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The impacts of COVID-19 on the global airline industry: An event study approach

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ABSTRACT

This study examines the short-term impact of the 2019 novel coronavirus (COVID-19) outbreak on 52 listed airline companies around the world by using event study methodology. The results demonstrate that airline stock returns decline more significantly than the market returns after three major COVID-19 announcements were made. Overall, investors react differently during the three selected events. The strongest overreaction is noted in the post-event period of the World Health Organization's and President Trump's official announcements. Moreover, the findings confirm that traders in Western countries are more responsive to recent information than the rest of the world. The findings call for immediate policy designs in order to alleviate the impact of the pandemic in the airline industry around the globe.

1. Introduction

The 2019 coronavirus (COVID-19) pandemic as the newest global risk has disrupted business operations in all industries. The airline industry is one of the first industries that was affected from the event because the disease is easily passed among people. To date, there is no official medical treatment for the disease, causing a tremendous panic for world citizens. Thus, governments around the world have prohibited cross-country transportation. The market value of the airline business has shrunk since then. Ultimately, this incident motivates us to study the impact of COVID-19 on the performance of the airline industry around the world.

Similar events can be seen in the catastrophic shocks from airline disasters (Kaplanski and Levy, 2010), the September 11, 2001 attacks (Gillen and Lall, 2003), and the impact of Severe Acute Respiratory Syndrome (SARS) on airline stocks (Loh, 2006). A recent study documents the impact of COVID-19 on employment in the airline industry (Sobieralski, 2020), but the impact of the COVID-19 on airline stock prices has not yet been investigated. In order to fill this gap, we aim to examine the airline stock returns during the spread of the COVID-19 pandemic.

Although the World Health Organization (WHO) announced the first COVID-19 infected case in China on December 31, 2019 (WHO, 2020), we consider three major dates related to COVID-19: (1) the first infected case outside China reported in Thailand (January 13, 2020); (2) the outbreak in Italy (February 21, 2020); and (3) the declaration by WHO on the global pandemic outbreak and the announcement of the U.S. ban on travelers from 26 European countries (March 11, 2020) (Dunford et al., 2020). We select these three dates because they demonstrate important steps regarding the uncontrolled COVID-19 infection.

We employ event study methodology in order to investigate the impact of COVID-19 official press releases on airline stock returns. Fifty-two listed airline stocks covering all continents are included in the study. The first event does not show a significant drop in cumulative abnormal returns, reflecting an underreaction to the severity of COVID-19. However, the situation is reversed in the subsequent two events, showing a huge decline in global airline stock prices. This in turn indicates the overreaction of stock market investors. Our findings support Ding et al. (2020) and Ru et al. (2020), who document that the COVID-19 outbreak economically affects stock returns. Moreover, traders in Western countries seem to absorb information faster than those in the other regions.

This study contributes to prior literature on catastrophes in the airline business. To the best of our knowledge, we are among the first to explore the impact of this unprecedented event on this sector. In addition, the sample is relatively distinctive, including major listed airline firms around the world, which is different from other papers that focus on a particular country. It also sheds light on the implications for policymakers in terms of implementing joint actions of fiscal and monetary

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policies, such as financial relief packages and taxes in order to alleviate the negative economic impact of COVID-19 on this capital-intensive industry.

The rest of this study is organized as follows. Section 2 describes the data and Section 3 discusses the research methodology. Empirical results and policy discussion are presented in Section 4. Section 5 provides the conclusion.

2. Data

We select active firms in the air transportation code (SIC 4512), in particular labeled travel and leisure. As of April 2020, the initial sample includes 103 listed firms around the globe. However, as most countries have only one listed airline firm, we decide to choose the countries with at least four listed firms as our sample setting in order to remove the potential bias of a small sample.[1] The remaining sample contains 50 firms in nine countries, located in Asia, Australia, Europe, and North America. We include Chile and South Africa as representatives of the remaining continents, although they have only one listed airline firm. Thus, the final global sample consists of 52 listed firms,[2] accounting for more than 50% of the entire sample. The major stock market index in each country is used to calculate the market return. Stock prices and market indices in local currencies are obtained from DataStream.

3. Methodology

Event study suggested by Fama et al. (1969) is the main methodology employed in this research. This approach a common methodology in the economic and finance literature to investigate the impact of new information arrival from a particular event on stock prices. It is used to test semi-strong form market efficiency[3] (Fama, 1970, 1991) which states that all publicly relevant information is already incorporated in stock prices. If this efficiency holds, stock prices should quickly and immediately reflect public information announcements. In other words, an announcement can be considered as newly relevant information to investors. A short event window is usually used to mitigate the effect of irrelevant information on stock prices.

The common approach of event study begins with a regression of stock returns on the market returns which provides the parameters to estimate expected stock returns (fair values). Abnormal returns are then estimated as the difference between the actual stock returns and its expected returns. If the market is semi-strong form efficient, abnormal returns should be zero, implying that market prices are the same as fair value. This approach has recently gained attention within the global airline industry (e.g. Gillen and Lall, 2003; Park, 2004; Gong et al., 2006; Gong et al., 2008; Ho et al., 2013).

We select three important events representing the development of the COVID-19 pandemic, which are (1) the first infected case outside China reported in Thailand (Event 1: January 13, 2020); (2) the outbreak in Italy (Event 2: February 21, 2020); and (3) the declaration by WHO on the global pandemic outbreak and the announcement of President Trump to ban travelers from 26 European countries (Event 3: March 11, 2020). The ultimate goal is to examine whether abnormal returns exist surrounding the determined event periods. The results imply time-varying behaviors of the participants in stock markets in the global airline industry. We begin with the market model as seen below.

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + u_{i,t}, \quad (1)$$

where $R_{i,t}$ and $R_{m,t}$ are daily returns of stock i and daily market index returns on stock market m at time t, respectively. $u_{i,t}$ is the residual of stock i at time t, which is independent and identically distributed.

Next, we estimate the parameters of the market model during the estimation window in 2019. The abnormal return of stock i at time t ($AR_{i,t}$) is

$$AR_{i,t} = R_{i,t} - \widehat{\alpha}_i - \widehat{\beta}_i R_{m,t}, \quad (2)$$

where $\widehat{\alpha}_i$ and $\widehat{\beta}_i$ are the estimated parameters of stock i from Equation (1).

$AR_{i,t}$ captures the impact of the event when the information of the three above mentioned events are announced to the markets. If $AR_{i,t}$ are significantly different from zero, it implies that market value deviates from fair value. $CAR_{i,(t_1,t_2)}$ is an accumulated abnormal return of stock i during period t_1 and t_2. We investigate whether the market value deviates from the fair value by testing if $CAR_{i,(t_1,t_2)}$ is significantly different from zero. Negative or positive $CAR_{i,(t_1,t_2)}$ implies that stock prices deviate from their fair value during the examined period when the market responds to the new information. The cumulative abnormal return of stock i from time t_1 to t_2 ($CAR_{i,(t_1,t_2)}$) is defined as

$$CAR_{i,(t_1,t_2)} = \sum_{t=t_1}^{t_2} AR_{i,t} \quad (3)$$

We use an event window of the period from 5 days before each event date to 5 days after the event date [-5,+5]. The [-5,+5] event window is selected to reflect the efficiency of stock markets. This is consistent with prior literature in transportation and logistics research that determines an event window no longer than 10 days (Park, 2004; Gong et al., 2006; Gong et al., 2008). Moreover, we choose the short event window in order to prevent the overlapping event window periods (McWilliams and Siegel, 1997). Further, a long event window can reduce the power of statistics (Brown and Warner, 1980, 1985).

4. Empirical results and discussion

4.1. Event study

Fig. 1 depicts the averages of the cumulative abnormal returns for the entire sample during the [-5,+5] event window period. All three events have negative impacts on stock prices in the global airline industry. However, the effect of the first event on the first case reported outside China (Event 1) seems to be underestimated by global stock traders. The negative impact is minimal, implying that the event did not call the attention of the markets worldwide. Notwithstanding the evidence, more harmful impacts occurred during the outbreak in Italy (Event 2). The airline stock performances continue to drop with cumulative negative abnormal returns of 7.84% over the five-day period after the official outbreak releases. Thus, the airline industry is dramatically impacted by COVID-19 which is considered to be the first responder to the crisis. The stock markets continued to plunge when WHO officially announced the global pandemic and when President Trump banned international travel (Event 3), causing anxiety and fear in global financial markets. The cumulative negative abnormal returns in the airline industry are 24.42% over the five-day period after the announcements. At this time, investors overreacted to the announcements which greatly deviated stock prices from their intrinsic values. The deterioration in stock prices in the airline industry calls for attention to regulators and policymakers, which is discussed and proposed in Section 4.3.

Table 1 presents the cumulative abnormal returns of airlines stocks in each country during three different event windows for the three major events based on the individual countries. We exclude Chile and South Africa in this section because they have only one listed airline firm in the sample. At the first glance, the mean and median of the cumulative

[1] The average number of listed firms in each country is 2.40 from 43 countries.

[2] Details of the sample are available upon request.

[3] There are three types of market efficiency: weak-form, semi-strong form, and strong form market efficiencies. See more details in Fama (1970, 1991).

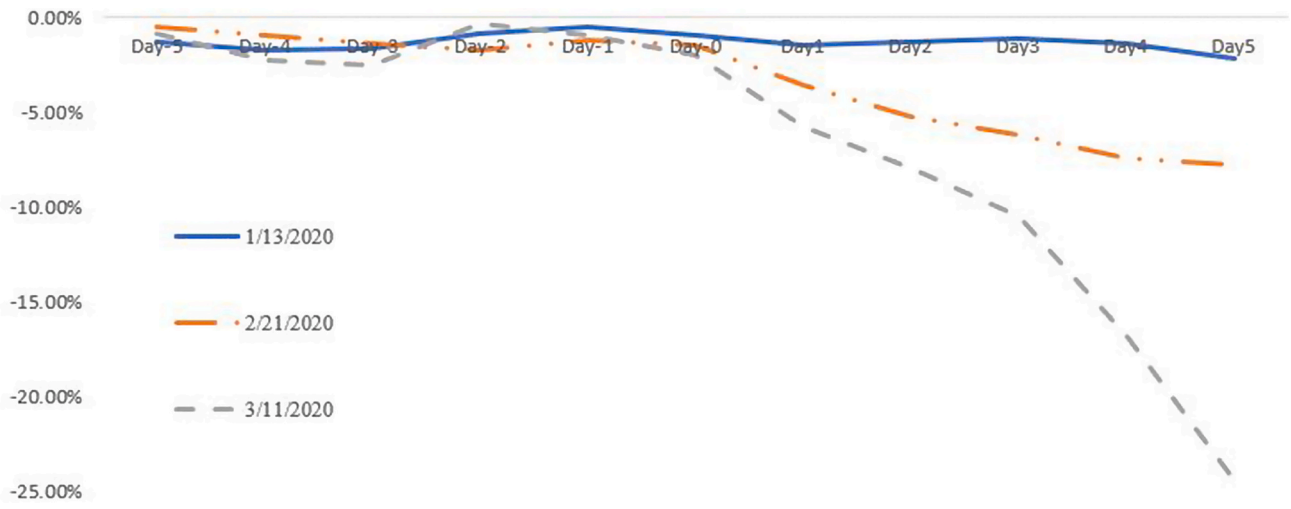

Fig. 1. Average cumulative abnormal returns for the entire sample.

Table 1
Cumulative abnormal returns in individual countries during different event window periods.

Market	Window	Event 1 (Jan 13, 2020)				Event 2 (Feb 21, 2020)				Event 3 (Mar 11, 2020)			
		Mean	Median	*t*-test	Wilcoxon	Mean	Median	*t*-test	Wilcoxon	Mean	Median	*t*-test	Wilcoxon
Pre-event													
Australia (4)	[-5, 0]	−2.41	−2.40	−2.440[a]	−1.461	−0.29	−0.47	−0.249	−0.365	−17.84	−14.57	−2.836[a]	−1.826[a]
Canada (5)	[-5, 0]	0.97	−0.10	0.617	−0.405	−3.41	−2.77	−1.366	−1.214	−4.63	−6.23	−1.947	−1.483
China (8)	[-5, 0]	0.99	−0.10	1.109	−0.560	1.64	0.25	0.883	0.280	7.07	6.15	4.393[c]	2.521[b]
India (4)	[-5, 0]	8.16	2.02	1.023	1.095	2.91	1.10	1.405	1.826[a]	−2.86	−0.30	−0.892	−0.365
S. Korea (7)	[-5, 0]	−3.24	−4.23	−1.540	−1.183	−4.62	−6.07	−2.172[a]	−1.690[a]	−1.55	0.51	−0.345	−0.845
Thailand (4)	[-5, 0]	−2.74	−3.01	−2.782[a]	−1.826[a]	−5.76	−5.63	−3.073[a]	−1.826[a]	5.57	7.38	0.740	0.730
U.K. (5)	[-5, 0]	2.29	6.01	0.589	0.674	1.22	0.10	1.193	0.674	−2.52	−1.40	−1.099	−1.214
U.S. (13)	[-5, 0]	−3.29	−1.89	−1.776	−3.040[c]	−3.12	−3.45	−6.436[c]	−3.180[c]	−0.54	−2.50	−0.179	−0.524
On-event													
Australia (4)	[0, 0]	0.67	0.38	1.553	1.826[a]	0.26	0.34	0.273	0.730	−4.20	−4.83	−4.172[b]	−1.826[a]
Canada (5)	[0, 0]	0.53	0.48	1.472	1.214	−1.38	−0.52	−1.628	−2.023[b]	−3.77	−4.36	−3.143[b]	−2.023[b]
China (8)	[0, 0]	−0.13	−0.40	−0.263	−0.700	−1.15	−1.66	−1.863	−1.540	3.59	2.63	3.533[c]	2.521[b]
India (4)	[0, 0]	0.57	0.07	0.399	0.730	0.13	0.00	0.778	0.365	−3.06	−3.99	−2.938[a]	−1.461
S. Korea (7)	[0, 0]	−0.50	−0.70	−0.874	−1.014	−0.13	−0.36	−0.171	−0.338	−0.20	0.95	−0.175	−0.676
Thailand (4)	[0, 0]	1.48	0.95	1.921	1.826[a]	−1.14	−1.31	−0.94	−1.095	−0.10	0.13	−0.073	−0.365
U.K. (5)	[0, 0]	−2.77	−0.85	−0.856	−0.944	−0.34	−0.33	−0.791	−0.405	−1.65	−0.32	−0.717	−0.674
U.S. (13)	[0, 0]	−0.91	−0.69	−2.658[b]	−2.621[c]	0.38	0.25	1.254	1.013	−1.45	−0.72	−1.303	−1.013
Post-event													
Australia (4)	[0,+5]	−0.48	−1.96	−0.263	−0.365	−8.78	−6.27	−2.089	−1.826[a]	−25.10	−28.87	−3.441[b]	−1.826[a]
Canada (5)	[0,+5]	0.05	−0.12	0.040	−0.674	−5.66	−5.79	−2.215[a]	−2.023[b]	−36.89	−49.95	−3.311[b]	−2.023[b]
China (8)	[0,+5]	−2.75	−4.76	−1.545	−1.120	−2.86	−3.60	−1.323	−1.400	−2.79	−2.36	−1.544	−1.400
India (4)	[0,+5]	0.57	1.73	0.319	0.365	−0.86	−0.93	−0.337	−0.365	−6.71	−5.44	−0.870	−1.095
S. Korea (7)	[0,+5]	−2.38	−3.95	−2.108[a]	−1.690[a]	5.31	3.62	0.957	0.676	−8.24	−3.15	−1.947[a]	−1.690[a]
Thailand (4)	[0,+5]	1.56	1.65	1.990	1.461	−14.44	−9.96	−2.339	−1.826[a]	−8.13	−8.41	−6.148[c]	−1.826[a]
U.K. (5)	[0,+5]	−4.03	−4.47	−1.668	−1.483	−14.68	−18.55	−2.047	−1.483	−53.73	−54.51	−2.786[b]	−1.753[a]
U.S. (13)	[0,+5]	−3.27	1.07	−0.706	1.153	−10.62	−10.69	−8.436[c]	−3.180[c]	−32.42	−38.53	−3.285[c]	−2.411[b]

The numbers shown in the parentheses are the number of airline firms.
[a] Statistical significance at the 10% level.
[b] Statistical significance at the 5% level.
[c] Statistical significance at the 1% level.

abnormal returns in most cases are negative, especially on the event date [0,0] and five days after the event date [0,+5]. We employ both parametric and nonparametric tests for the equality of the mean and median values, respectively. Overall, the *t*-test and the Wilcoxson signed rank test provide similar results with greater statistical significance shown in the nonparametric test. We present the results based on pre-event, on-event, and post-event windows as follows. First, during the pre-event window period [-5,0], the results are most significant in Event 2. India, South Korea, Thailand, and the U.S. truly show negative abnormal returns. The equality tests in the mean and median of the five days before Events 1 and 3 do not show a significant difference from zero. This implies an underreaction phenomenon, especially for Event 3. Possible explanations of this finding are that traders expect that the spread of the disease would be limited to particular regions (Ru et al., 2020), and that governments around the world may find a vaccine in the near future. More importantly, traders do not anticipate that the performances of cross-continental airlines would fall due to the lockdown policy in many countries. Thus, they underestimate the genuine effects of COVID-19 on global economic conditions.

Second, the abnormal returns are mostly not statistically significant on the event date for any of the events because investors take the information into account during the pre-event window periods. However, the stock markets in Australia, Canada, and China generate significantly negative returns during Event 3. Last, evidence in the last window

[0,+5] is strongest, especially for Event 3. As this event is directly associated with the U.S., the impact on the U.S airline business is dramatic. The U.S. traders overreact more than during the previous two events. The same evidence can be seen in Canada, as the policy and economic conditions are very close to those in the U.S. Nevertheless, the finding on the U.K. airlines shows the greatest impact, causing cumulative negative abnormal returns of 53.73%. We suspect that this result is driven by the herd-immunity policy, which has been debated among physicians around the world.

In general, Asia-based airline stock prices suffered less than the rest of the group, potentially due to government remedies. For instance, in February 2020, the South Korean government, via Korea Development Bank, provided state-backed loans to airlines that had cash crunches (Choi, 2020) and in March 2020, the government injected capital together with fee exemption and deferred payments (Kim, 2020). These schemes improve firm's financial strengths and then lessen the panic of the investors amid the COVID-19 pandemic crisis.

Our results are robust in two ways. First, we vary the estimation window using second-half data for the year 2019. Second, the pre-event and post-event widows are redefined according to the periods from [-5,0] to [-1,0] and from [0,1] to [0,+5], respectively. In general, the results remain qualitatively and quantitatively the same as seen in our presented findings.

4.2. Price-to-book valuation[4]

In addition to event study methodology, we measure fair value of airline companies based on their earnings, reported as of March 2020. Then, we examine the overreactions of traders to the events by testing the difference between the actual market prices and the fair values. We use the following price-to-book valuation to calculate for fair value of stock prices.[5]

$$Price_{i,\ 1Q2020} = (Price - to - book)_{2019} * (Book\ value)_{i,\ 1Q2020} \quad (4)$$

$(Price - to - book)_{2019}$ measures the average ratio of market value to book value in 2019. We calculate the average value of price-to-book ratios of each company to generate global price-to-book ratio. $(Book\ value)_{i,\ 1Q2020}$ is the book value of stock i in March 2020. $Price_{i,\ 1Q2020}$ is the fair value of company in March 2020, which is the product of price-to-book ratio and book value. We compare the market value to the computed fair value of each stock at the end of March 2020. Our hypothesis is that investors overreact to bad news in the first quarter of 2020 leading to a drop in market value.

We investigate more in depth by examining particular airline companies. However, due to data availability, the remaining samples equal 35 airline companies. The results are shown in Table 2. Column 1 shows market value of each stock. Column 2 reports fair value of stocks using Equation (4). Column 3 states percentage differences between market value and fair value. The results show that market values significantly drop below fair values for most companies, leading to significantly average differences in mean and median of −22.10% and −48.00%, respectively. Our findings, thus, confirm that investors overreact to COVID-19 pandemic events.

4.3. Policy discussions and suggestions

Our findings provide greater understanding of how the airline stock prices deteriorated during the crisis due to investors' interpretation of information. As seen in South Korea, policy announcement from the government lessens investor overreaction. In this section, we further discuss and suggest policy responses, covering fiscal and monetary measures as well as other measures (e.g., employment, waiving airport use charges, administration).

We suggest that policymakers should deploy prompt and adequate policy interventions. The stimulus packages (e.g., loans and loan guarantees) can help restore investor confidence from the economic impacts of COVID-19 in the airline industry since the investors timely respond to the new information. During the COVID-19 crisis, banks are reluctant to lend to the financial distressed airlines due to increasing bankruptcy risk of the airlines. Thus, the ability to access low interest loans or government-backed financing is critically important for a company to survive. In line with the suggestion by Ramelli and Wagner (2020), the governments may alternatively purchase newly issued bonds on the

Table 2
Market value and fair value.

Stock	(1) Market value ($US million)	(2) Fair value ($US million)	(3) Difference
Canada			
Air Canada	2,928.39	5,531.06	−47.06%
ACE Aviation Holdings	3.93	8.64	−54.56%
Chorus Aviation	336.01	790.34	−57.49%
Exchange Income Corporation	438.49	960.90	−54.37%
China			
Air China	12,102.42	22,968.64	−47.31%
China Eastern Airlines	8,304.13	16,119.37	−48.48%
China Southern Airlines	7,830.70	15,059.57	−48.00%
Hainan Airlines	3,688.16	11,802.55	−68.75%
Juneyao Airlines	2,776.73	2,649.66	4.80%
China Express Airlines	1,105.49	691.26	59.92%
Shandong Airlines	345.25	1,168.90	−70.46%
South Korea			
Spring Airlines	4,179.18	3,773.11	10.76%
Air Busan	128.22	69.42	84.69%
Asiana Airlines	617.50	190.76	223.71%
JejuAir	364.53	335.14	8.77%
Korean Air Lines	1,470.66	2,866.00	−48.69%
Jin Air	273.33	214.49	27.44%
T'way Air	112.40	229.34	−50.99%
Hanjin Kal	3,631.96	1,447.67	150.88%
Thailand			
Asia Aviation	157.03	955.23	−83.56%
Bangkok Airways	257.85	1,242.22	−79.24%
United Kingdom			
Dart Group	1,018.89	1,157.20	−11.95%
EasyJet	2,816.48	3,817.80	−26.23%
Wizz Air Holdings	2,446.44	2,253.45	8.56%
United States			
Allegiant Travel	1,339.10	1,478.03	−9.40%
Hawaiian Holdings	479.72	1,686.92	−71.56%
JetBlue	2,413.88	7,967.74	−69.70%
Mesa Air Group	115.79	805.45	−85.62%
SkyWest	1,316.24	3,948.17	−66.66%
United Airlines Holdings	7,822.86	17,187.40	−54.48%
Alaska Air Group	3,489.98	7,327.18	−52.37%
Copa Holdings	1,914.68	3,607.31	−46.92%
Delta Air Lines	18,197.47	26,113.25	−30.31%
Southwest Airlines	18,117.25	16,561.45	9.39%
Spirit Airlines	882.39	4,077.66	−78.36%
Mean			−22.10%
t-test			−1.96[a]
Median			−48.00%[b]
Wilcoxon			−2.72[c]

[a] Statistical significance at the 10% level.
[b] Statistical significance at the 5% level.
[c] Statistical significance at the 1% level.

[4] We thank an anonymous referee for suggesting this analysis.
[5] It is difficult to use discounted cash flows (DCF) valuation in this turbulent period as projecting future cash flows can be challenging. Besides, valuation using price-to-earnings ratio is impossible for many airline companies as they report negative earnings in March 2020.

primary market.

In addition, tax deferrals and aviation tax reductions should be implemented in the airline industry, especially for cash constrained airlines. To our knowledge, an exemption or reduction of inputs such as spare parts used in airline business from import taxes are used in a few countries. Governments should temporarily increase subsidies during COVID-19 crisis. For example, jet fuel tax cut can be implemented for domestic flights to reduce operating costs due to a decline in passengers. However, policymakers need to incorporate their country circumstances into the policy designs and link the measures with sustainability practices.

Other measures such as employment and waiving airport use charges (aircraft parking and landing fees) can be included in the relief package. Governments should have some conditions on accessing loans including maintaining employment. Unpaid leave programs may be a better alternative option than a lay-off policy. For instance, in South Korea, low cost carriers' employees who were off work would be guaranteed 70% of their average wages due to the special employment support from the Ministry of Employment and Labor (Choi, 2020).

Although the mentioned supportive measures may reduce the probability of bankruptcy or prevent liquidity crunch, several vulnerable airlines faced with financial distress ended with bankruptcy (Mahtani and Garg, 2018). Alternatively, the administrative measures should allow the airlines to change their business plans and establish alternative. Besides, they should be able to operate irregular flight schedules reflecting market demand. Such policies can alleviate investor panic. Table 3 summarizes suggested measures in response to COVID-19.

Table 3
Suggested measures in response to COVID-19.

Topic	Supportive Measures
Finance	Capital injection
	Loan guarantees
	Low interest rates
	Corporate bonds purchase
	Tax relief
Employment	Wage subsidies
	Unpaid leave program
	Special employment support
Airport Usage Charges	Discounted airport facility fees
	Exempting parking fees
	Exempting air navigation charges for certain periods
	Reductions in landing charge
	Discounting ground operators and deferring payment
	Deferring airport ancillary services
Administration	Permitting changes to business plans
	Re-routing
	Re-scheduling
	Restructuring

5. Conclusions

The COVID-19 pandemic has caused disruptions in all parts of the world. We investigate the impact on the global airline business. Three crucial announcements are selected to be studied, which are (1) the first case reported outside China (Event 1: January 13, 2020), (2) Italy outbreak (Event 2: February 21, 2020), and (3) the declaration by WHO on the global pandemic outbreak and the announcement of President Trump to ban travelers from 26 European countries (Event 3: March 11, 2020). We find the underreaction and overreaction to the announcements in Event 1 and Event 3, respectively. Airlines stocks in Australia, Canada, the U.K., and the U.S., are the worst performers in the post-event period in Event 3. We offer several potential explanations for the findings in this paper. As the COVID-19 pandemic has been ongoing, our results call for the policy implications below.

We understand that the government in each country is at an intersection—whether to provide financial support or guarantee existing debt, or to believe in market mechanisms and let the airline firms file for bankruptcy. In order to back up the airline industry, several alleviation policies may deal with mergers and acquisitions, tax policy, and government subsidies. These policies, of course, will increase the national debt. Otherwise, firm liquidation in the airlines is, perhaps, inevitable and subsequently will disrupt the global supply chain and related businesses.

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Author statement

Sakkakom Maneenop: Conceptualization, Methodology, Formal analysis, Software, Data curation, Writing - original draft preparation, Visualization, Investigation, Validation, Writing - review & editing.

Suntichai Kotcharin: Conceptualization, Methodology, Formal analysis, Software, Data curation, Writing - original draft preparation, Visualization, Investigation, Validation, Writing - review & editing, Funding acquisition.

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