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The Impact of China's COVID-19 Prevention and Control Measures Release on Japan's Air-transportation Industry

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Abstract: On December 7th, 2022, the Chinese State Council held a press conference and released a notification on further optimizing the COVID-19 control policies. This signifies that all COVID-19 pandemic control measures in China have been eased. The transformation in the Chinese government's attitude towards COVID-19 prevention and control has had a significant influence on China's market and most industries. This change has also had an undeniable impact on certain industries, especially the air transportation industry in developed countries around the world, including Japan, which is China's most important neighboring country. This paper focuses on the Japanese air transportation industry, specifically analyzing the Nikkei-500 and TOPIX indices. It collects weekly closing data from April 26th, 2020, to April 23rd, 2023, and utilizes the ARIMA model to analyze the data. The aim is to explore how the Japanese air transportation industry has been affected by the relaxation of COVID-19 pandemic control policies in China. Furthermore, this paper discusses the insights gained from the research findings and provides advice for policymakers and investors.

Keywords: China, Japan, COVID-19, control measures, release, air-transportation, ARIMA model

1. Introduction

Since the COVID-19 pandemic rapidly spread throughout China and beyond, the Chinese State Council and provincial governments adopted extremely strict prevention and control measures to contain the epidemic. While these measures effectively controlled the epidemic in China, they also had a serious and negative impact on the country's economic development. Furthermore, due to China's crucial role in the global economy and international trade, the industrial development of many countries was affected. In response to the rapid spread of the COVID-19 pandemic, the Chinese government implemented a series of policies to reduce the number of inbound tourists, with the main measure being a circuit breaker arrangement for international passenger flights. According to the Civil Aviation Administration of China, if five passengers test positive on a flight, the airline's operations will be suspended for two weeks. Additionally, if the number of positive cases reaches ten, the suspension will be extended to four weeks. This specific policy resulted in a significant decline in the frequency of flights between Japan and China.

On November 12th, 2022, the Chinese State Council released a notification on further optimizing COVID-19 control policies, which included 20 new measures. However, these policies did not alleviate China's fiscal pressure, and opposition to COVID-19 prevention and control measures in society

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grew stronger. Under pressure from financial constraints and public opinion, the Chinese government lifted all COVID-19 prevention and control measures starting from December 7th, 2022.

The main objective of this paper is to utilize the ARIMA model to predict the air transportation indices, Nikkei-500 and TOPIX, in Japan after the easing of China's epidemic prevention and control policies. The paper aims to observe the impact of the removal of China's COVID-19 pandemic control measures on Japan's air transport industry by comparing the forecasted data with the actual data of Japan's air transportation indices. The inclusion of both Nikkei-500 and TOPIX indices in this research is because they are the two major stock indices in Japan. Together with their sub-indices, they track large Japanese listed stocks. The Nikkei-500 is price-weighted, while the TOPIX is market capitalization-weighted. Including the air transport index from both these stock indices enhances the accuracy, persuasiveness, and comprehensiveness of the results.

The remainder of this paper is structured as follows: Part 2 presents the literature review, which includes studies related to the influence of COVID-19 pandemic control policies in China and research on Japan's response to the COVID-19 pandemic. This is followed by Part 3, which introduces the data sources, explains the division of training and testing data, tests the stationarity of the data, and describes the construction of the ARIMA model. Next, ARIMA models are identified using ACF and PACF plots, and combined plots of actual and predicted values are generated to visualize the impact. The total effect and net effect are then calculated based on the fitted values, actual values, and market returns, leading to the research findings. Finally, Parts 5 and 6 discuss the similarities and differences between the conclusions of this paper and the opinions in the literature, highlight the implications of the research results, and provide suggestions for investors and policymakers. A conclusion is then provided to summarize the research.

2. Literature Review

2.1. Studies Related to the Influence of China’s COVID-19 Prevention and Control Policies

The COVID-19 pandemic has been persistently spreading in China and many countries around the world for the past three years, resulting in significant public concern within the international community. To mitigate the impact of the COVID-19 pandemic, most cities in China have implemented extremely strict prevention and control policies to contain the epidemic. These measures include home quarantine, transportation restrictions, and inbound travel controls, which have had a severe impact on international trade and labor employment in China, ultimately dealing a heavy blow to the country's economic system. Tan argues that due to the COVID-19 prevention and control measures, Chinese companies and activities associated with transportation and service sectors have been among the most affected, resulting in increasing economic losses [1]. However, Liang argues that the "COVID-zero" strategy, which is the primary policy for COVID-19 epidemic prevention and control in China, has allowed for the resumption of economic activities within a few months and has had a positive effect on economic recovery [2]. Conversely, Ali contends that the "COVID-zero" strategy is unreasonable and has a negative impact on China's foreign trade, leading major cities like Shanghai to suffer significant losses [3]. Regarding the negative influence of China's COVID control policies on the tourism industry, Wang suggests that sectors such as restaurants, accommodations, entertainment, and trade services have been severely impacted by the "COVID-zero" strategy in China, with the transportation industry facing tremendous challenges [4]. Additionally, Zhao notes that the number of international flights between China and other countries has decreased by over 90% due to China's epidemic control policies [5]. Furthermore, Hu highlights that the number of international passengers decreased by 98.7% in April 2020 and has remained stagnant due to the circuit breaker arrangement for international passenger flights [6].

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2.2. Research about the Japan's Response to the COVID-19 Pandemic

The COVID-19 pandemic has also had a significant impact on Japan's economic development. According to Phillip, the pandemic has dealt a devastating blow to Japan's already struggling economy, resulting in a significant regression in its real GDP and causing tremendous losses for domestic industries [7]. Furthermore, Ines points out that Japan's economy has been directly affected by the disruption of flows with its largest trading partner, China [8]. On the other hand, as the COVID-19 pandemic rapidly and continuously spread in Japan, the Japanese government implemented travel restrictions and advised people to refrain from nonessential outings to control the spread of infections. Liu suggests that these measures have further exacerbated the challenges faced by Japan's tourism industry, which was already impacted by the pandemic, and have undermined the stability of the local economy [9]. Additionally, Kumpol highlights that the number of Chinese tourists in Japan has significantly decreased since March 2020. The ongoing pandemic, along with soaring airfares, burdensome entry screening policies, and isolation measures, have seriously dampened people's enthusiasm for traveling abroad [10]. Regarding the impact of the COVID-19 pandemic on Japan's air transport industry, Okazaki explains that the implementation of restrictive border measures by many countries has hindered air traffic movement and caused significant damage to Japan's aviation industry [11].

2.3. Review

From the literature mentioned above, it can be observed that most studies related to the influence of COVID control measures in China indicate that China's response to the COVID-19 pandemic has had a negative impact on its domestic economic activities, foreign trade, and tourism industry. It has also resulted in a significant decrease in outbound tourists and international flights from China. Moreover, research on Japan's response to the COVID-19 pandemic demonstrates that the pandemic has had a negative influence on Japan's industrial economy, and China's COVID control policies have strongly affected Japan's tourism and air transport industry.

However, based on the available literature, it is not possible to ascertain how the Japanese air transport industry has been specifically affected by the relaxation of China's control policies regarding the pandemic. Therefore, this paper aims to address this research gap by utilizing empirical data and a logical analytical approach.

3. Research Design

3.1. Data Source

This paper utilizes investing.com, which is recognized as one of the world's most reputable and professional financial platforms. This website provides market quotes and accurate information on stocks, options, analysis, and commodities. The paper leverages this platform to search for and obtain the Japan's air-transportation index of Nikkei-500 and TOPIX. Subsequently, the data of weekly closing prices from April 26th, 2020 to April 23rd, 2023 is selected. Following this, the data is divided into training data and testing data, with December 7th, 2022 being the dividing point corresponding to the release of COVID-19 control measures in China. The training data covers the period from April 26th, 2020 to December 4th, 2022, while the testing data encompasses the period from December 11th, 2022 to April 23rd, 2023.

3.2. Stationarity Test

Prior to establishing the ARIMA model, it is crucial to conduct a stationarity check. In this paper, the ADF (Augmented Dickey-Fuller) test is utilized to test for the presence of a unit root and determine

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the stationarity of the training data. If the p-value in the test result is less than 0.05, it suggests that the ADF test has been passed and confirms that the data is stationary. Conversely, if the p-value is greater than 0.05, it indicates that the data is non-stationary, and it becomes necessary to transform the data through differencing to ensure the series exhibits stationarity and can be used in establishing ARIMA models.

This section initially applies a logarithmic transformation to the training data and employs the ADF test to check for stationarity. According to Table 1, the results indicate that the p-values for both the Nikkei-500 and TOPIX data are not less than 0.05. This implies that both series fail to pass the test and are non-stationary. Subsequently, after differencing the logarithmic-transformed data, it can be observed that the p-values for both the Nikkei-500 and TOPIX data are now less than 0.05. This signifies that the series, referred to as the yield, obtained through the differenced logarithmic transformation, are stationary and suitable for utilization in ARIMA modeling.

Table 1: ADF test.

Variables	t-statistic	p-value
Price		
Nikkei 500	-2.9443	0.1836
Topix air	-3.302	0.07388*
Yield		
Nikkei 500	-4.901	0.01***
Topix air	-5.1787	0.01***

3.3. Model Specification: ARIMA

ARIMA is an acronym for Auto Regressive Integrated Moving Average. The full model can be seen from Formula (1).

$$y_t' = c + \phi_1 y_{t-1}' + \cdots + \phi_p y_{t-p}' + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (1)$$

In this model, the y_t' is the differenced series, and the "predictors" on the right-hand side include both lagged values of y_t and lagged errors. Separately, $c + \varepsilon_t + \phi_1 y_{t-1}' + \cdots + \phi_p y_{t-p}'$ is the autoregression model which forecast the variable of interest using a linear combination of past values of the variable, and $c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}$ is the moving average model which uses past forecast errors in a regression-like model. This can be called an ARIMA (p, d, q) model, where "p" is the order of the autoregressive part, "d" is the degree of first differencing involved, and "q" is the order of the moving average part.

4. Results and Analysis

4.1. Model Identification

Based on the results depicted in Figure 1, which display the ACF and PACF plots of the differenced logarithmic data from Nikkei-500 and TOPIX, it is evident that there is at least one lag outside the confidence interval, indicating a significant autocorrelation in each plot. This observation suggests that all the plots do not exhibit characteristics of white noise, thereby allowing for the continuation of ARIMA modeling.

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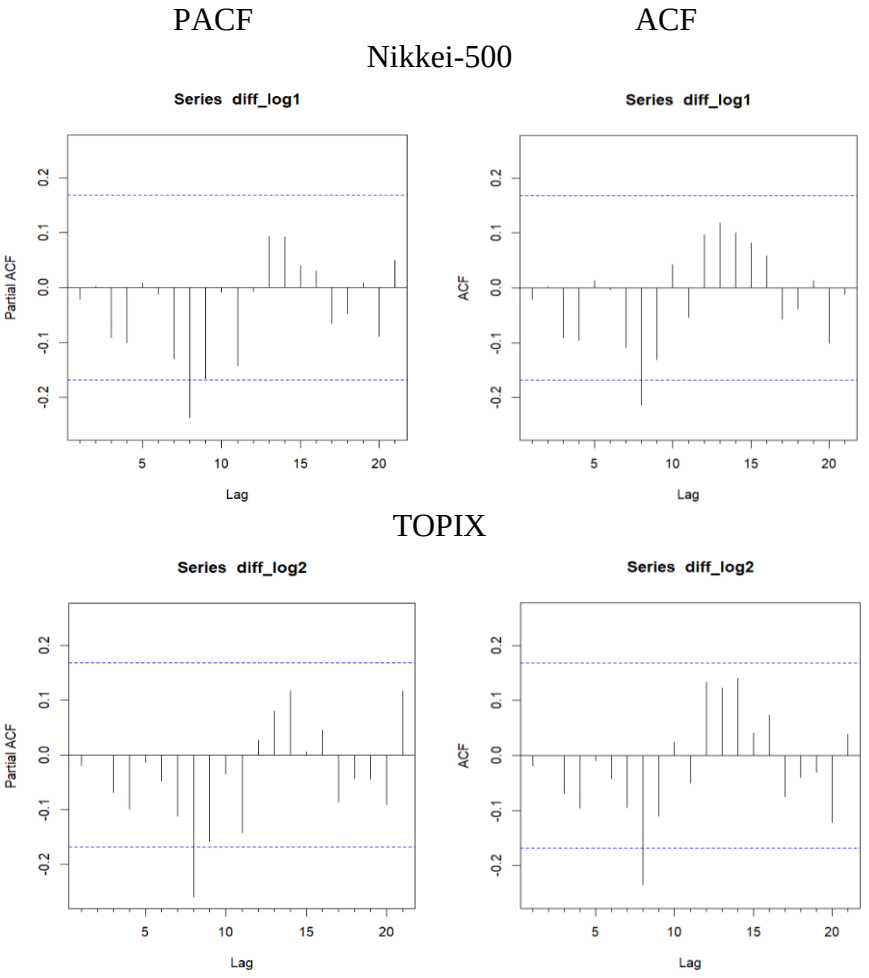

Figure 1: PACF and ACF (Photo credit: Original).

As observed in Figure 1, the ACF plot of the selected data from the Nikkei-500 air-transportation index reveals that lag 8 falls outside the confidence interval, indicating significant autocorrelation. Furthermore, the PACF plot of the Nikkei-500 also identifies lag 8 as an outlier. These findings suggest that for the Nikkei-500 case, the values of "p" and "q" in the ARIMA (p, d, q) model are both 8. Additionally, the value of "d" can be determined as 1 since the training data of the Nikkei-500 air-transportation index has undergone first-order differencing.

Similarly, the ACF plot of the TOPIX data reveals that lag 8 is an outlier with significant autocorrelation. The PACF plot of TOPIX also shows that lag 8 falls outside the confidence interval. These observations indicate that for the TOPIX case, the values of "p" and "q" in the ARIMA (p, d, q) model are both 8. Additionally, the value of "d" can be determined as 1 since the data of the TOPIX air-transportation index has undergone first-order differencing.

Based on the analysis of Figure 1, this paper concludes that the ARIMA (8, 1, 8) model will be used to fit and predict the air-transportation index data for both the Nikkei-500 and TOPIX.

4.2. Prediction Analysis

After fitting the training data of the Nikkei-500 and TOPIX in R Studio using the ARIMA model identified above, this paper obtained the results, including the coefficients and standard errors of each AR and MA lag for the Nikkei-500 and TOPIX cases, as shown in Table 2.

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Table 2: ARIMA Model.

	(1) Nikkei 500		(2) Topix air	
	Coefficient	s.e.	Coefficient	s.e.
AR				
L1	0.7500	0.1454	0.5664	0.1915
L2	-0.1173	0.0839	-0.1357	0.1036
L3	0.0347	0.0772	0.0889	0.0874
L4	-0.4454	0.0867	-0.3529	0.0925
L5	0.0491	0.0792	-0.0406	0.0885
L6	-0.3566	0.0811	-0.4366	0.0901
L7	0.7890	0.0905	0.6441	0.1355
L8	-0.6957	0.0951	-0.6256	0.1367
MA				
L1	-0.8966	0.1805	-0.6764	0.2147
L2	0.2202	0.1103	0.1443	0.1304
L3	-0.1113	0.1031	-0.2084	0.0939
L4	0.4757	0.0976	0.4062	0.1003
L5	-0.0131	0.1044	0.0599	0.1075
L6	0.3357	0.0980	0.4797	0.0954
L7	-1.0939	0.1191	-0.9513	0.1441
L8	0.7130	0.1653	0.4899	0.2003

From the parameters in Table 2, it can be noticed that in the case of Nikkei-500, the $|t|$ which can be calculated by the formula $|\frac{coefficient}{s.e.}|$ of L1, L4, L6, L7 and L8 of AR, and L1, L2, L4, L6, L7 and L8 of MA are larger than 1.96. That means these lags are significant in the forecasting result. In the case of TOPIX, it can be confirmed that the $|t|$ of L1, L4, L6, L7 and L8 of AR, and L1, L4, L6, L7 and L8 of MA are larger than 1.96. That suggests these lags are significant in the prediction result.

By using the ARIMA model mentioned above to predict the data, this paper generates a combined plot that includes the actual and fitted values for the Nikkei-500 and TOPIX cases. From Figure 2 and Figure 3, the visual impact of the release of China's pandemic control measures on Japan's air-transportation industry can be observed.

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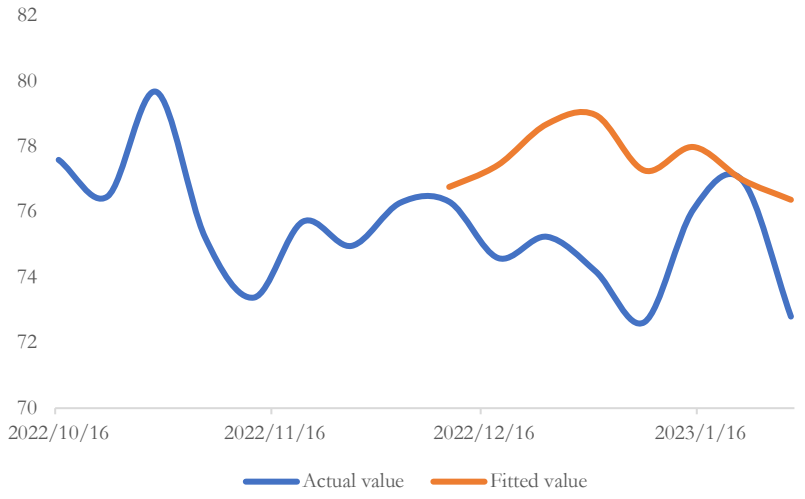

Figure 2: Nikkei-500 Air-transportation, actual and fitted value(photo credit: original).

Based on Figure 2, it can be observed that in the case of Nikkei-500, there is a noticeable difference in the trend between the actual and fitted values from December 11th, 2022 to January 29th, 2023. The actual data exhibits a clear decreasing trend in the first four weeks, followed by a period of strong fluctuations over the next seven weeks. In contrast, the predicted data only shows minor fluctuations during this period.

Furthermore, based on Figure 4, it can be observed that in the case of TOPIX, there is also a divergence between the actual and predicted data trends from December 11th, 2022 to January 29th, 2023. The actual data shows a distinct decreasing trend in the first four weeks, followed by a period of volatile fluctuations over the next seven weeks. Conversely, although the predicted data also exhibits significant fluctuations during this period, it demonstrates a significant increasing trend in the first five weeks.

In addition, according to Table 3, the total effect can be calculated based on the fitted value and the difference between the actual and fitted values. This can be obtained by calculating the quotient of the average difference and the average fitted value, expressed as "Average(Difference)/Average(Fitted)". Using this formula, the total effect for the Nikkei-500 case is calculated to be -3.49%, and for TOPIX, the total effect is -1.57%.

Based on these results, the net effect can be calculated using the formula "Total Effect - Market Trend", where the market trend is the return of the overall market between December 11th, 2022 and January 29th, 2023. For the Nikkei-500, the market trend during this period is approximately 1%, resulting in a net effect of -4.49%. In the case of TOPIX, the market return over the seven weeks is 0.9%, leading to a net effect of -2.47%.

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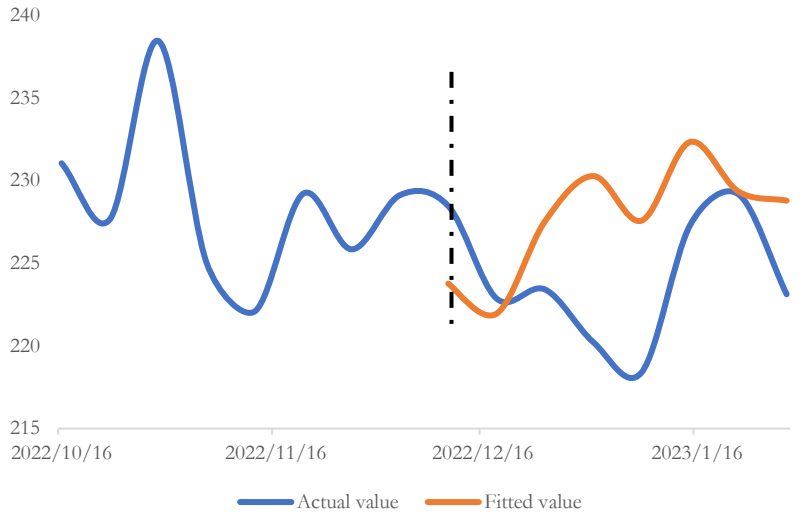

Figure 3: TOPIX Air-transportation, actual and fitted value (photo credit: original).

Considering the net effect values for Nikkei-500 and TOPIX, it can be observed that both values are negative. Based on this observation, along with the findings in Figure 2 and Figure 3, the research concludes that the lifting of COVID-19 control policies in China has had a negative impact on Japan's air-transportation industry.

Table 3: Actual value and fitted value.

Date	Actual value	Fitted value	Difference	Actual value	Fitted value	Difference
Nikkei 500				TOPIX		
2022/10/16	77.59			231.06		
2022/10/23	76.47			227.67		
2022/10/30	79.67			238.47		
2022/11/6	75.22			225.03		
2022/11/13	73.38			222.1		
2022/11/20	75.7			229.22		
2022/11/27	74.96			225.85		
2022/12/4	76.28			229.13		
2022/12/11	76.31	76.76297	-0.45297	228.47	223.7716	4.6984
2022/12/18	74.59	77.43291	-2.84291	222.87s	221.9571	0.9129
2022/12/25	75.24	78.68295	-3.44295	223.42	227.5453	-4.1253
2023/1/1	74.18	78.96112	-4.78112	220.23	230.2867	-10.0567
2023/1/8	72.63	77.26406	-4.63406	218.4	227.5886	-9.1886
2023/1/15	76.07	77.98339	-1.91339	227.3	232.3484	-5.0484
2023/1/22	76.97	76.98973	-0.01973	229.19	229.3544	-0.1644
2023/1/29	72.8	76.36992	-3.56992	223.13	228.7966	-5.6666

To explain why this situation occurred, this paper provides three reasons. First, after the Chinese government lifted all COVID-19 prevention and control measures on December 7th, 2022, the number of COVID-19 infections in China rapidly and dramatically increased. According to estimates

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from the Chinese government, more than 5 million people in China were infected with COVID-19 in the first three weeks of the last month in 2022. The sharp rise in the number of infected people in China led to a significant decline in the number of Chinese outbound passengers, including those traveling to Japan.

Furthermore, following the lifting of China's COVID-19 control policies, Japanese Prime Minister Fumio Kishida announced that Japan would strengthen border control measures for Chinese travelers. This included requiring immigrants from China to undergo COVID-19 testing and quarantining those who tested positive for 7 days. This policy had a negative impact on the consumer confidence of Chinese people who had planned to visit Japan, resulting in a decrease in the number of Chinese tourists to Japan.

Lastly, as a result of the easing of circuit breaker arrangements for international passenger flights, flights between China and Japan operated by Chinese air-transport companies increased in the first four weeks after December 7th, 2022. This created a crowding-out effect in the air-transport market and led to a significant reduction in passengers traveling between China and Japan using Japanese airlines.

5. Conclusion

The objective of this thesis is to research how the Japanese air transportation industry has been influenced by the release of COVID-19 pandemic control policies in China. This paper uses the ARIMA model to analyze and forecast Japan's air transportation index of Nikkei-500 and TOPIX and represents the impact on Japan's air transportation industry caused by the cancellation of China's COVID control measures. By observing the difference between predictions and actual values in combined plots and calculating the net effect from the market trend and total effect, the research concludes that the release of China's pandemic control measures had a negative impact on Japan's air transportation industry. This paper also provides three reasons for this situation: the increasing infections in China, Japan's strict border control measures for Chinese visitors, and the crowding out effect in the air transport market since China's COVID control measures eased on December 7th, 2022.

According to the literature and research above, it can be focused on the disparity between the consequences of this paper and the extrapolation from the standpoint of literature. From the literature review, it can be noticed that most authors point out that China's COVID-19 prevention and control measures had a negative impact on China's domestic economic activities, foreign trade, and the tourism industry, leading to a significant decrease in China's outbound tourists and international flights. The literature also supports the viewpoint that the COVID-19 pandemic had a considerable impact on Japan's industrial economy, and China's COVID control policies seriously affected Japan's tourism and air transportation industry. Based on the opinions in the literature, it can be inferred that the air transport industry in Japan will recover after the Chinese government releases all COVID prevention and control measures. However, the findings of this paper show that the cancellation of China's pandemic control policies had a negative influence on Japan's air transportation industry due to the large-scale infections in China, Japan's strict border control measures for Chinese travelers, and the crowding out effect in the air transport market. This comparison yields the insight that the release of COVID control measures in China may not necessarily benefit all industries in each country. The impact of the increasing number of infections in China must be noted, understanding the effect of Japan's response on consumers and travelers is crucial, and the changes in the air transport market should be considered. Based on the results of this paper, Chinese policymakers should realize that the cancellation of COVID control measures may have a negative impact on the air transport industry of foreign countries in the short term, while Japanese policymakers should recognize that the recovering domestic air transport industry will be affected by the serious response to China's policy. Additionally, investors in Japan's air transport industry need to consider the influence of the increasing number of

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COVID infections in China, understand the impact of the response from the Japanese government, and focus on the transformation in the air transport market.

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