External Event Crises on The Stock Market: Taking Japan's Sea Discharge Incident as An Example

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Abstract. On August 22, 2023, the Japanese government announced that it would start discharging nuclear wastewater into the sea from August 24. This decision was widely questioned and opposed by the international community and caused strong concerns in Japan. This article aims to take the Japanese nuclear sewage discharge incident into the sea as an example to explore the impact of social crisis on Japan's domestic stock market. The main research method of this article is based on stock return analysis, using the ARIMA model to predict the Japanese stock price trend after excluding the impact of this event, and then comparing it with real data. The results of this study provide evidence that the predicted stock prices are close to the actual stock prices, indicating that as of mid-September, there was no short-term negative impact on the Japanese stock market due to the event, but from a long-term perspective, the predictions remain It is uncertain whether stock prices in Japan's financial markets will fall because of this incident. The main conclusion drawn from this study is that external events may not have a large impact on stock prices in the short term. Different from previous literature, this study uses ARIMA analysis on daily data and weekly data to obtain the relationship between them. Recommendations include organizing a team of experts; hiring a legal team; establishing a complete procedure to handle social media information, and having a dedicated public relations team may be helpful.

Keywords: International events, Stock returns, Japan, ARIMA model.

1. Introduction

On August 22, 2023, the Japanese government officially announced after holding a relevant cabinet meeting that the nuclear wastewater used for cooling the Fukushima nuclear power plant on August 24 will be diluted and directly discharged into the high seas two years later. This decision triggered It has aroused serious concerns and widespread worries among the Japanese people, neighboring countries, and the inter-national community. The voice of resistance is particularly strong in Asia, especially Japan's neighboring countries, China, South Korea, North Korea, and Russia. Chinese Foreign Ministry spokesperson Wang Wenbin responded on August 21 that the Japanese government's push for a plan to discharge nuclear-contaminated water into the sea was a serious breach of trust [1], which directly led to the China General Administration of Customs imposing sanctions on Japan - suspending the import of Japanese aquatic products because Products exported from Japan to China may have risks of radioactive contamination. BBC also published a discussion on whether Japan's nu-clear wastewater discharge is safe. The article pointed out that time factors and legal factors are the key points that need to be paid attention to. After all, no one can guarantee that this incident will not have subsequent and potential impacts [2]. In addition, the scientific community has also expressed its opinion. The scientific community, including the Helmholtz Marine Research Center in Kiel, Germany, pointed out through simulation analysis that the nuclear radiation produced by the discharge of nuclear wastewater into the sea can spread to the ocean in just 57 days with ocean currents. It covers most of the Pacific Ocean and spreads around the world through the ocean circulation system. The radioactive isotopes in it flow into the human body and other animals and plants through marine life and seawater, which will be a disaster for the whole world and all mankind. Not only will the aquatic products and related food industries in the Asia-Pacific region be the first to be affected, but it will also spill over to other industries and pose a huge threat to them; of course, it will not only cause disasters to other countries, but also the reverse. It has caused an unbearable blow to Japan's economy and society [3].

This article explores the possible short-term or long-term impact of the Japanese sea discharge incident on Japan by reviewing the literature on previous external events that had a huge impact and analyzing relevant data. This study proposes a method for quantitative analysis of international events, filling the gap in previous literature in this field that did not use the ARIMA model to predict international events and stock prices. This research can provide some suggestions for policymakers when important international events occur.

The structure of the rest of this article is as follows: The second part is a literature review, including related research on similar cases and the impact of external events on the country and society. Finally, the literature review is summarized. The following Section 3 provides information on data sources, data stationarity and model description. After that, the fourth part will use the relevant data obtained to conduct ARIMA model analysis. The results will also be discussed in Section 4 and can be used to demonstrate the impact of Japan's sea discharge on Japan's stock prices. Next, Section 5 discusses the professionalism and purpose of the study and how to understand and use the findings of this article from the perspectives of government and investors respectively. Finally, Section 6 briefly reiterates the conclusions.

2. Literature Review

2.1. Studies Related to Previous Similar Incidents

The reason why this incident in Japan has such a big impact is that there have been similar external incidents before, such as The Deepwater Horizon oil spill, also known as the Gulf of Mexico oil spill, the largest maritime oil spill in history, was caused by an explosion on April 20, 2010 on the Deepwater Horizon oil drilling in Gulf of Mexico, about 66 kilometers (41 miles) off the coast of Mexico, the USS Louisiana - and the subsequent sinking of the ship on April 22. This incident resulted in a very dire situation for the Gulf Coast states, as the oil spill affected not only the environment but also many industries that residents depended on for their survival. At the same time, many people face unemployment because few tourists are willing to face oil- contaminated beaches, making it difficult for those who rely on tourism to supplement their income [4]. This means that the stock prices of many industries will plummet, and even to the point of bankruptcy.

In addition, there is an epidemic event in 2020. At the beginning of 2020, the emergence of new coronavirus pneumonia (COVID-19) became an international pandemic. The impact of the pandemic was felt almost immediately in the stock market. Lockdowns were imposed across the world, leading to business closures and mass layoffs. This resulted in significant supply chain issues. In addition, some economic problems are also being felt in global financial markets. This is also a manifestation of the impact of external events on financial markets [5].

2.2. External Events on Business

Today, the entire world is connected by globalization. Globalization basically views the world as an interconnected market rather than a single independent market. To succeed in the era of globalization, governments and companies must adapt to different cultures and adopt a flexible approach to updating strategies. The risks of entering global markets are high, but if successful, the rewards are unparalleled [6]. On the other hand, globalization also means that any action taken by a government or company, that is, external events will affect all aspects of an industry or policy. Therefore, the impact of external events on companies or the entire country's financial markets is crucial.

2.3. Review of the Literature

Overall, these previous studies highlight the impact of external events on financial markets. External events can have a very good impact on countries and enterprises, driving the prosperity of the entire economy and financial markets, but they may also bring unpredictable risks and losses. Furthermore, despite the temporary damage to the Japanese government 's reputation, these events had no long-term impact on the stock market. Therefore, the impact of external event risks on businesses and even governments remain difficult to predict. Therefore, this article aims to further fill the research gap in this field, taking the Japanese sea discharge incident as an example, and using empirical data to quantitatively demonstrate the impact of acoustic external event risks on the stock market.

3. Research Design

3.1. Data Source

This article uses the daily and weekly closing stock prices of the Japanese stock market from September 27, 2013, to September 27, 2023, from investment. In fact, the data used in the modeling below only includes the period up to August 22, 2023, as this study aims to predict the original movement of Japanese stock prices, excluding the impact of the announcement of a nuclear wastewater discharge into the sea. The rest of the data is for comparison purposes only. To put it into context, stock return is calculated by dividing the difference between the two days ' closing prices by the previous day's closing price. Assume that the original data is index1, use the formula $ln(1 + index1)$to convert the data, and continue the study on the logarithmic scale. In the analysis below, some missing data for specific dates are omitted. Stata was the primary tool used in this study to process and analyze the following portions of data.

3.2. Augmented Dickey -Fuller (ADF) Unit Root Test

In statistics, the unit root test is a common tool for determining whether a given time series is stationary [7]. In this analysis, the ADF unit root test is used. For the ADF unit test, the null hypothesis is that the data are non-stationary and have a unit root. According to the ADF test processed in Stata, Table 1 shows that the p-value of the original daily data is 0.0254, which is greater than the significance level of 0.05. Table 2 shows that the p-value of the original weekly data is 0.0279, which is greater than the significance level of 0.05. Therefore, there is no valid evidence to reject the null hypothesis. The difference between consecutive observations needs to be calculated because the difference can help eliminate the unit root. After two differences, the p-value of the processed data is 0, as shown in Table 1. This means there is enough evidence to reject the null hypothesis. Therefore, the data after the second difference is stationary.

Table 1. Weak stationarity test

	t	p
Daily		
Ln index	-3.657	0.0254
1st order difference	33.617	0
2nd order difference	-58.336	0
Weekly		
Ln index	-3.623	0.0279
1st order difference	-17.045	0
2nd order difference	-28.932	0

3.3. Autoregressive Integrated Moving Average (ARIMA) model specification

ARIMA is an acronym for “autoregressive integrated moving average.” [8] It is an efficient and powerful tool in short-term financial time series prediction. It has been widely used in economic and financial fields. It always has better performance than other complex models in short-term prediction. If the variables in the ARIMA model are linear combinations of past values and past noise, the future values can be written as:

$$y_t = c + \phi_1 y_{t-1} + \cdots + \phi_p y_{t-p} + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (1)$$

Where y_t is the actual difference sequence, ε_t is the random error at t, ϕ_t and is θ_q the coefficient. The integers p and q are often called autoregressive and moving averages, respectively.

The ARIMA model combines the autoregressive (AR) model and the moving average (MA) model. It can be written as ARIMA (p, d, q). p represents the order of the autoregressive model, d represents the difference time, and q is the order of the moving average model.

4. Empirical Results and Analysis

4.1. Model Ordering Identification

To determine the order of ARIMA (p, d, p), the study of correlated autocorrelation and partial autocorrelation will be helpful. The values of p and q are estimated by examining the autocorrelation factor (ACF) and partial ACF (PACF). After the second difference, the time series is stationary. Therefore, the value of d is 2. By observing and analyzing Figure 1 below, the first significant spike in the daily data is located at lag 9 in the PACF chart, which indicates that the order of AR(p) is 9 and the value of p is 9. There is a significant peak at lag 1 in the ACF plot. It represents that the order of MA(q) is 1 and the value of q is 1. Therefore, the ARIMA model for the entire daily data can be determined by ARIMA (9,2,1). Similarly, by observing and analyzing the PACF chart of weekly data, the first significant peak is located at the last 6 points in the PACF chart, which means that the order of AR (p) is 6 and the value of p is 6. There is a significant peak at lag 2 in the ACF plot, which represents that the order of MA(q) is 2 and the value of q is 2. Therefore, the ARIMA model for the entire weekly data can be determined by ARIMA (6, 2, 1).

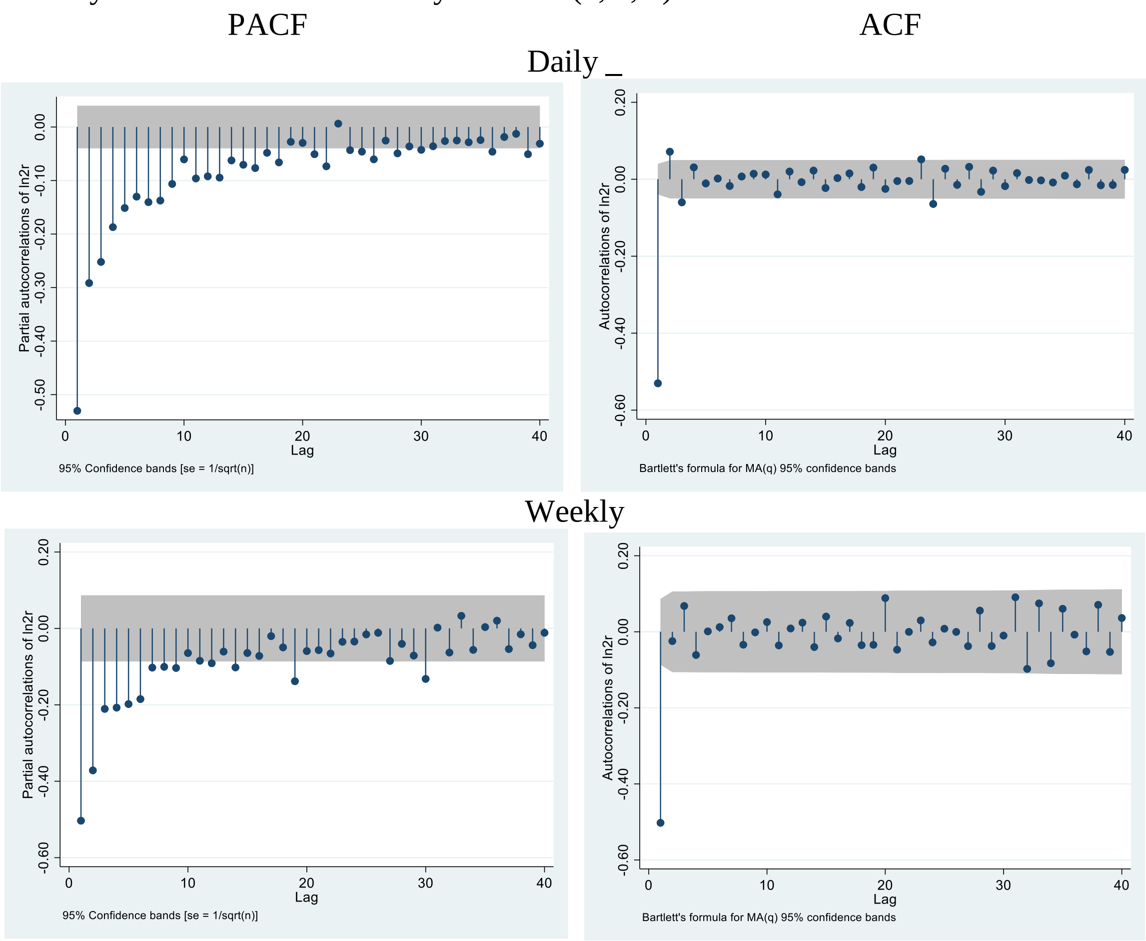

Figure 1. ARMA (p, q) identification

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4.2. Estimate Results

To test the performance of the obtained ARIMA model, a mixture test needs to be derived. This article uses the Ljung-Box test. This test was introduced by Ljung and Box in 1978 and is more accurate than the original test proposed by Box and Pierce in 1970 because the modified statistic can standardize residual autocorrelation [9]. The mixed test statistic is based on:

$$Q = T(T+2)\sum_{k=1}^{\ell}(T-K)^{-1}\gamma_k^2 \tag{2}$$

Where γ_k is the autocorrelation at lag k, and T is the number of observations.

The null hypothesis is that the model does not show lack of fit, which means that there is no significant autocorrelation in the residuals. As can be seen from Table 2, the p-value of daily data is 0.9902, and the p-value of weekly data is 0.9884, which is relatively large.

Table 2. Residue testing

Model _	Portmanteau (Q) statistic	Prob>chi2
Daily -ARIMA(9,2,1)	22.1269	0.9902
W eekly -ARIMA(6,2,1)	22.5040	0.9884

Therefore, there is no valid evidence to reject the null hypothesis. It means that the residual is indistinguishable from a sequence of white noise. Therefore, both daily data ARIMA (9,2,1) and weekly data ARIMA (6,2,1) can fit the required data well, so both models can be used for forecasting.

4.3. Forecasting and Analysis

This article aims to analyze the impact of the Japanese government's announcement of the discharge of nuclear sewage into the sea on the Japanese stock market. To achieve this goal, the daily closing price trend of stocks excluding the impact of the nuclear wastewater discharge incident can be compared with the actual raw trend. Using the two sets of models obtained above for daily data ARIMA (9, 2, 1) and weekly data ARIMA (6, 2, 1), the trend after excluding the impact of the nuclear sewage incident can be found. This study uses the above model to predict the closing price of Japanese stocks from August 22, 2023, to September 27, 2023, and then compares it with real data.

The results are shown in Figures 2 and 3. From Figure 2, the red line represents the predicted value through the daily data ARIMA (9,2,1) model, while the blue line represents the actual closing price of Japanese stocks. These two trends are similar. Between August 22nd and August 24th, Japanese stocks rose slightly, which shows that Japan's announcement of discharging nuclear sewage into the sea did not immediately have a significant impact on Japanese stock prices. This means that the stock price itself should rise. On August 25, the stock price dropped significantly, reaching its lowest point within a month. This may be due to the opposition of Japan's neighboring countries such as China, South Korea, North Korea, and Russia to sanctions, such as China's suspension of Japan's import of aquatic products [10], which played a certain role. This also coincides exactly with the fitted values. However, after August 25, compared with the fitted value with minimal fluctuations, the actual value was much larger than the fitted value, and the difference was very large, which means that the Japanese nuclear wastewater discharge event occurred within a few days of the event. There is indeed an impact, but the impact is not sustainable. Another possible reason is that this incident only aroused strong attention and protests from neighboring countries and did not have an important impact on other countries.

From Figure 3, the predicted value of the ARIMA (6, 2, 1) model through weekly data, while the blue line represents the actual closing price of Japanese stocks. These two trends are similar. The fitted values start to be predicted after August 22, and the actual values differ greatly in the two weeks from August 22 to September 10, and even reach the maximum difference on September 10. But after September 10th, the difference gradually narrowed, and around September 24th the actual value and the fitted value reached overlap. This means that there was no strong impact on Japanese stocks after this incident initially occurred. But as time goes by, the price of Japanese stocks continues to fall. This may be because this incident has a huge negative impact on the natural ecology and marine environment and has an impact on the profits of various industries.

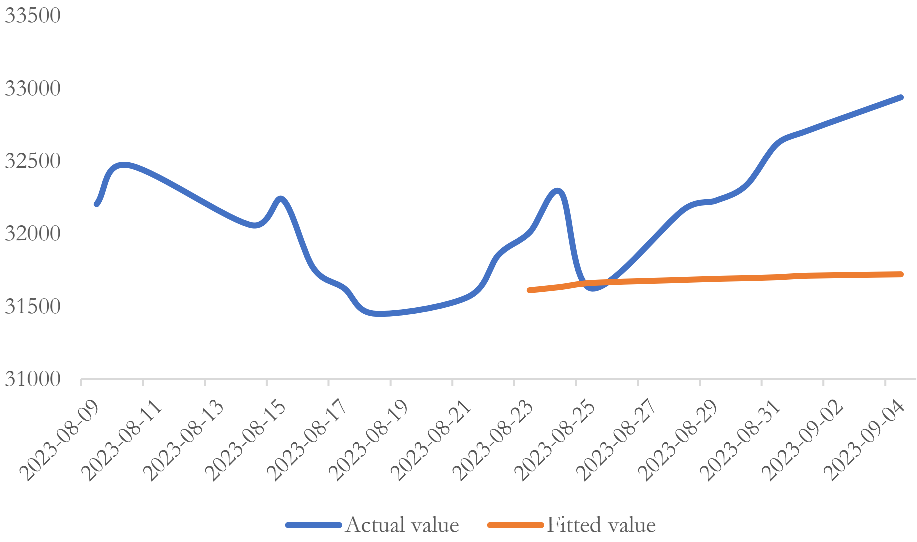

Figure 2. Actual value and fitted value, daily
Photo credit: Original

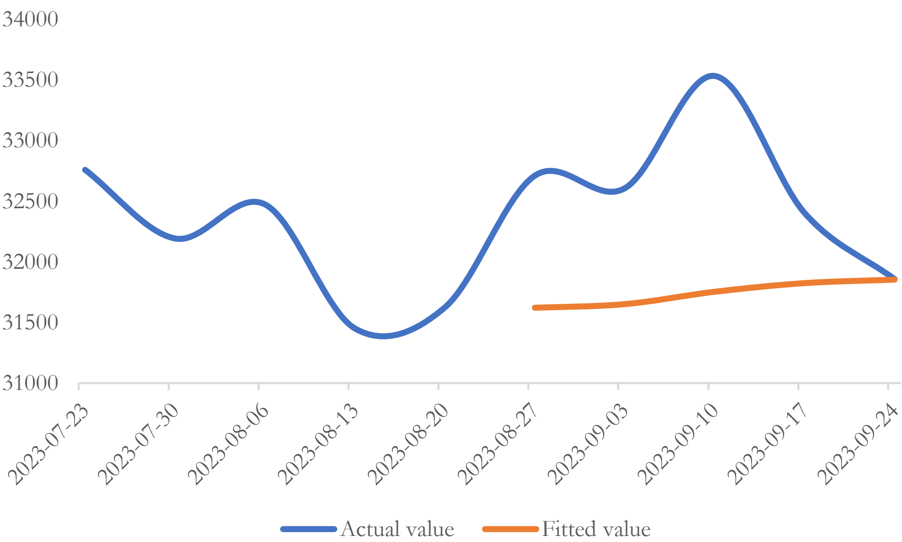

Figure 3. Actual value and fitted value, weekly
Photo credit: Original

5. Discussion

Compared with previous literature, this paper focuses on how external events quantitatively affect Japanese stock returns, specifically discussing this impact through ARIMA model forecasts. Previous articles have studied stock market performance using entirely qualitative methods or using some other quantitative method (ordinary least squares regression models). Furthermore, although some previous papers have investigated the impact of social media on stock market performance, their conclusions and themes relate more to entire industries or countries rather than to specific companies. This article derives the ARIMA model to analyze the impact of external events on the Japanese stock market. It fills the gap of a few studies using ARIMA models to estimate the impact of external events by predicting possible trends when the event does not occur.

Through this article, policymakers can pay more attention to the impact of external events on the country and the entire social economy and financial markets. Managers can organize a team of experts to evaluate and produce professional reports, or they can launch public opinion surveys to investigate the reaction of the country's people to this decision, and then issue corresponding policies accordingly, which is conducive to the rationalization of policies; they can also hire a legal team to provide legal advice. National policies should formulate correspondingly complete legal provisions to provide a legal template and requirements for subsequent policy decisions; in addition, a complete procedure can be established to handle social media information, and a dedicated public relations team may be helpful. This will help companies gain a more timely and clear understanding of what is being said about the company on social media. Although this article proves that Japan's sea discharge incident had little impact on the stock market in the short term, the long-term impact is still unknown.

6. Conclusion

The purpose of this study is to explore the relationship between external events and the stock market. By deriving quantitative methods, this article chooses to implement the ARIMA model process in Stata and predict possible future data. After transforming the data to stationary, select the desired model by observing the corresponding ACF and PACF plots. Then, it is necessary to adopt Ljung-Box test to check the model performance. Finally, this paper obtains the predicted values and draws conclusions by comparing the actual data and the fitted data.

In summary, this article demonstrates that the impact of external events on the stock market will not have much impact in the short term, but the long-term impact is still unknown. In the case of Japan's sea discharge that this article focuses on, the news of Japan's sea discharge only had an impact on neighboring countries, and reports from professional organizations stated that it would not have a major impact in the short term. The company's stock price trend predicted in this article is very different from the actual trend in the short term, but it seems that the difference between the actual value and the fitted value in the long term tends to become smaller. As a result, the impact of external events is becoming increasingly important, providing a good opportunity for policymakers to reflect on and improve practice.

The goal of this study is to examine the relationship between social scandals and business. By deriving a quantitively method, this paper chooses to implement ARIMA model process in Stata and predict the possible future data. After transforming the data to be stationary, the required model is selected by observing the corresponding ACF and PACF plot. Then, employing a Ljung-Box test to check the model performance is necessary. Finally, this paper obtained the predicted values for the next 10 days and deduce the conclusion by comparing the actual and fitted data.

In summary, this paper demonstrates that the impact of the social scandal on the company is only a short-term shock, and there is not exist lasting effect. In the case of the BMW ice-cream focused on this paper, The company's timely approach resulted in the scandal not having a significant impact on the actual financial operation of the company. This article predicts a trend in the company's stock price that is very close to the actual trend, excluding the effect of events. Moreover, the differences between the actual and fitted value are also very small. Hence, it is a good opportunity to or managers, policy makers and investors to reflect on and improve their practices since social media becomes more and more important in real life.

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