Pharmaceutical industry in Long-term Uncertain Market: An Empirical Research Based on Time Series Model

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Abstract. The outbreak of covid-19 pandemic has brought a huge tide to the financial market across the globe, due to the fluctuation in the performance of a variety of sectors, it kept vacillating in the investors' opinions, resulting in a drastic fall in the stock market, but pharmaceutical companies were excluded from the main trend. This paper is going to discuss whether the fluctuation in the medical market will be affected by the covid-19 pandemic and then assume the long-term performance of Chinese pharmaceutical companies under the influence of the pandemic. The main analytical methods that have been applicated are the series model, the order of VAR Model, the ARMA-GARCH Model and impulse and response analysis. Finally, we will draw our conclusion that under that if another sudden outbreak can be prevented, the long-term performance of the medical industries will have minor damage from the pandemic. The study provides investors and leaders in the industry with a front-sight of future market performance. We suggest that the medical industry needs to learn from experience to maintain the rise in performance, and the investors can also put faith in them, believing that the overall performance of the pharmaceutical market will not let them down.

Keywords: Uncertain Market; Pharmaceutical industry; Empirical research.

1. Introduction

The COVID-19 virus has been dominating their lives for over 2 years since 2019 and has caught global attention starting from the WHO Announces Mysterious Coronavirus-Related Pneumonia in Wuhan, China on the 9th of January 2020. Starting from a small number of cases, the virus is now responsible for millions of excess deaths worldwide. The unprecedented pandemic is also posing threat to the global financial market.

The financial market outlook across the world has been downgraded to negative due to the impact of the COVID-19 outbreak starting from 2020, and the main cause of the pessimism in global investors is believed to be the high inflammation and the tragic stock market performance due to political instability [1]. The virus has brought unprecedented repercussions on daily life, spending behaviours and travel plans to the household at the onset of the COVID-19 pandemic, the last thing the investors want is to inflict damage to their benefit and future income [2]. Surprisingly, the tide started to return in some industries in this lagging industry, for example, the pharmaceuticals and biotechnology sectors while the others remained in the shadow of the pandemic [3]. However, this optimism did not last long, a drastic decline in the performance of the pharmaceutical industry was witnessed by investors at the beginning of 2021, It is believed that there are multiple factors driving the fluctuations, and the cause of it remains controversial. A simple way to interpret the changes is that boots in the stock index are always followed by swings or reversals in the market, and the pharmaceutical industry seems to overdraft the gains for the next two years, it has been described as an "over-reaction" on the pharma sector. The follow-up of the 'over-reaction' remain uncertain in the long run, and the concept is still yet to be confirmed.

The global impact on the financial market can easily remind people of the Great Financial Crisis, but research on the topic is surprisingly low. The COVID-19 epidemic has caused a serious impact on the financial industry around the world and has brought a huge challenge to financial management in the post-epidemic era. By analyzing the trend in the financial market, we can have a better insight

into the future and be prepared for the series of chain reactions brought by the changes. We can also learn from this experience to make the correct move in the future.

In this paper, various analytical methods such as a time series model, order of VAR Model, ARMA-GARCH Model and impulse and response analysis were adopted to systematically analyse the impact of COVID-19 on the financial industry by comprehensively considering the stock market, Pharmaceutical and biological industry index, daily new cases reported in China and in the rest of the world. The COVID-19 pandemic has negatively impacted each sector of the financial market to various degrees. Based on the empirical analysis, the paper will draw conclusions about how the volatility of the pharmaceutical industry gain will be affected by the COVID-19 pandemic and followed by explaining the trend of the traditional Chinese medicines industry in the long run.

The remaining parts of this paper are organized as follows: Par 2 is the literature review, which introduces the general impact of the COVID-19 pandemic on the stock market worldwide, and on the pharmaceutical industry specifically; Parr 3 will discuss the methodology including data sources, unit root test and model specification; Part 4 would be the result and the analysis; finally, the discussion and conclusion would be the Part 5 and 6.

2. Literature review

2.1 Impact of COVID-19 pandemic on the stock market in general

Almost 200 countries were claimed to be affected by COVID-19 with reported confirmed cases and deaths, government policies like quarantine have brought a great impact on financial activities, such as producing, spending, and investing. In the long run, countries would have to endure the consequences of business failure, unemployment, and reduced standard of living. The most impacted industries include hotel & restaurant, tourism, wholesaler, retail and etc [4].

In line with this result, the financial index plunged sharply due to the massive capital outflow from the financial market. According to Statista, the stock index points the Asia, Europe, and the United States fell by approximately 20% to 25%, 40%, and 40% respectively [5], in March 2020 compared to 5th of January 2020. If we look at the US stock market (US30) fluctuation in March, the stock has been cut by nearly a half within one month. The change was reasonable at the beginning of the pandemic as people can only see the unlimited downside of the crisis and were facing uncertainties they have never encountered before.

2.2 Impact of COVID-19 pandemic on the pharmaceutical industry

There is no doubt that the pharmaceutical and biotechnology industries were the first ones to recover, as there was a drastic increase in demand for medicines, vaccines, and medical devices due to the rise in hospitalization [6]. The least affected industries include Health Care Equipment & Supplies, Life Science Tools & Services and Pharmaceuticals [7].

However, the optimistic trend did not sustain. Medical ETF (512170) has continued to plummet by 27% since the beginning of July this year and is 53% more compared to last year [8].

Looking at the aspect of the policy, centralized procurement might be another factor worth considering. This is because the net profit and cash flow of the company will be suppressed by the change in policy. Considering the clinical trial for medicines against the virus, it has been clear that all clinical trials should provide subjects with the optimum treatment and improving the success and efficiency of clinical trials should never be the orientation, it will significantly raise the cost and reduce the success rate. Moreover, because of the negative effect brought by the COVID-19 news, the clinical trial teams were facing difficulties keeping social distance while transporting the subjects and ensuring the safety of the team members. Patient enrolment in clinical trials has become more and more challenging [9]. As a majority of the scientific research was focused on vaccines and new medicines development, changes in authorized regulations and uncertainties due to the virus outbreaks will drag the pharmaceutical industry to some extent. The supply chain of the medicine manufacturer was also interrupted significantly due to the increase in sick leave, work form come,

shortage of raw material, and importer supplies, so the performance of the pharmaceutical industry is unpredictable [10].

2.3 Review

In the summaries, the pandemic had a great impact on the global market and the fluctuations caused the investor to lose their confidence in the performance of industries like tourism and retail. This trend seemed to be within the expectation of investors because the restriction and policy changes made the decline reasonable, and it is believed that the decline will continue as long as the restrictions are not reversed. On the other hand, unlike the others, the medical industries have experienced growth in market share. However, this optimism did not seem to be sustainable due to negative news, strict medical affairs restrictions, and disturbance in supply chin. In this paper, instead of analyzing the existing trend, we will look at the long-term change of the medical industries and make predictions on their future performances, thus providing businesses with reasonable suggestions for the future.

3. Research Design

3.1 Data Source

In order to analyse the pharmaceutical industry under the long-term influence of Covid-19 epidemic, sector index data, Global Covid-19 daily new cases and Chinese Covid-19 daily new cases data are collected from Choice, WHO and China National Health Commission respectively.

3.2 Augmented Dickey-Fuller (ADF) Test

The first step before processing all those data is ADF test, which can exam the stationarity of the data. Stata was used to conduct the ADF test. Based on the result as shown In Table 1, the p-value for stock return of the pharmaceutical industry is 0.6043, which is not considered as statistically significant, so an alternatively the Log-return of stock has been calculated by Ln (1+Index), which shown as Yield in Table 1 and its p-value equals 0, now it is believed to be statistically significant. Additionally, the p-values for both daily confirmed cases in China and around global can be considered as statistically significant. This means the data of Yield, daily confirmed cases, CN and Daily confirmed cases, Global are stationary, which can be used for modelling.

Table 1. ADF Test

Variables	t-statistic	p-value
Index	-1.995	0.6043
Yield	-37.034	0.0000***
Daily confirmed cases, CN	-3.740	0.0199**
Daily confirmed cases, Global	-3.127	0.0999*

3.3 Vector Autoregression (VAR) Model

The VAR model was developed by Christopher Sims in 1980, which is a multivariate time series model. The lagged values of a variable are used to explain the current value of it. [11] As the VAR model can capture complex real-world behavior and the intertwined dynamics of time series data. It was chosen to find the intercorrelation between Yield and Daily confirmed cases.

The three time series variables are shown as $T_{1t}, T_{2t}\ and\ T_{3t}$, which represent the log-return of pharmaceutical stock, daily confirmed cases in China and around the global respectively.

$$T_{1t} = \beta_{10} + \beta_{11}T_{1,t-1} + \cdots + \beta_{1p}T_{t-p,1} + \gamma_{11}T_{2,t-1} + \cdots + \gamma_{1p}T_{2,t-p} + \delta_{11}T_{t-1,3} + \cdots + \delta_{1p}T_{t-p,3} + \varepsilon_{1t} \quad (1)$$

$$T_{2t} = \beta_{20} + \beta_{21}T_{1,t-1} + \cdots + \beta_{2p}T_{t-p,1} + \gamma_{21}T_{2,t-1} + \cdots + \gamma_{2p}T_{2,t-p} + \delta_{21}T_{t-1,3} + \cdots + \delta_{2p}T_{t-p,3} + \varepsilon_{2t} \quad (2)$$

$$T_{3t} = \beta_{30} + \beta_{31}T_{1,t-1} + \cdots + \beta_{3p}T_{t-p,1} + \gamma_{31}T_{2,t-1} + \cdots + \gamma_{3p}T_{2,t-p} + \delta_{31}T_{t-1,3} + \cdots + \delta_{3p}T_{t-p,3} + \varepsilon_{3t} \quad (3)$$

To clarify, in the first equation, $\beta_{10} + \beta_{11}T_{1,t-1} + \cdots + \beta_{1p}T_{t-p,1}$ stands for the past lags of log-return of stock, $\gamma_{11}T_{2,t-1} + \cdots + \gamma_{1p}T_{2,t-p}$ stands for the past lags of daily confirmed cases in China, and $\delta_{11}T_{t-1,3} + \cdots + \delta_{1p}T_{t-p,3}$ stands for the past lags of daily confirmed cases around the global. The ε_{1t} stands for white noise.

Combine three time series into a matrix:

$$\begin{pmatrix} T_{1t} \\ T_{2t} \\ T_{3t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \\ \beta_{30} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \cdots & \beta_{1p} \\ \beta_{21} & \cdots & \beta_{2p} \\ \beta_{31} & \cdots & \beta_{3p} \end{pmatrix} \begin{pmatrix} T_{1,t-1} \\ \cdots \\ T_{1,t-p} \end{pmatrix} + \begin{pmatrix} \gamma_{11} & \cdots & \gamma_{1p} \\ \gamma_{21} & \cdots & \gamma_{2p} \\ \gamma_{31} & \cdots & \gamma_{3p} \end{pmatrix} \begin{pmatrix} T_{2,t-1} \\ \cdots \\ T_{2,t-p} \end{pmatrix} + \begin{pmatrix} \delta_{11} & \cdots & \delta_{1p} \\ \delta_{21} & \cdots & \delta_{2p} \\ \delta_{31} & \cdots & \delta_{3p} \end{pmatrix} \begin{pmatrix} T_{3,t-1} \\ \cdots \\ T_{3,t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix} \quad (4)$$

3.4 ARMA-GARCH Model

The ARMA-GARCH model was used to forecast the rate of return and volatility of the pharmaceutical market.

The first part of the model is AMRA, which can be expressed as following:

$$x_t = \alpha_0 + \sum_n^p \alpha_n x_{t-n} + \varepsilon_t - \sum_n^q \beta_n \varepsilon_{t-n} \quad (5)$$

Where the ε_t is white noise, d and c is nonnegative integer. The first sum is the AR(p) model, and the second sum is the MA(q) model. Both parts forecast the future value of pharmaceutical market, while AR(p) uses past stock return, MA(q) uses ε_t.

The second part of the model is GARCH, which was developed by Bollerslev in 1986 [12]. The GARCH model introduced lagged conditional variances into ARCH model. In this research GRACH (1,1) was used, which can be expressed as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma D_t \quad (6)$$

Where D_t stands for an extra explanatory variable, which is the confirmed cases.

4. Results and analysis

4.1 Order of VAR Model

LR, FPE, AIC, HQIC, and SBIC statistics were used to determine the order of VAR model.

Table 2. VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-333.323				.0005	1.0693	1.0776	1.0905
1	1096.09	2858.8	9	0.000	6.4e-06	-3.4470	-3.4141	-3.3622
2	1192.42	192.66	9	0.000	4.8e-06	-3.7247	-3.6670	-3.5763
3	1221.77	58.688	9	0.000	4.5e-06	-3.7894	-3.7070	-3.5774*
4	1244.91	46.285	9	0.000	4.3e-06	-3.8343	-3.7273	-3.5588
5	1261.59	33.352	9	0.000	4.2e-06	-3.8587	-3.7270	-3.5196
6	1283.44	43.716	9	0.000	4.1e-06	-3.8996	-3.7432	-3.4969
7	1295.01	23.136	9	0.000	4.0e-06	-3.9078	-3.7266	-3.4415
8	1311.3	32.576	9	0.000	3.9e-06	-3.931	-3.7251	-3.4011
9	1335.22	47.842	9	0.000	3.8e-06	-3.97845	-3.7479*	-3.3849
10	1349.99	29.543	9	0.001	3.7e-06	-3.9968	-3.7415	-3.3397
11	1359.05	18.121*	9	0.034	3.7e-06*	-3.9969	-3.7170	-3.2763
12	1363.06	8.0189	9	0.532	3.7e-06	-3.9811	-3.6764	-3.1968

As shown in Table 2, lag order 3,9 and 11 have asterisks sign, among which order 9 was chosen. Then stationarity of VAR model has to be examined in order to have a converged impulse-response function. As shown in Figure 2, all roots of the companion matrix sit in the circle, which indicates the model is stationary.

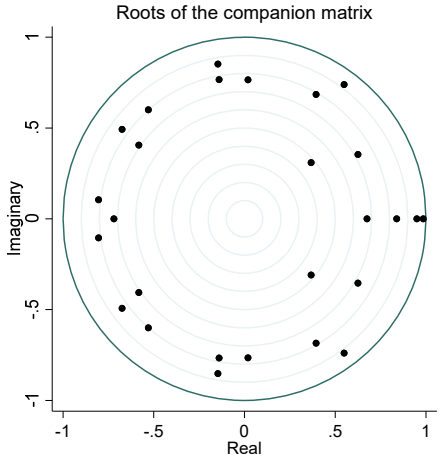

Figure 1. VAR stability
Photo credit: Original

4.2 Impulse Response

Since the outbreak of Covid-19 happened in 2020, the global financial market was highly effected. Panic spread through all investors from Chinese, American, European market. As most of the investors are risk averse, huge amount of capital exited the financial market, causing a dramatic fall in all sector indexes. However, the pharmaceutical industry was one of a small group of industry that had a sharp rise shortly after the epidemic started. In contrast, after 2021 a huge drop appeared in the pharmaceutical industry. As time goes by, people are having deeper knowledge about covid-19, however whether people returned to rationality still require an empirical analysis.

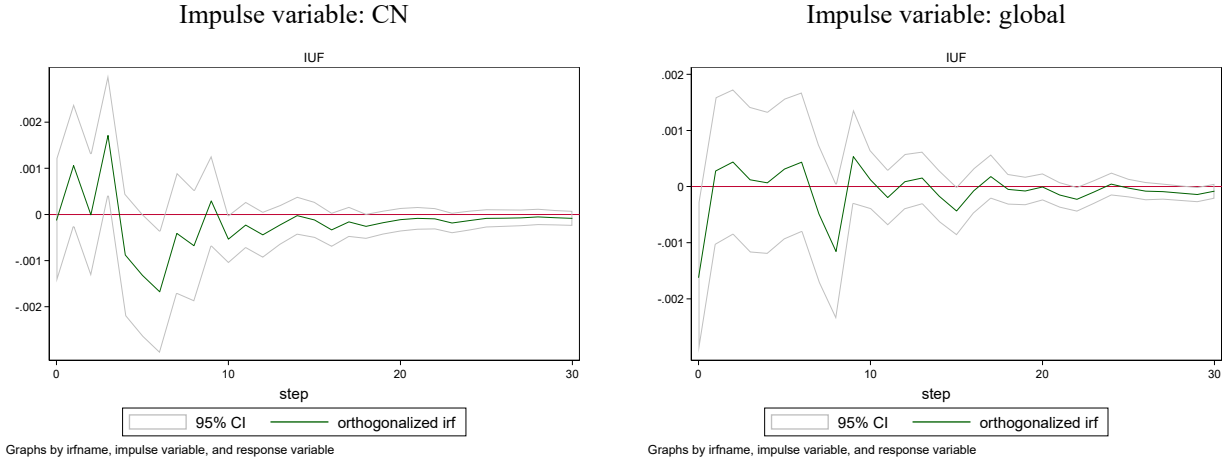

Figure 2. Impulse response
Photo credit: Original

From the impulse response (Figure 2), when the number of daily confirmed cases increased by 1% at t=0, the influence on pharmaceutical industry return was positive between t=0 and t=3, with a peak of 0.15% at t=3. At t=4 and after the impact from t=0 become negative, the magnitude was almost 0.2%. In addition, it can be seen from the graphs that the duration and magnitude of negative effect were both large then those of positive effect. As a result, with long-term continuous daily confirmed cases, the pharmaceutical industry return would decrease. From the result found above, it seems like that investors did not learn from experience, the return of pharmaceutical industry almost repeated the history, but reduced in time.

Additionally, from the impulse response with global daily confirmed cases as the impulse variable, the increase in global daily confirmed cases also cause significant negative effect on Chinese pharmaceutical industry.

From time perspective, the impulse at t=0 decays to zero after 20 period.

4.3 Result of ARMA-GARCHX

Figure 3 shows that PACF and ACF are both not statistically significant lagging from t=1 to t=30. Therefore, this part set the mean equation of ARMA-GARCH model as a constant.

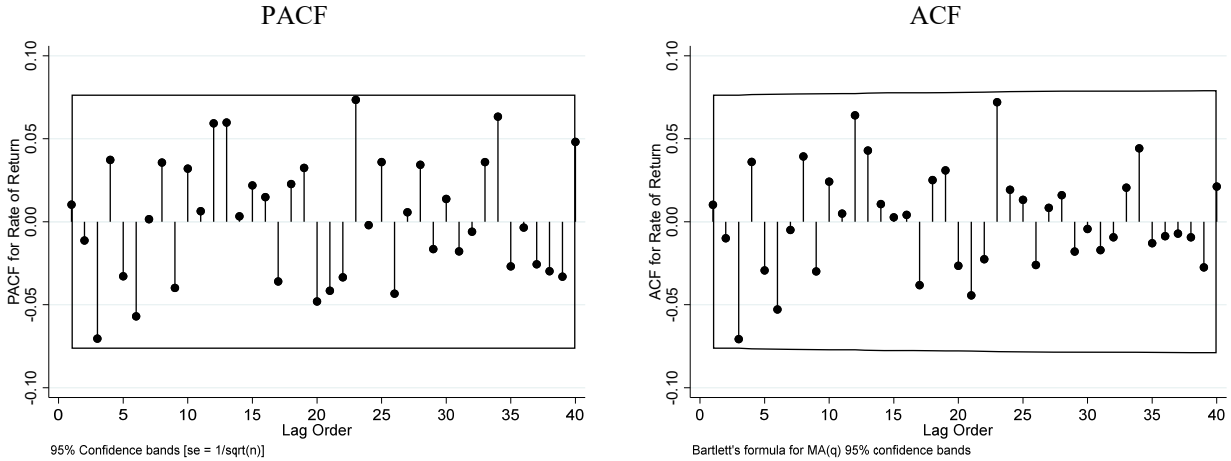

Figure 3. PACF and ACF
Photo credit: Original

From Figure 4, the return of pharmaceutical industry showed an obvious aggregation. However, tests are still needed for us to believe that this behaviour is significant statistically.

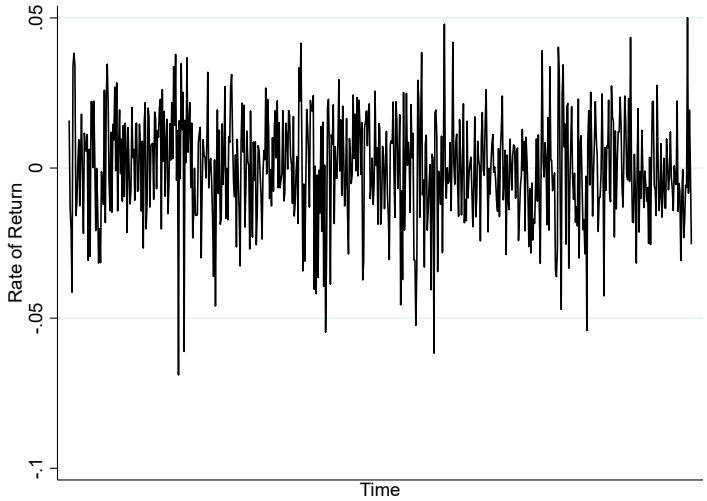

Figure 4. Yield
Photo credit: Original

From Table 3, both the ARCH and GARCH components of the return of pharmaceutical industry are statistically significant, which suggests that there is significant conditional heteroscedasticity within the return data. As a result, GARCH modelling is feasible.

According to the external explanatory variable, regardless of Chinese or global daily confirmed cases, the influence on volatility of pharmaceutical industry return is insignificant.

To conclude, the result shows that in long-term, as long as large-scale epidemic does not happen, the volatility of pharmaceutical industry return would not be effect by the epidemic.

Table 3. ARMA-GARCHX estimation result

	(1)			(2)		
	Coef.	Std. err	p>|Z|	Coef.	Std. err	p>|Z|
	Daily confirmed cases					
CN	.03166	.1127	0.28			
Global				-.0395	.1055	-0.37
GARCH (1, 1)						
ARCH, L1	.0609	.0257	0.018	.0601	.0260	0.019
GARCH, L1	.8850	.0503	0.000	.8850	.04896	0.000
Constant	-11.0535	.0503	0.000	-10.4504	1.4241	0.000

5. Discussion

In comparison with similar studies, where the majority of them focus on the short- and long- term impact of the COVID-19 pandemic, the object of this paper is to forecast and to make an explanation on what the long-term trend of the traditional Chinese medicine industry will be in the future. Although many paper have made it clear that COVID-19 have posed a considerable impact on the healthcare sector and medicine market and things will be back to our control with the subsequent policy adjustment and ease in labile mood, the majority of them stop here. However, the one similarity this essay shares with the other studies is that we have adopted the same analytical methodology, for example, the VAR and the ARMA-GARCH-X model. One of the flaws of this paper is that it does not take into account of the unexpected changes which are nearly impossible for us to predict for the future, so rational thinking and flexibility are still required during the decision-making process. On the other hand, it might be difficult for some investors to determine the level of influence of the future possible pandemic outbreak, so information mining remains important. By analyzing the long-term trend of the medical industry under the influence of COVID-19, this essay might help the decision-makers and future investors to expand their ideas and choose the correct path when a similar crisis happened in the future. To prepare the medical industries for the future facing a similar situation, investors can put some faith in the long-term performance of the market and can see the early fluctuation as an adjusting period.

6. Conclusion

In the present day, with the deepening of people's understanding of COVID-19 virus, it is hard to make any assumptions about the future trend and performance of the medical industry. Although the result of this paper is to demonstrate the confronting risk to financial benefit for the market, whether or not the public can restore their rational thinking still required further verification.

Results came from the analytical methodologies have demonstrated that the benefit of the pharmaceutical industry will be disadvantaged if the increase in diagnostic cases is chronic in the future. Investor seems to fail to learn from the past experience resulting in history repeating itself, the only difference is just the shortened time frame. Looking at the global newly confirmed cases as the variable of pulse response, it can be found that the increase of the global newly confirmed cases in the current period also has a significant negative impact on the return rate of China's pharmaceutical industry. According to the rate-to-yield diagram, the rate of return in the pharmaceutical industry shows an obvious clustering effect, but whether this effect is statistically significant still needs further testing for confirmation. Finally, in line with the estimation results of the ARMA-GARCH-X model, the return rate can be used for GARCH modelling due to the significance of the conditional heteroscedastic property, thanks to the significant ARCH and GARCH terms of the return rate of the pharmaceutical industry.

The estimation results of external explanatory variables tell us no matter whether the newly infected cases are happening in China, overseas or globally, it will have a significant impact on the volatility of pharmaceutical industry earnings, but in the long run, as long as another large-scale

epidemic outbreak is prevented, the volatility of pharmaceutical industry returns can no longer be affected by the epidemic.

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