Game Industry in Long-term Uncertain Situation: A Normalized Covid-19 Pandemic Perspective

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Abstract. An unprecedented pandemic of Covid-19 hit the world and impacted the stock price of the game industry in China and overseas. How largely the game industry stock price is impacted, and the prediction of the future trends is being studied in this paper. To have a better understanding of data and to make sure predictions are accurate, this article employs VAR and ARMA-GARCH models. It is found that the relationship between the game industry and Covid-19 in the beginning stage is highly and positively related in China and overseas markets, but then the relationship turns to be negative. In the long run, the impact of Covid-19 on the game industry turned negligible, and the relationship became stable. It is also found that investors do not seem to learn from their previous experiences, and the earning yield of the game industry is repeated over and over in history, but the time for the recurrence of history has been shortened.

Keywords: Covid-19; Stock Price; Game Industry; China; Overseas; ARMA-GARCH.

1. Introduction

On January 1, 2020, the Huanan seafood wholesale market in Wuhan was required to close due to the worrisome reprise of SARS-like virus. According to World Health Organization, On January 3, China reported that they have identified 40 cases of an unknown disease. On January 10, WHO announced the outbreak in Wuhan China is caused by Novel Coronavirus. Later, WHO found evidence that Coronavirus can have human-to-human transmission. In February, many countries began to report that they have Covid-19 patients [1].

The outbreak of Covid-19 in early 2020 has caused turmoil in global financial markets. Investors, in not only China but the US, Europe and anywhere else, have panicked in a short term after the rapid spread of coronavirus. The risk-averse tendency of funds has led to a large amount of money "fleeing" from the financial market, which causes financial market indices to cliff down. The stock market crashed in March 2020. Within four days, Dow Jones Industrial Average (DJIA) plunged 6400 points, or about 26% [2], mostly due to the quarantines and shutting down of businesses imposed by governments across the world. A survey that has sample size of 5800 and conducted between March 28 and April 4 in 2020 shows that 43% of small enterprises had temporarily closed, and nearly all the closures were due to Covid-19 [3]. According to Chris Bradley, in the first month of the crisis, it is apparent to see historically large and rapid declines across almost all industries. The recovery of these industries was far from even, and many industries – aerospace, air and travel, banking, insurance, and oil and gas - remained down significantly from the pandemic peak [4].

Among all industries, there are a few industries that have survived: pharmaceutical, game, and precious metal markets. Indeed, there has been a bullish market for these industries within a short time. The pharmaceutical industry has skyrocketed. At the beginning of the covid-19, Moderna was trading at $15.05 [4]. On March 11, 2020, the day the World Health Organization promulgated the COVID-19 pandemic, Moderna was priced at $23.61 [4]. On February 12, 2021, Moderna's stock was priced at $183.74 [5]. But after that, there has been a sharp decline in the pharmaceutical industry. Some scholars interpreted this as "overreaction." The extreme emotional response to the rapid change

in pharmaceutical stock leads investors to overbuy and oversell the stock, which is caused by greed or fear. Investors assume that the massive exposure to Covid19-related items will lead the pharmaceutical stocks to hit a high price until one day, people realize that the price is inflated. When it is inflated, people start to withdraw their funds. In the game industry, the stock market price increases largely. People in the quarantine are required to stay at home or reduce the frequency of going out. Under these circumstances, people need to find a way to entertain, and this is the time when game shows its advantage. Research has found that video games allow players to have enjoyable ways of maintaining social interaction, releasing stress, and mentally stimulating escape from the effect of lockdown [6]. Due to these benefits, the number of gamers surged. As one of the biggest game distributors, Steam announced a record in its 16-year history: the number of users simultaneously using this platform exceeded 20 million during COVID-19 [7]. Nielsen Games Video Game Tracking (VGT) reported that gamers who claim to have spent more time on electronic-game increased due to the COVID-19 pandemic and has risen since March 23, 2020. Among all the countries that have an increase in the number of gamers, the U.S. (46%) has the highest growth, followed by France (41%), the U.K. (28%), and Germany (23%) [8]. People spend time gaming not only for entertainment purposes but social purposes. Thus, people are more willing to spend more time and money on games. Activities that do not require people to go outdoors gain immense popularity. Tom Espiner states that Japanese gaming giant Nintendo's profits are soaring as a coronavirus boom video continues [9]. Since March 2020, global industry sales have dramatically increased to $10bn (£7.6bn) each month, and this number is still growing each month. Andrew Little, the research analyst at Global X, reported that "In mid-March, this paper saw that consumers spent around 65% more on video games compared to the same period last year [9-10]". The profit before tax of Nintendo company has leaped to approximately 300bn yen (£2.2bn) in the six months to September 30, up from 85bn yen in the same period a year ago [9-10]. Gaming Merchants sold out PS5 consoles, Xbox, and other gaming consoles or equipment quicker than ever because of the pandemic.

Though there is a significant increase in the game's stock market, stockholders began to be rational with a better understanding of the coronavirus. Whether this effect still exists needs to be empirically tested.

The rest of this paper will be organized as follows: Part 2 is the research design, which includes data sources, unit root test, and identification strategy; Part 3 is the result and analysis. It contains VAR identification, impulse response, and ARMA-GARCH model that are used to analyze data. Part 4 is the discussion that will cover the purpose of this research and offer advice for investors. Part 5 will summarize our findings and list the limitations of this research.

2. Research Design

2.1 Data Sources

This paper assumes that changes in the epidemiological landscape in China and elsewhere have an impact on the choices made by Chinese and foreign investors, respectively. Three separate datasets were used to conduct the analysis.

The first dataset that searched from the search engine Choice Financial Terminal, includes the Opening price, the Highest price, the Closing price and some other important numerical variables of the online game industry stock from 2011 to 2022. While the other two datasets show the China's/Overseas' daily increasing amount in the new confirmed cases of COVID-19 since 2020 are collected from National Health Commission of the People's Republic of China and World Health Organization. To analyze the relationship between the three variables, we first filter the datasets with the same date. That is, some vacation dates include weekends are removed from all the three data.

We also mutate a new variable represents for the rate of return defined by formula:

$$return\ rate\ = \frac{(cp_1 - cp_2)}{cp_2} \tag{1}$$

where cp_1 represents for today's closing price and cp_2 represents for yesterday's closing price. Then to build the model, we will also logarithm the three variables and that obtains 3 different log returns, which are $\log(1 + \text{return rate})$, $\log(1 + \text{China increase})$, $\log(1 + \text{oversea increase})$.

2.2 ADF Test

We must first conduct a unit root test (also known as a smoothness test) on the model once it has been constructed. By using Stata to perform the ADF test on the data, the results from Table 1 below shows that the p-value of the log-returns is equal to 0, which is less than 0.1. So, we can reject the null hypothesis which indicates that the model is not smooth. In other words, the model is feasible and stable to be analyzed.

Table 1 ADF test

Variables	t-statistic	p-value
Online game		
Index	-3.094	0.1077*
Yield	-6.006	0.0000***
New confirmed cases		
China	-9.236	0.0000***
Overseas	-17.205	0.0000***

2.3 VAR Model Specification

The vector autoregressive model is a kind of model that does not need to distinguish between endogenous and exogenous variables, and because all the explanatory factors are lag variables, it is able to make prediction in a simple way. To build a VAR model, we only need two conditions: (1) Endogenous/Exogenous variables that will be analyzed; (2) The greatest lagged order.

In this paper, we will have three variables which are Online game logarithmic rate of return, China's daily amount of new confirmed cases and overseas' daily number of new confirmed cases. The maximum lagged order will be confirmed by using Stata. The form of the VAR(p) is:

$$X_t = \sum_{i=1}^{p} \Pi_i X_{t-i} + U_t, \ U_t \sim IND(0, \Omega) \tag{2}$$

where the X_t is a $N \times 1$ time series column vector and U_t is the random error column vector.

2.4 ARMA-GARCH Design

ARMA is a forecasting model that uses well-behaved time-series data to apply the methods of moving average (MA) and autoregression analysis (AR) analysis. In ARMA, it is presupposed that the time series is stationary and that any fluctuations occur uniformly at specific.

The form of ARMA (p, q) model is:

$$x_t = \phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i} + a_t - \sum_{i=1}^{q} \theta_i a_{t-i} \tag{3}$$

where $\phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i}$ represents the AR(p) model and $a_t - \sum_{i=1}^{q} \theta_i a_{t-i}$ represents the MA(q) model.

Specifically, the AR model in this study uses historical returns of the log return rate for the online game industry stock for the COVID period to August 9, 2022, while the MA model forecasts the future using an error term.

This research then develops ARMA-GARCH models for the log returns of the stocks in the online gaming industry. This study adds two exogenous variables—the logged daily total of new confirmed cases in China and those in abroad—to the model for computation. This article will evaluate the relationship between the logged daily number of new confirmed cases in China as well as those in abroad and the logged returns of the stocks of the online gaming industry. The conditional variance is represented autoregressively in the ARCH model and a moving average component can be included as well. As a result, the GARCH(p,q) process is obtained. The form of GARCH (p,q) model is:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2 + \gamma_1 \sigma_{t-1}^2 + \cdots + \gamma_p \sigma_{t-p}^2 \tag{4}$$

where $\alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2$ represents the ARCH part and $\gamma_1\sigma_{t-1}^2 + \cdots + \gamma_p\sigma_{t-p}^2$ represents the GARCH part.

3. Result and Analysis

3.1 VAR Identification

To identify the greatest order of the VAR model, we can compare the results in Table 2. By choosing the minimum values from SBIC and HQIC, we notice that the lag will be either 5 or 6. The lagged order of VAR is not as small as possible. If the order is too small, the error term is prone to autocorrelation. Hence, we will choose lag $p = 5$ within the model.

Table 2 VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-756.723				.002494	2.51981	2.52833	2.54171
1	-337.017	839.41	9	0.000	.000639	1.1576	1.1917	1.2452
2	-237.647	198.74	9	0.000	.000473	.857866	.91753	1.01117
3	-189.286	96.722	9	0.000	.000415	.727316	.812549	.946317
4	-161.23	56.111	9	0.000	.00039	.664114	.774917	.948815
5	-85.4116	151.64	9	0.000	.000312	.442493	.578866	.792894*
6	-64.5939	41.635	9	0.000	.0003	.403297	.56524*	.819398
7	-55.2054	18.777	9	0.027	.0003	.402008	.589522	.88381
8	-49.3763	11.658	9	0.233	.000303	.412525	.625609	.960027
9	-36.7318	25.289	9	0.003	.0003	.400437	.639091	1.01364
10	-25.4689	22.526	9	0.007	.000297	.392932	.657156	1.07183
11	-16.2462	18.445	9	0.030	.000297*	.392193*	.681987	1.1368
12	-10.8725	10.747	9	0.293	.000301	.404221	.719585	1.21452

Before building the model, we should test the stationary of the variables by using unit circle test (Figure 1). It shows that all the points are in the circle which indicates the variables are all feasible.

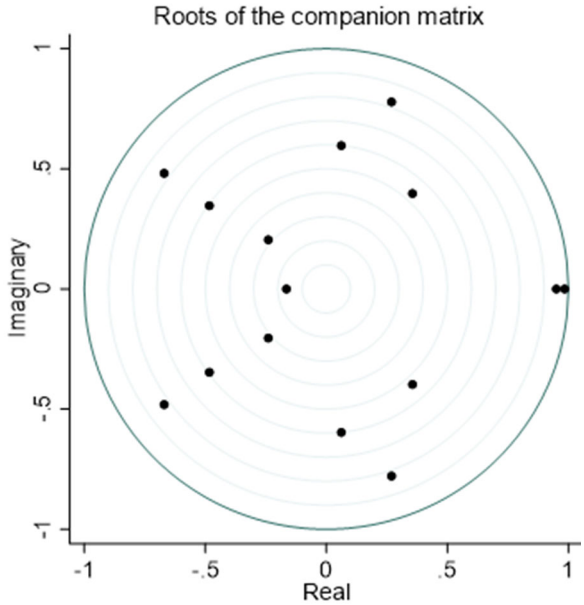


Figure 1 Unit circle test

Therefore, the model VAR (5) will be in the form:

$$Y_t = \sum_{p=1}^{5} \phi_{1p}\, Y_{t-p} + \sum_{p=1}^{5} \beta_{1p}\, X_{t-p} + \sum_{p=1}^{5} \delta_{1p}\, Z_{t-p} + \sum_{p=1}^{5} \varepsilon_{1p}\, A_{t-p} + \sum_{p=1}^{5} \gamma_{1p}\, B_{t-p} + \alpha_1 + e_{1t} \qquad (5)$$

$$X_t = \sum_{p=1}^{5} \phi_{2p} Y_{t-p} + \sum_{p=1}^{5} \beta_{2p} X_{t-p} + \sum_{p=1}^{5} \delta_{2p} Z_{t-p} + \sum_{p=1}^{5} \varepsilon_{2p} A_{t-p} + \sum_{p=1}^{5} \gamma_{2p} B_{t-p} + \alpha_1 + e_{2t} \quad (6)$$

$$Z_t = \sum_{p=1}^{5} \phi_{3p} Y_{t-p} + \sum_{p=1}^{5} \beta_{3p} X_{t-p} + \sum_{p=1}^{5} \delta_{3p} Z_{t-p} + \sum_{p=1}^{5} \varepsilon_{3p} A_{t-p} + \sum_{p=1}^{5} \gamma_{3p} B_{t-p} + \alpha_1 + e_{3t} \quad (7)$$

$$A_t = \sum_{p=1}^{5} \phi_{4p} Y_{t-p} + \sum_{p=1}^{5} \beta_{4p} X_{t-p} + \sum_{p=1}^{5} \delta_{4p} Z_{t-p} + \sum_{p=1}^{5} \varepsilon_{4p} A_{t-p} + \sum_{p=1}^{5} \gamma_{4p} B_{t-p} + \alpha_1 + e_{4t} \quad (8)$$

$$B_t = \sum_{p=1}^{5} \phi_{5p} Y_{t-p} + \sum_{p=1}^{5} \beta_{5p} X_{t-p} + \sum_{p=1}^{5} \delta_{5p} Z_{t-p} + \sum_{p=1}^{5} \varepsilon_{5p} A_{t-p} + \sum_{p=1}^{5} \gamma_{5p} B_{t-p} + \alpha_1 + e_{5t} \quad (9)$$

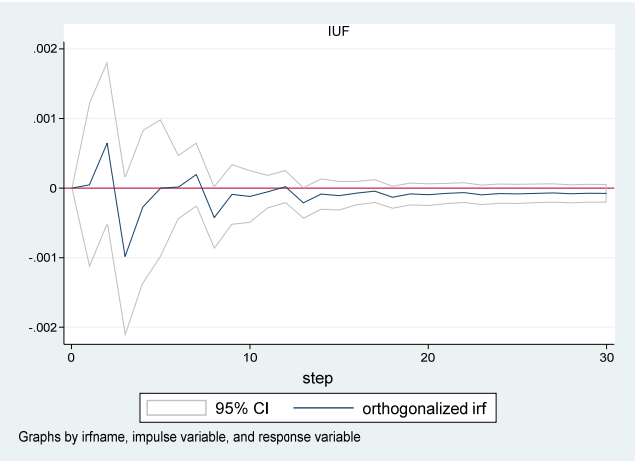
3.2 Impulse Response

Among all industries, there are a few industries that have survived: pharmaceutical, game, and precious metal markets. Indeed, there has been a bullish market for these industries within a short time. The pharmaceutical industry has skyrocketed, but after 2021, there has been a sharp decline. Some scholars interpreted this as "overreaction".

In the long run, with a better understanding of the coronavirus, stockholders began to be rational. Whether this effect still exists needs to be empirically tested.

According to the estimated impulse response results (Figure 2), during the time of t=0, there is an increase of 1% in the number of newly diagnosed cases in China. This has a positive impact on the profitability of the online game industry in the following two phases, with the largest positive effect being about 0.05%. At t=3 and later, negative impacts predominate; the biggest negative effect is roughly 0.1%. After 10 periods, the shock from the present period starts to gradually fade in terms of temporal impacts.

China



Overseas

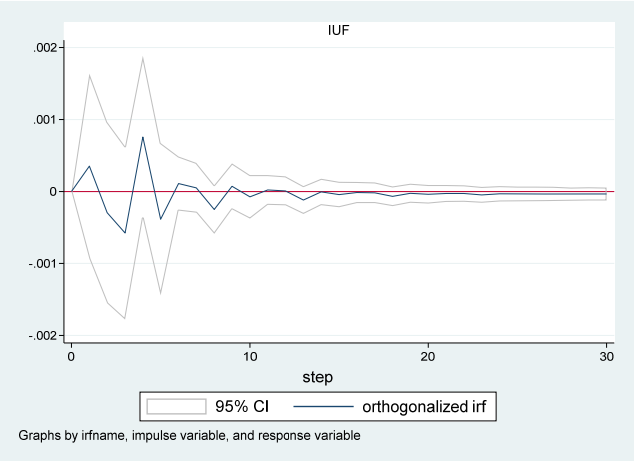


Figure 2 Impulse and response

The results show that investors do not appear to have a "long memory" for past events, and that the game industry's return rate has virtually exactly duplicated history, though with a shorter time interval. One distinction, however, is that investors' concern is no longer as severe in the normalized epidemic situation, and the effects on the profitability of the gaming sector are not as significant. Changes in the quantity of new diagnoses in other countries did not have a comparable impact.

3.3 ARMA

We may deduce the following for the Components based on the cut off of ACF and PACF (Figure 3): The cut off of ACF are all after lags of 14, and PACF tails off at those lags, whereas the cut off of PACF is likewise after lag 14 and ACF is tailing off. As a result, it suggests that $p = q = 14$.

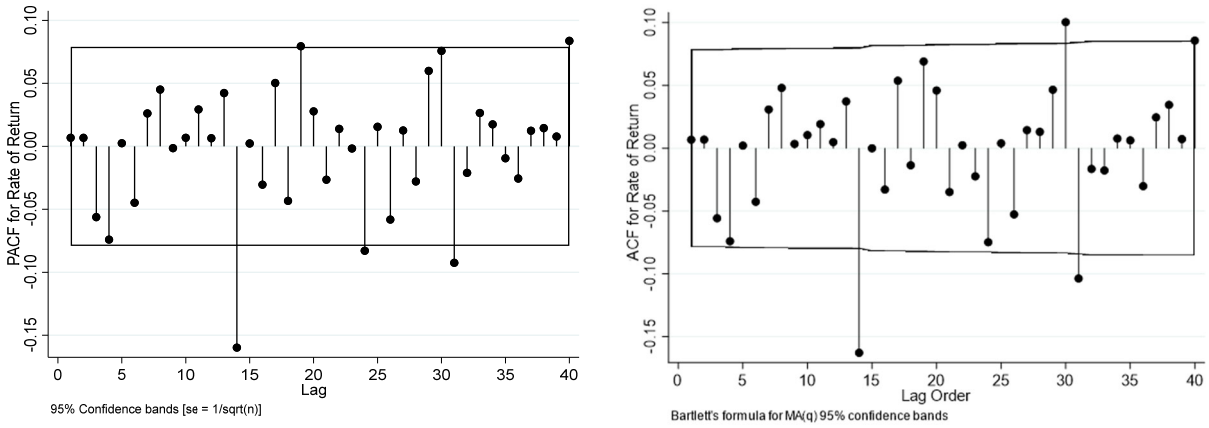


Figure 3 PACF and ACF, SSEC

From the time series diagram (Figure 4), the game rate of the game industry has a relatively obvious clustering, but whether this effect is statistically significant needs further empirical testing.

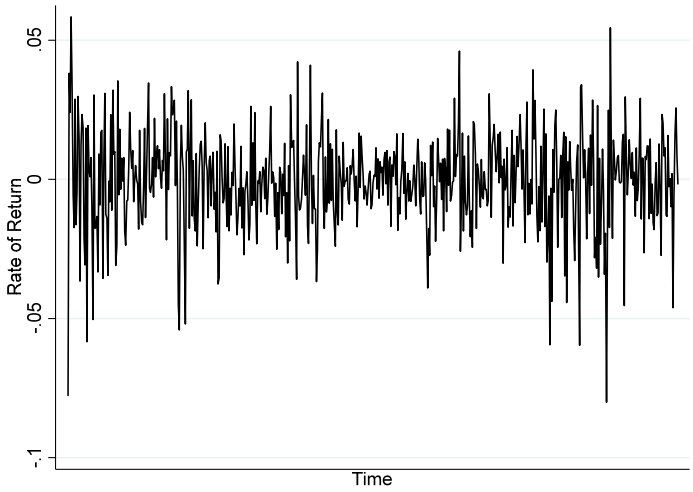


Figure 4 Yield

Now, we can perform the ARMA (14,14) model which is in the form:

$$x_t = \phi_0 + \sum_{i=1}^{14} \phi_i x_{t-i} + a_t - \sum_{i=1}^{14} \theta_i a_{t-i} \tag{10}$$

3.4 ARMA-GARCH

After controlling for autocorrelation in the mean equation, the estimation results of ARMA-GARCH (Table 3) show that the ARCH and GARCH terms in the models in columns (1) and (2) are both significant, demonstrating a statistically significant increase in the profitability of the online game industry. So, it is possible to process GARCH modelling with conditional heteroskedasticity. Since the GARCH model is built to have fewer parameters, we can iteratively reduce ARCH(p) to GARCH (1,1) which is in the form of:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2 + \beta \theta_t \tag{11}$$

where θ_t represents for the external explanatory variables confirmed cases of COVID.

Table 3 ARMA-GARCH estimation results

	(1)			(2)		
	Coefficient	Std. err	p>|Z|	Coefficient	Std. err	p>|Z|
Mean equation						
AR, L14	.1040	.2707	0.701	-.0353	.2833	0.901
MA, L14	-.2421	.2657	0.362	-.1128	.2827	0.690
Constant	-.0005	.0005	0.273	-.0005	.0005	0.306
Vairance equation						
New confirmed cases						
China	.3717	.0554	0.000			
Overseas				-.2274	.0548	0.000
ARCH, L1	.1147	.0318	0.000	.0775	.0202	0.000
GARCH, L1	.7608	.0574	0.000	.8985	.0239	0.000
Constant	-11.8625	.4959	0.000	-9.1109	.6038	0.000

The number of newly diagnosed patients in China grew by 1%, and the volatility of the online game market increased by 0.3717 units, according to the estimated results of external explanatory variables. The coefficient was significant at the 1% level. Confirmed incidents abroad did not affect volatility in the same way as they did in the former article.

4. Discussion

With the eruption of the COVID-19, people are required to be quarantined at home and are away from their friends and family. The game industry, which is easy to access at home, quickly substitute

other entertainment sectors and has become one of the most popular ways to have fun. As researcher Gough reports that, a total of 1.58 million physical games were sold worldwide from March 16 to March 22, 2020 [11]. In some degree, our model reflects the correct and positive relationship between the severity of COVID-19 and game industry.

More than that, the new thing this article discovers is that this positive effect which is contributed from quarantine only works in short run. The impact of pandemic on game industries gradually tends to be less and less significant in long run. Possibly, it is because people found substitution to recover their normal live, such as zoom for work, free of dependence on game.

This article devotes to research how COVID-19 quantitively affects the trend of game industry in both short run and in long run. Through learning the coefficients that impacted on game industry, model can further predict the stock market trend of game industry and lay emphasis on the significant factors to boost the industry.

As an investigator, from theoretical perspective, the Arch model is useful to forecast the variance of future game industries' return by looking at the characteristics of game industries' return volatility. In Arch model, greater volatility in current period or a few past periods means higher probability of greater volatility in future, and vice versa. From the results of ARMA-GARCH estimation, the ARCH and GARCH remain significant, and factors of daily COVID-19 infection in China and Overseas is significant as well, indicating that the volatility of game industries' return become greater with an increase in the daily number of COVID-19 new confirmed cases. Therefore, with the expectation of less COVID-19 infection, investigating game industries should be prudent. From real perspective, nowadays the game market gradually tends to be saturated. At the beginning of the pandemic, most game companies recognized great interest in games and this great interest supports and pushes them to expand scale in a pretty short time. While after the pandemic, as people return to normal life, the demand of game is not as much as before, so the surge size become a surplus and burden now.

5. Conclusion

This paper investigated how game industry in China has been affected and impacted in the short and the long run respectively under the COVID-19 in China and overseas, and to predict the future trend and development of the game industry in China after pandemic. In the experiment, ARMA-GARCH model is mainly used to integrate and analysis the relevant data. The impact on game industry is reflected through the fluctuation in stock returns and the severity of pandemic is reflected by the daily number of COVID-19 new confirmed cases. Through examining the relationship between the stock returns and the daily increased number in China and overseas, the experiment result concludes that game industry is positively affected at the beginning of the pandemic, while turns to be negative in the short run. However, in the long run, the impact is not as significant as before and tend to be stable.

In addition, it should be acknowledged that this experiment exists many limitations. For example, stock can never reflect the situation of game industries in weekend and festival. Stock markets are close for the weekend and festival, while the number of people infect with COVID-19 increases every day. Especially, in China, the eruption of COVID-19 happened with Chinese New Year coincidently. Therefore, how COVID-19 impacts game industries at the beginning of the pandemic is unable to be reflected in this research. In the future further investigation, the experiment can choose other references to reflect the situation of game industries.

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