	182913.88	203133.629	11.054 %	0.890
Added value of agriculture, forestry and fishery (1)	y=2969.8t+50961.325	81396.5	74719.725	-8.203 %	0.873
Industrial added value (2)	y=14889.105t+201997.458	312902.9	321110.3	2.623 %	0.9640
Added value of construction industry (3)	y=4767.789t+35375.425	72444.7	73517.737	1.481 %	0.9936
Added value of wholesale and retail industry (4)	y=6473.158t+49400.208	96086.1	101185.472	5.307 %	0.9952
Added value of transportation, warehousing and postal services (5)	y=2746.023t+23115.658	40582.9	45083.842	11.091 %	0.9980
Added value of accommodation and catering industry (6)	y=1223.91t+9014.75	15285.4	18806.03	23.033 %	0.9979
Added value of financial industry (7)	y=5846.074t+35962.242	83617.7	82730.834	-1.061 %	0.9854
Added value of real estate industry (8)	y=5817.354t+28248.725	73425.3	74787.557	1.855 %	0.9785
Added value of other industries (9)	y=19434.525t+84861.1	237825.3	240337.3	1.056 %	0.9987

Note: The actual and predictive values of the data here refer to 2020, and the numbers in brackets represent which industry. For example, industrial added value is the second industry.

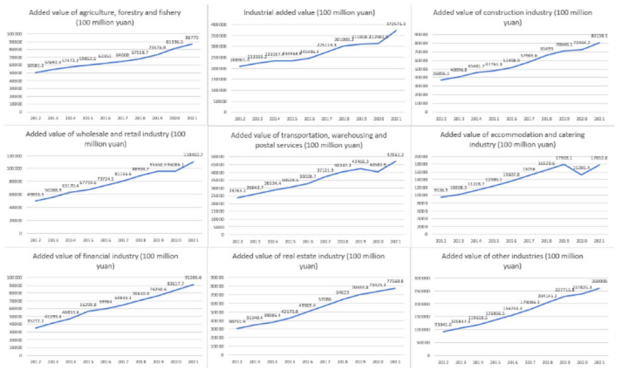

Fig.2 The correlation coefficient between the indicators from 2012 to 2019

By analyzing the data, we found that the correlation coefficient between the indicators from 2012 to 2019 studied here and the year is greater than 0.96, so it is very suitable for linear regression. Among the above indicators, added value of first and seventh industries are almost not affected negatively by COVID-19, and the indicators that

are greatly affected by the COVID-19 are national revenue, added value of fourth fifth and sixth industries, especially the last one. Even though other indicators change relatively little, they also impact China's economy. The most seriously, Chinese national revenue has fallen sharply compared with expectations. Even under the trend of annual growth, the fiscal revenue in 2020 is not as high as that in 2018 and 2019. Therefore, the COVID-19 has a very bad impact on China's fiscal revenue.
Using python for programming, we get the contribution rate of each principal component as follow:

Tab.2 Using python for programming, we get the contribution rate of each principal component as follow:

Principal component rank	1	2	3
Contribution rate	0.9858	0.0119	1.372*10 ^ (-3)
Principal component rank	4	5	6
Contribution rate	7.380*10 ^ (-4)	8.687*10 ^ (-5)	3.929*10 ^ (-5)
Principal component rank	7	8	9
Contribution rate	3.466*10 ^ (-5)	1.623*10 ^ (-6)	8.883*10 ^ (-7)

Tab.3 Using python for programming, we get the contribution rate of each principal component as follow:

The number of the industry	1	2	3	4	5	6	7	8	9
weight	5.6574%	25.5679%	7.3091%	9.6854%	3.8065%	1.4435%	8.9868%	8.4081%	29.1353%

As the contribution rate of the first principal component is 98.58%, far exceeding 85%, first principal component can be analyzed separately. The expression of first principal component can be obtained by calculating the coefficient of first principal component as follows:
$F_1 = 0.1315x_1 + 0.5945x_2 + 0.1699x_3 + 0.2252x_4 + 0.0885x_5 + 0.0336x_6 + 0.2089x_7 + 0.1955x_8 + 0.6774x_9$ ($x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9$ respectively represent the added value of the nine industries)

It can be seen that this expression is weighted sum of the nine random variables, so when the first principal component is larger, it can be inferred that at least one of the nine random variables is larger; On the contrary, when some of the nine random variables are larger, the value of the first principal component is also larger. It is also not difficult to find that GDP is the sum of these nine random variables. This shows that first principal component can represent China's economy on behalf of GDP. We might as well call it "Chinese economic quantity". Calculate the predictive and actual Chinese economic quantity in 2020, which are 427,701.776 and 435,333.077. The influence coefficient of Chinese economic quantity is 1.784%. Comparing influence coefficient of China's GDP with it, we find that they are almost the same. Chinese economic quantity is the weight sum of the added value of nine industries and its contribution rate exceeds 98%. Therefore, Chinese economic level can be better described by Chinese economic quantity. Through this expression, we can also see the proportion of the added value of these nine industries to China's economy, as shown in the following table:

Tab.4 In the similar way, we can calculate the influence coefficient of the data of 2021 as follow:

Index	Actual value [9]	Predictive value	Influence coefficient
GDP	1143669.7	1096446.61	-4.13%
national revenue	202538.88	213689.711	5.51%
Added value of agriculture, forestry and fishery (1)	86775	77689.325	-10.47%
Industrial added value (2)	372575.3	335999.403	-9.82%
Added value of construction industry (3)	80138.5	78285.526	-2.31%
Added value of wholesale and retail industry (4)	110492.7	107658.63	-2.56%
Added value of transportation, warehousing and postal services (5)	47061.2	47829.865	1.63%
Added value of accommodation and catering industry (6)	17852.6	20029.94	12.20%
Added value of financial industry (7)	91205.6	88576.908	-2.88%
Added value of real estate industry (8)	77560.8	80604.911	3.92%
Added value of other industries (9)	260008	259771.825	-0.09%

Note: The actual and predictive values of the data here refer to 2021

It can be seen from the table that the data of 2021 is much better than that of 2020. The added value of the first, second, third, fourth, seventh and ninth industries have exceeded the expected level, and GDP is also higher than expected. However, the added value of the fifth, eighth and ninth industries are lower than the expected level, although their influence coefficients have already decreased. What's more, the situation of the national revenue is still serious. Actual and predictive Chinese economic quantity in 2021 are 486515.585 and 462650.585, whose influence coefficient is -5.158%. Its actual value is obviously higher than the predictive value. The reason is that in 2021, the added value of the industries that accounted for a relatively large proportion of nine industries increased obviously compared with the predictive value, while those didn't increase obviously and those decreased compared with the expected value accounted for a relatively small proportion.

5. Conclusion

5.1 Data conclusion

From the above research, we can get many practical and important conclusions.

In 2020, China's fiscal revenue will be seriously affected. Although the fluctuation of GDP is small, these changes can't be underestimated under a large GDP base. Among the nine added-value industries that make up GDP, added value of accommodation and catering industry, added value of transportation, warehousing and postal services and added value of wholesale and retail industry are greatly affected, while industrial added value, added value of construction industry, added value of real estate industry and added value of other industries are less affected, while Added value of agriculture, forestry and fishery and added value of financial industry are almost immune to the negative impact of the COVID-19. In 2021, although some indicators still have a small gap with the expected value, the economic recovery has basically been completed. Among the nine industries' added value, the sixth and eighth industries still have a gap with the expectation, but it has increased compared with last year, while the fifth industry almost has to catch up with the predictive value, other industries all exceed the predictive value, and even the added value of some industries greatly exceeds the predictive value. Although the national fiscal revenue has increased, it still lags behind the expected value, and the situation seems still dispiriting.

For our newly introduced variables “Chinese economy quantity”, it is based on China's overall data from 2012 to 2021. As the first principal component whose contribution rate is 98.58%, it is beyond doubt its accuracy of China's economic description and the difference between its influence coefficient and GDP is small, which just proves that both of them can describe the Chinese economy well. But in my opinion, due to the data dependence of China's economy quantity, it will be more accurate than the description of GDP.

In conclusion, China’s economic recovery is relatively successful. But there are still some places that need attention.

5.2 Suggestion

First of all, increasing fiscal revenue is imminent. The government should coordinate all department and give full play to their enthusiasm and creativity, so that China's economy can develop continuously and vigorously.

Secondly, from the expression of the China economy quantity, it can be seen that the added value of other industries and the industrial added value account for a relatively large proportion. The government should pay attention to improving the development level of the two industries under the premise of epidemic prevention and control. However, when the epidemic situation is more urgent, the investment in accommodation and catering can be appropriately adjusted, because its added value contributes little to China's economy, while other industries should maintain stable and healthy development.

Last but not least, epidemic prevention and control is very important, and China has played a leading role in this respect for the world. The economic development should be based on the safety of the country and the people. Although the China's fiscal revenue cannot relax its vigilance, we should advocate fiscal expenditure based on epidemic prevention and control.

5.3 The limitation

First of all, the types of economic data processed in this paper are still relatively few, so we can't get a more comprehensive conclusion. Secondly, the mathematical method used in this paper is relatively simple, although it is easy to understand. Moreover, this paper does not quantify the recovery level of China's economy like the influence coefficient, but only makes a qualitative analysis. As for the government's suggestions, we can't give some more specific suggestions, but only the general direction. It is hoped that more people will conduct further research on this basis in the future.

References

1. Data source: National Health Construction Committee of China
2. Tan, L., Wu, X., Guo, J., & Santibanez-Gonzalez, E. D. R. (2021). Assessing the impacts of COVID-19 on the industrial sectors and economy of China. Risk Analysis, 42(1), 21–39. https://doi.org/10.1111/risa.13805
3. Habibi, Z., Habibi, H., & Mohammadi, M. A. (2022). The potential impact of covid-19 on the Chinese GDP, trade, and economy. Economies, 10(4), 73. https://doi.org/10.3390/economies10040073
4. Liu, K. (2021). Covid-19 and the Chinese Economy: Impacts, policy responses and implications. International Review of Applied Economics, 35(2), 308–330. https://doi.org/10.1080/02692171.2021.1876641
5. Shlomo, M. E. B.(2020). The Global Economic Impact of COVID-19: A Summary of Research. Samuel Neaman Institute.
6. Jia, Z., Wen, S., & Lin, B. (2021). The effects and reacts of COVID-19 pandemic and International Oil Price on Energy, economy, and environment in China. Applied Energy, 302, 117612. https://doi.org/10.1016/j.apenergy.2021.117612
7. Yang, W., Wang, X., Zhang, K., & Ke, Z. (2020). Covid-19, Urbanization Pattern and Economic Recovery: An Analysis of Hubei, China. International Journal of Environmental Research and Public Health, 17(24), 9577. https://doi.org/10.3390/ijerph17249577
8. Data source: National Bureau of Statistics of China