The Impact caused by the COVID-19 Pandemic on the Price of Chemical Raw Materials: Take Butyl Acrylate (BA) for Example

Leyao Dong

School of Economics and Finance, Shanghai International Studies University, Shanghai, 200083, China

0231123006@shisu.edu.cn

Abstract. The chemical manufacturing industry was deeply shocked by COVID-19 pandemic in the first half of 2020, however, the price change of chemical raw material didn't present an apparent trend. This paper explores and analyses the situation of chemical raw material market in detail by collecting the weekly price offers for butyl acrylate in East China before and after the outburst of COVID-19 in China. After building an ARIMA model for the price and comparing its prediction with the actual value, it was clearly found the price of chemicals dropped severely because of the pandemic, and conclusion is made that the in-depth reason was the sharp drop of demands in downstream industry, which is also appropriate for most chemicals, especially those related to petrochemical industry. The study highlights its detailed research on the factors related to price fluctuation and the use of ARIMA model for simulating the price under the hypothetical situation with no pandemic happening, which is a new method for researches on chemical industry researches, and it provides subsequent researchers with a more effective perspective comparing with traditional chemical researches using quantitative experiment and comparison. And the study is also referential for policy makers in the government on making market regulation and macroeconomic control, as the interpretation for price change of chemicals in this study is important for all industry workers concerned.

Keywords: COVID-19; butyl acrylate; chemical industry; commodity prices.

1. Introduction

Butyl acrylate is a kind of important organic compound which is widely used as raw material for manufacturing fuels, paints, plastics and many other industrial products. The price change of butyl acrylate has an great impact on purchasing costs of paints and it has tight connection with various chemicals, so butyl acrylate can be considered as a wind vane for part of the chemical raw material market [1].

As a large country in the chemical industry, China's market scale reached 1.7 trillion euros in 2021, and its industrial output value has long ranked first in the world, currently accounting for 43% of global total in 2021. It is expected that the chemical industry of China will be growing rapidly in the following decade, and according to government planning, by 2030 China's chemical industry output value may account for 50% of the world. As 39% of the global output of butyl acrylate locates in China, butyl acrylate is an important chemical raw material in China, and its price change during the COVID-19 pandemic in East China (which has one of the largest demands of butyl acrylate in the world) can to some extent reflects the influence of COVID-19 pandemic on the global chemical raw material market.

This paper aims to find out the detailed impacts caused by COVID-19 pandemic on raw chemical material prices and their specific reasons, by analyzing the data set of the price of butyl acrylate in East China, thus seeking for the underlying influence of the pandemic on the chemical industry.

The rest of the paper is organized as follows: Section 2 introduces the current research situation on the topic of COVID-19 pandemic and the butyl acrylate; Section 3 introduces the source of data and the research approach used in the paper; Section 4 is the detailed analysis and calculation process of the data set; Section 5 discusses the reasons of the completed analysis and the reflections; Section 6 is the final conclusion.

2. Literature Review

2.1. Studies Related to the Influence of COVID-19 Pandemic on Chinese Chemical Manufacturing Industry

Since the COVID-19 pandemic broke out in China at the end of 2019 and began to have a significant impact on the whole country in early 2020, the manufacturing industry including the petroleum refining industry (which is the upstream industry of many chemical raw material) was also deeply influenced inevitably. Because of the policies of epidemic prevention and control, limits of cargo transportation, reduction of demands and lockout of factories jointly lead to a pretty serious production cut in chemical raw materials [2].

Globally speaking, the second season of 2020 is the most terrible one for the petroleum and chemical industry. The five largest international oil companies had a loss of 52.699 billion dollars in total in a season, and their operation income decreased by 38.28%, which seriously affected the downstream market [3].

As the centre and the beginning point of COVID-19 pandemic, despite the Chinese government had taken timely prevention measures and made great efforts to promote the work resumption, the dramatically changing global epidemic situation still continuously brought great stabilizing factors for the whole industry from 2020 to 2023, thus the Chinese chemical manufacturing industry still went through a time of trouble. According to Shanghai Chemical Industry Association, the total output of main enterprises producing petrochemicals and fine chemicals in Shanghai (which is the largest producing area in East China) had a drop of 19.67%, while the profit dropped 92.75% on year-on-year basis [4].

As results of the global economic recession in 2020, the price of crude oil maintains low (West Texas Intermediate drop down to -37.63 dollars per barrel in April 2020) and it also encumbered the price of most petrochemicals (which involves butyl acrylate) [5].

2.2. The Condition of Production and Demands of Butyl Acrylate

As an important chemical product, researchers have been improving the production process of butyl acrylate for long [6]. But in general, the widely used production process, the acrylic acid esterification method, has remained unchanged in long term, using 0.62 tons of n-butyl alcohol and 0.45 tons of acrylic acid to produce 1 ton of butyl acrylate. So, its price mainly depends on the price of acrylic acid and n-butyl alcohol, whose production dropped from 2.02 million tons in 2019 to 187.06 tons in 2020 affected by the pandemic because of the industrial reduction during the COVID-19 pandemic, and their prices have gone high in 2020[7]. Because the strong relativity of the production among these three chemicals, the production decrease and price increase of butyl acrylate during the COVID-19 pandemic can be predicted to certain extent. The butyl acrylate is currently the largest down-stream product associated to acrylic acid, as acrylic ester takes up a proportion of 56% of all demands. Meanwhile the butyl acrylate also accounts for 54% of the demands for butyl alcohol. So, the production of butyl acrylate is widely focused in the chemical production industry.

On the side of demands, over 50% of the butyl acrylate products are used for producing adhesive which is mainly used in the express industry. Because of the particularity of the express industry, it was among the only few industries which didn’t go down during the early stage of pandemic because of the fast increasement of, with the output of adhesive in China rising from 8.819 million tons in 2019 to 9.23 million tons in 2020 [8]. Through the data above it can be concluded that despite the damage on the commodity market during the COVID-19 pandemic, the demands for butyl acrylate and some other chemical raw materials didn’t drop, even in the hardest time of early 2020.

2.3. Review of the Literature

Overall, the research on analyzing the situation of the production and market of raw chemical material in China has been relatively well researched, but there is little research on the detailed impact caused by particularly the COVID-19 pandemic, especially research on the price change from the

perspective of time series model and combination forecasting model. This paper hopes to cover the vacancy in the field, using empirical data in the past four years (2020-2024) to show the imapct of COVID-19 pandemic on the price of chemical raw material.

3. Research Design

3.1. Data Source

This paper uses ICIS (Independent Commodity Intelligence Services), a global commodity market information service provider affiliated to RELX PLC, to collect its empirical data of the fluctuations in weekly prices of butyl acrylate in East China from January 2018 to the present, namely begins from two years before the COVID-19 Pandemic with an experiment span of six years, as a data source and data basis for empirical analysis to study the impact of the COVID-19 Pandemic on the price of chemical raw materials. And the paper chooses January 24, 2020, as the ending piont of the training set, because the time is generally considered as the beginning of the COVID-19 pandemic having huge influence on the social production. After collecting and processing the data, the data analysis software Stata was employed for data analysis and to use the logarithmic return data from January 5th, 2018, to January 24th, 2020, constructing an ARIMA model of the price which suppress the interference of the pandemic. Then the predicted data can be compared based on the data given above with actual data collected from January 24th, 2020, to January 19th, 2024, to figure out the pandemic's impact on the price of butyl acrylate.

3.2. ADF Test

After finishing the basic data processing and building the model, a unit root test needs to be taken on the model first. This paper chooses a test method based on the null hypothesis of the presence of a unit root, the ADF (Augmented Dickey-Fuller) test, in which the original assumption is the model is not smooth (if the result of ADF test is larger than 0.1). The test could compare the actual data with the linear trend of the model and calculate their absolute difference. After taking the ADF test of the model in Stata, the following table can be got as result.

It can be seen in the table that the p-value for the Ln price is 0, which is less than 0.1. So, the original hypothesis can be rejected, revealing that this model is stable and feasible.

Table 1 Weak stationarity test

	t	p
Ln price	-3.220	0.0805
1st order difference	-5.720	0.0000
2nd order difference	-8.237	0.0000

3.3. ARIMA Model

ARIMA model, fully named the Autoregressive Differential Moving Average Model, is widely used to predict future outcomes by calculating data already given in the past. Using the principle of serial correlation that past data points influence future ones, ARIMA model is composed of three parts, AR (Autoregressive Model), I (Differential process) and MA (Moving Average Model) [9]. A standard model of ARIMA features as ARIMA (p, d, q), in which:

'p' stands for the lagged values of the observations in the model, namely the values of proceeding p periods, which is 'AR(Autoregressive)' in the word 'ARIMA'. The AR model aims to consider the observation as the linear combination for p values that precede.

'd' stands for the order of difference. It represents the times of differencing which aims to transform a non-stationary time series to a stationary one.

'q' is 'MA (Moving Average)' in 'ARIMA', which stands for the lagged value of the error term used in the model, namely the value of the previous q periods, as the MA model relates the current values to past white noise.

In this paper, ARIMA is a relatively ideal model to calculate the impact of COVID-19, because ARIMA model can reflect the trend of butyl acrylate price without external influence more accurately than most prediction model. Thus the comparing result can be more objective than just watching for the fluctuations.

4. Empirical Results and Analysis

4.1. Order Determination and Residual Test

Before using the ARIMA model, PACF and ACF pairs should be used to order the weekly logarithmic returns of the first order difference and the second order difference perspectively, and the results are shown in Figure 1.

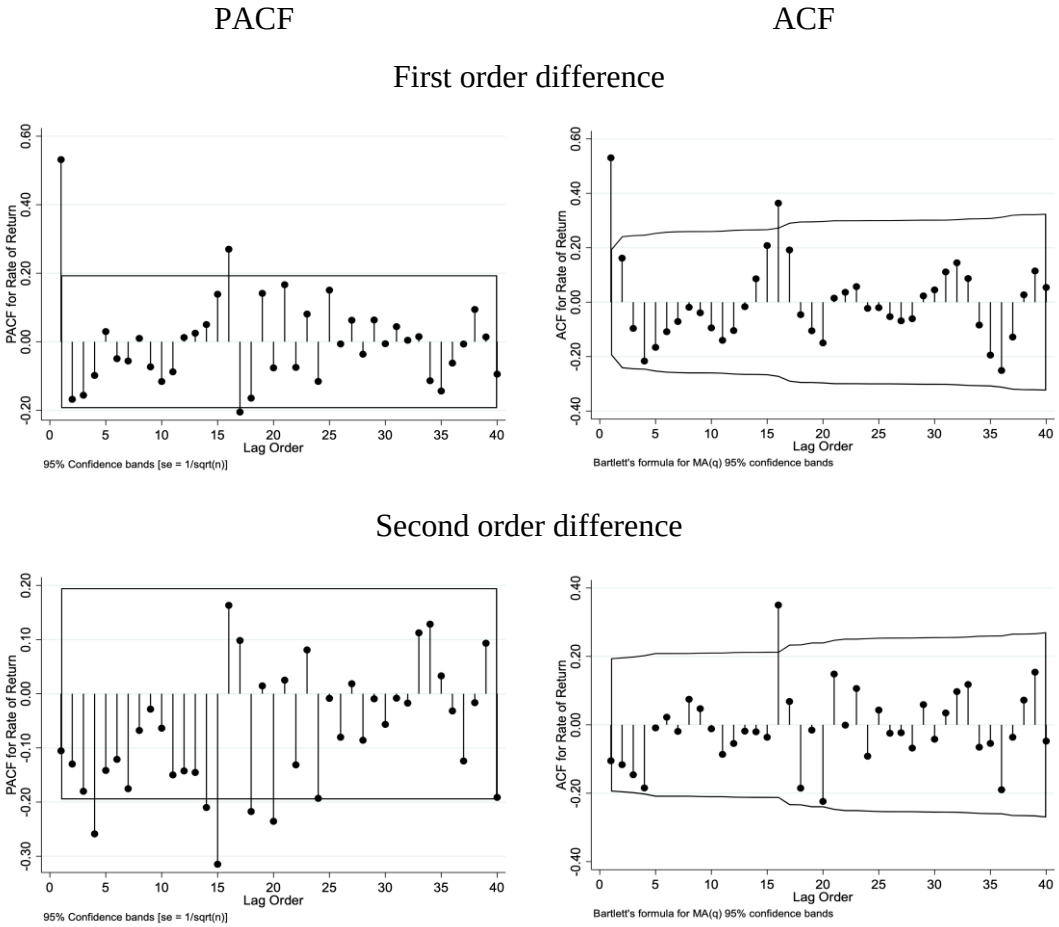

Figure 1 ARMA (p, q) identification
Photo credit: Original

For time series, if the ACF image shows the features of trailing tail while the PACF exhibits a shortened one, the AR model tends to apply the current time series, and the lag order of PACF trunction can be set as the parameter 'p' in ARIMA model. And for the same reason, the lag order of the ACF truncation can be used as the parameter q in the MA model, as the MA model can be applied to current time series when PACF image has a trailing and ACF exhibits a truncated one [10]. By using the methods above a completed ARIMA (p, d, q) model can be bulit, firstly choosing (4, 2, 0) and (16, 1, 1) as the values of (p, d, q), and the residual test of the model can be got as Table 2:

Table 2 Residual test

Model	Portmanteau (Q) statistic	Prob > chi2
ARIMA (4,2,0)	113.1574	0.0000
ARIMA (16,1,1)	170.0677	0.0000

The ARIMA (4, 2, 0) passed the residual test successfully as its error term is highly consistent with tha of unpredictable white noise series, which means ARIMA (4, 2, 0) is an ideal model for the price change of butyl acrylate in theory. After inputting the training data, the following Figure 2 can be outputted by using the four predicting results based on ARIMA (4, 2, 0) model, which reveals a worth affirmed predictive ability despite an acceptable minor difference:

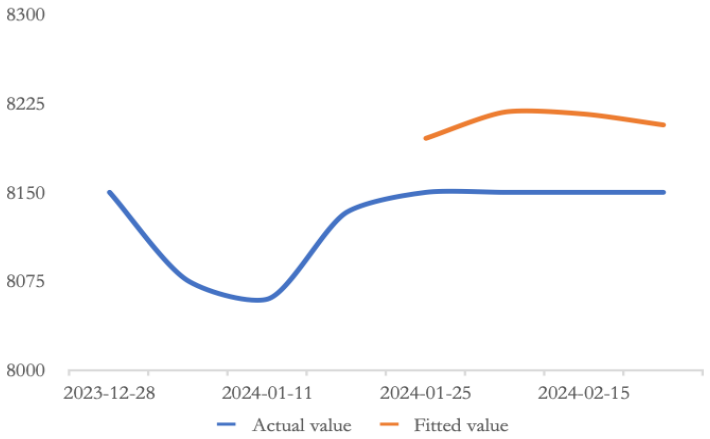

Figure 2 Actual value and predicted value, ARIMA (4,2,0)
Photo credit: Original

Following the same steps, another model of ARIMA (16, 1, 1) can be built in the same way, which turns out to be another possible optimal solution by observing the ACF and PACF images. As ARIMA (16, 1, 1) model can give the prediction of following 16 periods (much larger than ARIMA (4, 2, 0) which can only give four periodical predictions), its deviation with actual data also grows as the Figure 3 below shows:

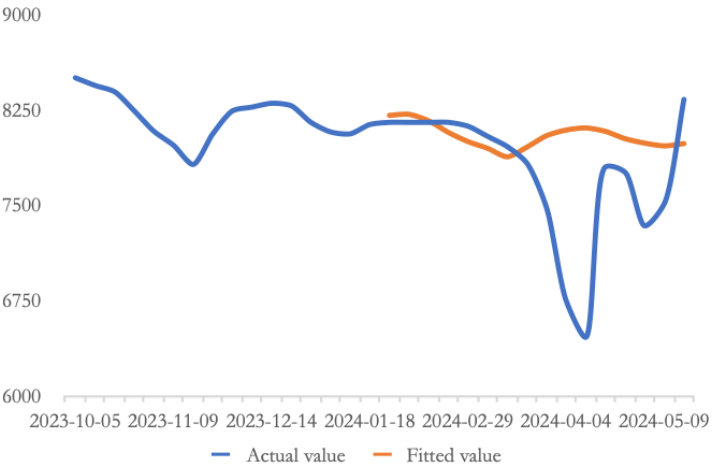

Figure 3 Actual value and predicted value, ARIMA (16,1,1)
Photo credit: Original

However, the trend of the price change in the test set basically meet, as the predicting trail meets the actual data trail several times in 16 periods, so it could be considerd that the ARIMA (16, 1, 1) model is also available for further study on the influence of the pandemic.

Therefore, ARIMA (4, 2, 0) and ARIMA (16, 1, 1) were finally chosen in this research as the reference data of price change without being affected by the COVID-19 pandemic.

4.2. Forecast Results and Interpretation

After the ARIMA model building and the residual tests, the Stata software was kept being used for data prediction for periods after the pandemic breakout. First, ARIMA (4, 2, 0) is used as it is more concise and easier to examine, its results summarized in Table 3 below:

Table 3 Actual value and predicted value, ARIMA (4,2,0)

	Actual value	Fitted value	difference	Difference (%)
2019-12-27	8150			
2020-01-03	8075			
2020-01-10	8060			
2020-01-17	8133.3			
2020-01-24	8150	8195.5879	-45.5879	-0.56%
2020-02-07	8150	8217.7479	-67.7479	-0.82%
2020-02-14	8150	8216.024	-66.024	-0.80%
2020-02-21	8150	8206.8626	-56.8626	-0.69%

By comparing the four fitted values after calculation with actual ones, it is observed that the actual prices of butyl acrylate were only slightly lower than prediction, and the decreasing rate of the price was smaller than analytical expectation. To explain this phenomenon, it should be noted that because of the relative chaotic situation of the commodity market during the early pandemic period, both the supply side and the demand side were affected seriously, which to some extent restrict the rangeability of the price. Moreover, the price data collected in the research is the transaction price instead of its practical value, largely depending on trade turnover which also decreases, thus explaining the small range of price change.

To have a broader view of the butyl acrylate price, the study of ARIMA (16, 1, 1) is taken as the following step, in which 16 periods of data can be compared and 32 time periods can be taken in consideration in total. The results are put in Table 4 below:

Table 4 Actual value and predicted value, ARIMA (16,1,1)

	Actual value	Fitted value	Difference	Difference (%)
2019-10-04	8500			
2019-10-11	8440			
2019-10-18	8390			
2019-10-25	8240			
2019-11-01	8080			
2019-11-08	7970			
2019-11-15	7820			
2019-11-22	8060			
2019-11-29	8240			
2019-12-06	8270			
2019-12-13	8300			
2019-12-20	8280			
2019-12-27	8150			
2020-01-03	8075			
2020-01-10	8060			
2020-01-17	8133.3			
2020-01-24	8150	8205.2851	-55.2851	-0.67%
2020-02-07	8150	8213.0547	-63.0547	-0.77%
2020-02-14	8150	8161.9634	-11.9634	-0.15%
2020-02-21	8150	8071.389	78.611	0.97%
2020-02-28	8120	7998.9501	121.0499	1.51%
2020-03-06	8040	7946.5015	93.4985	1.18%
2020-03-13	7960	7879.8493	80.1507	1.02%
2020-03-20	7830	7956.0781	-126.078	-1.58%
2020-03-27	7480	8045.603	-565.603	-7.03%
2020-04-03	6750	8089.8417	-1339.84	-16.56%
2020-04-10	6462.5	8106.4642	-1643.96	-20.28%
2020-04-17	7800	8079.2505	-279.251	-3.46%
2020-04-24	7758.3	8021.8721	-263.572	-3.29%
2020-05-01	7337.5	7987.1746	-649.675	-8.13%
2020-05-08	7512.5	7965.5255	-453.026	-5.69%
2020-05-15	8330	7983.1496	346.8504	4.34%

Different from the previous test on ARIMA (4, 2, 0) model, these results reveal a much more obvious tendency. Given the data set from March 27th to May 8th, 2020, a very significant decline can be seen, which cannot be explained by normal price fluctuations.

Take the data of April 3rd and 10th as example, the price decrease with an extent of around 20% confirmed a drastic change on the relation between supply and demand for butyl acrylate, which take place just after the containment policy were partly canceled and the first wave of pandemic comes to the end in mainland China (there were only 19 newly confirmed COVID-19 cases on April 3th, 2020, 18 of which from foreign countries). Because the output of supply side couldn't have increase rapidly in short term, the only interpretation for the price fall is the sharp decreasement of demands.

Besides, it's worth pointing out that the price data sees a rise after May 2020, which is reasonable because most kinds of trade and production have recovered then in mainland China, which didn't need to be considered when having analysis on the influence of the pandemic in East China. With all things above, the final discussing object in this paper should be the data set from the beginning of the pandemic to early May, 2020.

5. Discussion

From the analysis on the empirical data, especially taking the data of April 3rd and 10th as example, the price decrease with an extent of around 20% confirmed a drastic change on the relation between supply and demand for butyl acrylate, which take place just after the first wave of pandemic comes to the end in mainland China (according to National Health Commission of China, there were only 19 newly confirmed COVID-19 cases on April 3rd, 2020, 18 of which from foreign countries[11]) and the containment policy were partly canceled to encourage the resumption of work and production, as the Joint Prevention and Control Mechanism of the State Council releases 'Guidelines on Covid-19 Prevention and Control for Localities at Different Risk Levels to Resume Work' on April 7th [12]. And according to the data from the National Bureau of Statistics of China, the Purchasing Managers' Index (PMI) dropped from 50% in January 2020 to 35.7% in February, which reflects the sharp drop of industrial demands during the pandemic. What's more worth mentioning, the PMI orders index sees an even larger decline from 51.4% to 29.3%, which means the manufacturing market demand decreases largely in the first half of 2020 [13].

All the above evidence can explain the the deduction that the quantity demanded for butyl acrylate in East China dropped sharply because of the pandemic, which is also the only possible interpretation for the price fall (which could only be caused by output increase or demands drop, while the output of supply side couldn't have increase rapidly during the pandemic as there are no new factories on operation). And in this way this paper successfully explains the seemingly irrational phenomenon that the price of important raw material went down during the pandemic.

6. Conclusion

The main research purpose of this study is to delve deeper into the impact of the COVID-19 pandemic on chemical raw material price change and its supply-demand mechanism. To achieve this objective, the paper selects butyl acrylate for detailed analysis and observes its price change situation right before and during the pandemic.

During the research, the ARIMA model was introduced to quantificate the price fluctuations and predict the log returns of the price of butyl acrylate in a situation without COVID-19 pandemic happening. This approach manages to suppress the interference of seasonal reasons or other factors specialized for certain chemicals and get the analysis result that the price dropped dramatically at the start of the pandemic, which is somehow unsuited to common sense that price goes up in emergency time.

Based on the findings, the paper goes on comparing the output and demanding situation of the chemical industry, noticing the significant reduction of industrial demands in the early half of 2020.

After enumerating the possible reasons of the price drop, the paper finally reaches the conclusion that sharp decrease of demands is the real reason for serious price drop of chemical raw materials.

The paper still has its imperfection despite reasonable experiment designing, as all the research data are based on one kind of chemical, which has certain limitation and deviation. For further researches in the relevant field, a larger data set and sample size should be taken into consideration, thus a more completed and accurate model could be built on the price change of chemical raw materials influenced by COVID-19 pandemic.

References

[1] Bauer Jr W. Acrylic acid and derivatives. Kirk‐Othmer encyclopedia of chemical technology, 2000.

[2] Yang Ming, Huang Xingliang, Liu Zongyan, Yi Tianli. Impact of COVID-19 on China's oil refining and Chemical Industry. Technology & Economics in Petrochemicals, 2020, 36(2):5.

[3] Lu Xiaoru, Zhu He. Surviving through 2020: the review of important events for Petroleum and petrochemical industry in 2020. China Petrochem, 2021, (01): 12-25.

[4] Yang Shengping. Analysis of economic operation of Shanghai chemical industry in June 2020 and the first half of the year. Shanghai Chemical Industry, 2020, 45 (04): 2-4.

[5] Look back at the chemical industry these two years. China State-owned Enterprise Management, 2021, (12): 32-39.

[6] Ji Shixiong, Zhao Yijun, Hechun. Progress in the synthesis of butyl acrylate[C]//China Chemical Society 2010 Petrochemical Academic Annual Meeting. China Chemical Society, 2010.

[7] Ding Guorong, Wang Yong, Wang Meng, Zhao Qingguo. Production and Market Analysis of n-Butanol in China. Chemical Industry, 2023, 41 (01): 47-51.

[8] Intelligence Research Group (Beijing Zhiyan Kexin Consulting Co., Ltd.). An article provides an in-depth analysis of the industrial chain situation of China's adhesive industry in 2022. (2023-2-24) [2 024-3-3]. https://baijiahao.baidu.com/s?id=1758673836371634513&wfr=spider&for=pc

[9] Xue D, Hua Z. ARIMA based time series forecasting model. Recent Advances in Electrical & Electronic Engineering (Formerly Recent Patents on Electrical & Electronic Engineering), 2016, 9(2): 93-98.

[10] Kedem B, Fokianos K. Regression models for time series analysis[M]. John Wiley & Sons, 2005.

[11] National Health Commission of the PRC. The Joint Prevention and Control Mechanism of the State Council, the news conference transcript of April 4th, 2020. (2020-4-4) [2024-3-3]. http://www.nhc.gov.cn/xcs/fkdt/202004/49796d8018c34161821b83920b884d7c.shtml

[12] Central People's Government of the People's Republic of China. 'Fighting Covid-19 China in Action' White Paper. (2020-6-7) [2024-3-3]. https://www.gov.cn/zhengce/2020-06/07/content_5517737.htm

[13] National Bureau of Statistics of China. The Operation of China Purchasing Managers Index in February 2020. (2020-2-29) [2024-3-3]. https://www.stats.gov.cn/xxgk/sjfb/zxfb2020/202002/t20200229_1767764.html