Journal of Air Transport Management 105 (2022) 102281

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Airline stock markets reaction to the COVID-19 outbreak and vaccines: An event study

António Miguel Martins [a,b,c,*], Susana Cró [b]

[a] University of Madeira - Faculty of Social Sciences, Caminho da Penteada, 9020-105, Funchal, Portugal
[b] CEFAGE-UE and University of Évora, School of Social Sciences, Largo Dos Colegiais, 2, 7004-516, Évora, Portugal
[c] Centre of Applied Economic Studies of the Atlantic (CEEAplA), Ponta Delgada, Azores, Portugal

A R T I C L E I N F O

Keywords:
Airline industry
COVID-19
Vaccination
Stock returns
Event study

A B S T R A C T

This paper examines the short-term market reaction of the airline industry to the declaration of COVID-19 as a global pandemic and to the announcements of the effectiveness of COVID-19 vaccines in the US. Using an event study, we observe a negative and statistically significant stock price reaction to the announcement of COVID-19 as a global pandemic. In contrast, we find a positive impact on the stock market due to the announcements of the effectiveness of COVID-19 vaccines in the US. These results are consistent with the investor sentiment hypothesis and the asset-pricing perspective. The empirical results also show a higher stock market reaction to the announcement of the effectiveness of the Pfizer–BioNTech COVID-19 vaccine in the US compared to the announcements of the effectiveness of subsequent vaccines. This result is explained by the innovation race competition effect and the greater reduction in investor uncertainty levels. These reactions were reinforced or mitigated by firm-specific characteristics such as liquidity, size, leverage, ownership concentration, state control and business model (i.e., low-cost *versus* full-service).

1. Introduction

The global outbreak of the novel coronavirus (COVID-19) has led to unprecedented declines in the financial markets due to increased uncertainty (e.g., Altig et al., 2020; Fetzer et al., 2020). The just-cited authors show a substantial increase in economic anxiety and a weakening of economic sentiment among the population with the onset of COVID-19. As a corollary of this situation, on March 23, 2020, the S&P 500 and the S&P Europe 350 lost more than a third of their value relative to their historical maximum achieved on February 19, 2020, with a 12% single-day drop in mid-March.

However, the effects of COVID-19 on financial markets are quite heterogenous: while some businesses are struggling, other businesses are thriving (Donthu and Gustafsson, 2020). The industries more conducive to virus transmission and therefore more heavily affected by the imposition of social distance, such as entertainment, travel, tourism, and hospitality, are often identified as the most affected by the COVID-19 pandemic, while other industries, like high-tech industries and internet-based businesses (related to online entertainment, online shopping, online education), appear to have adapted quite well to social distancing requirements (e.g., Alfaro et al., 2020; Baker et al., 2020; Masur et al., 2021; Pagano et al., 2020).

In this study, we investigate the stock market reaction to the declaration of COVID-19 as a global pandemic and to the announcements of the effectiveness of COVID-19 vaccines in the US. Previous studies have examined the impacts of COVID-19 on the global airline industry (He et al., 2020; Maneenop and Kotcharin, 2020). He et al. (2020) show that the COVID-19 pandemic has had a severe impact on China's traditional industries, notably in the transportation industry. Maneenop and Kotcharin (2020) demonstrate that airline stock returns declined more significantly than the market returns after three major COVID-19 announcements.

Our contribution to the literature is twofold. First, although empirical studies have examined the short-term impact of the COVID-19 outbreak on listed airline firms around the world (He et al., 2020; Maneenop and Kotcharin, 2020), none of these studies analyse the cross-sectional determinants of abnormal returns. Our study fills this important gap. Second, to our knowledge, this study is the first attempt to investigate a novel dimension of COVID-19 effects, namely the market impact of the effectiveness of COVID-19 vaccines in the US on the airline industry. We also evaluate the relation between the observed abnormal returns and a set of firm-specific and industry attributes considered

* Corresponding author. Centre of Applied Economic Studies of the Atlantic (CEEAplA), Ponta Delgada, Azores, Portugal.
E-mail addresses: antonio.martins@staff.uma.pt (A.M. Martins), srgcro@uevora.pt (S. Cró).

https://doi.org/10.1016/j.jairtraman.2022.102281
Received 13 January 2022; Received in revised form 1 August 2022; Accepted 3 August 2022
Available online 22 August 2022
0969-6997/

important by previous studies. The analysis of the effects of vaccination on the airline industry constitutes a novel addition to the literature. A safe and effective vaccine would undoubtedly save lives. In response, investors are likely to update their beliefs regarding future economic growth. According to the asset-pricing perspective and the investor sentiment hypothesis, the stock market is expected to respond immediately and positively to the announcement of the COVID-19 vaccine effectiveness, reflecting the fundamental changes in the net benefits for the society.

The airline industry is chosen as the object of study because it belongs to a sector that has experienced great exposure to the COVID-19 pandemic and high drops in market value. The images of entire aircraft fleets parked at airports when lockdowns and border closures were the dominant policy response are very present in our memory. The COVID-19 pandemic inflicted a heavy toll on airlines firms, resulting in rating downgrades, liquidation, and bankruptcy of several airlines (e.g., Dube et al., 2021). The situation could have been more catastrophic if governments had not intervened to ensure that the airline industry did not collapse, given its economic importance. Indeed, the declaration of COVID-19 by the World Health Organization (WHO) as a global pandemic and the announcements of the effectiveness of COVID-19 vaccines in the US had significant impacts on stock prices in the aviation industry.

Using an event study methodology for 59 listed airline stocks, we show that airline stocks react negatively to the declaration of COVID-19 as a global pandemic. In contrast, we find a positive effect on airline stocks due to the announcement of the effectiveness of COVID-19 vaccines in the US. Finally, we show that airline stock reactions were reinforced or mitigated by firm-specific characteristics such as liquidity, size, leverage, ownership concentration, state control and business model (low-cost *versus* full-service).

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 provides the testable research hypotheses. Section 4 presents the data and the event study methodology. In Section 5, we present and discuss our main findings. Section 6 concludes the paper.

2. Literature revision

2.1. Airline industry: brief characterization

As highlighted by Tretheway and Markhvida (2014), the airline industry is the central part of the commercial aviation value and supply chain. Despite this, it is the industry with the lowest profit margin and return on investment compared to other sectors in the chain. According to these authors, in the best of times, the airline industry earns only a modest 1–2% net profit margin on revenue. The problem faced by the airline industry can be summarized in the following sentence: it makes profit for everyone along the aviation value chain except for itself (Economist, 2012).

As a result, several authors have questioned whether the airline industry is sustainable in the long term—the so-called 'empty core' problem (Button, 1996), an economist jargon for a situation whereby airline competition can never reach a financially sustainable equilibrium. Tretheway and Markhvida (2014) note that competition between airlines tends to be so intense that companies compete on price until it reaches the marginal cost of the service, leaving fixed costs uncovered. Lee and Jang (2007) state that airline fixed costs represent on average more than 80% of total costs.

The scenario described above worsened with the onset of the COVID-19 pandemic. The pandemic has inflicted heavy losses on global aviation, resulting in rating downgrades, liquidation, and bankruptcy. Dube et al. (2021) report that the cost of borrowing has increased significantly for airlines, jeopardizing the survival of many of these firms. Consequently, most US airlines have seen their ratings downgraded to junk status, leading to the liquidation of many of these firms. The situation could have been more catastrophic but for state aid provided to airlines to ensure that the industry did not collapse, given its significance in assisting business and trade (e.g., Abate et al., 2020).

It should also be noted that airlines face pro-cyclical demand. Most studies reveal that air travel demand is highly income-elastic (income elasticities are between 1.5 and 2.7, depending on the market). This means that when there is an economic recession, air travel demand falls at roughly double the rate (Tretheway and Markhvida, 2014). Tretheway and Markhvida (2014) also report the existence of a fare effect, which exacerbates the effect of economic recessions on airline revenues, contributing to the drop in demand.

Finally, it is important to highlight that the losses resulting from the COVID-19 pandemic did not affect all airlines in the same way. Full-service and international carriers were seen as the major losers (e.g., Dube et al., 2021; Suau-Sanchez et al., 2020). Regional carriers seemed to be more adapted to the new normal caused by the COVID-19 pandemic, as they have a fleet of aircrafts with less capacity, which is more suitable for thinner routes, given the cross-border travel restrictions imposed by governments to limit the transmission of the virus. In addition, by having a generally lower and more variable cost structure and a lower breakeven load factor, regional carriers tend to react to a changing environment more quickly than conventional airlines (Flouris and Walker, 2005) and to get new business opportunities from downsized international carriers.

2.2. Market impact of the COVID-19 pandemic

Recent extensive event study literature focusing on the effects of key announcements during the COVID-19 pandemic provides evidence that, on average, stock price reaction is consistent with market efficiency: market prices adjust rapidly and fully to the release of new information on the evolution of the COVID-19 pandemic and on public policies to mitigate or eliminate the disease (e.g., Alfaro et al., 2020; Ding et al., 2020; Chan et al., 2021; Chang et al., 2021; Heyden and Heyden, 2021; Huo and Qiu, 2020; Liu et al., 2020; Mazur et al., 2021; Narayan et al., 2021; Pagano et al., 2020; Ramelli and Wagner, 2020; Salisu and Vo, 2020; Shen et al., 2020).

Under the null hypothesis of efficient markets, market prices should reflect the significance of any unexpected news that influences cash flows (CF) (or dividends) or discount rates (R) (e.g., Fama, 1991; McQueen and Roley, 1993). From a theoretical asset-pricing perspective, in its most simplistic form, the value of the stock prices (V) at a time t is given by:

$$V_t = \int_0^\infty \mathbb{E}_t[CF_t(n)]e^{-r_t n}\, dn \tag{1}$$

where $\mathbb{E}_t[CF_t(n)]$ are the expected cash-flows in the next n years and r_t is the expected discount rate in the next n years. According to the asset-pricing theory, the market value of shares tends to decrease when there is an expectation of a decline in the firm's prospective cash flows and/or an expectation of an increase in discount rates. Changes in discount rates are the result, among other factors, of uncertainty about long-term growth rates or shifting risk attitudes (Campbell, 2000).

Hong et al. (2021) develop a model of pandemic risk management and firm valuation based on a dynamic asset-pricing model. According to these authors, the unexpected onset of the COVID-19 pandemic tended to directly affect firms' cash flows through three channels. First, in most industries, firms' cash-flows tended to exhibit a significant negative jump, except for a few industries such as technology. Second, growth in cash flows and earnings was also potentially adversely affected by the worsening number of people infected by COVID-19, since higher infection rates meant an increase in the number of sick workers and a decrease in productivity. Third, stochastic transmission shocks also increased risk premiums. The authors conclude that although reducing the spread of the disease might result in costs and, therefore, decreases in the firms' earnings in the short term, this reduction in the disease spread results, in the future, in increases in expected earnings, in amounts sufficient enough to be optimal for the firm even from a value-maximizing perspective. As a result, even without considering the health benefits, there are economic benefits to controlling COVID-19.

Recent empirical literature shows that, on average, stock prices seem to respond negatively to announcements of increased COVID-19 contagion (e.g., Alfaro et al., 2020; Ashraf (2020a,b); Ding et al., 2020; Heyden and Heyden, 2021; Liu et al., 2020; Mazur et al., 2021; Ramelli and Wagner, 2020; Salisu and Vo, 2020; Shen et al., 2020) and positively to announcements of disease elimination or mitigation, as is the case of governments' responses to fighting the COVID-19 pandemic (e.g., Chang et al., 2021; Narayan et al., 2021) or human clinical trials of COVID-19 vaccines (e.g., Acharya et al., 2021; Chan et al., 2021; Rouatbi et al., 2021). These results are in line with the model developed by Hong et al. (2021).

Regarding the airline industry, Maneenop and Kotcharin (2020) demonstrate that airline stock returns declined more significantly than the market returns with the emergence of the COVID-19 pandemic. Baker et al. (2020) provide evidence that government restrictions on commercial activity and voluntary social distancing, operating with powerful effects in a service-oriented economy, are the main reasons the US stock market reacted much more forcefully to the COVID-19 pandemic than to previous pandemics. A strong overreaction is noted in the post-event period of the global pandemic declaration by the WHO and the announcement of the US's ban on travellers from 26 European countries (March 11, 2020).

This result can be explained by three factors present in a basic asset-pricing model. First, the sharp drops in sales in airline industry. Forsyth et al. (2020) reveal an unprecedent reduction in the number of passengers due to the COVID-19 pandemic. The fall in air transport stemmed mostly from cross-border travel restrictions imposed by governments to limit the transmission of the virus. As highlighted by Yong and Laing (2021), the industries with a high foreign exposure to sales, assets, exports, and imports, such as the airline industry, tend to experience more pronounced short-term impacts on abnormal returns. Second, as explained by Tretheway and Markhvida (2014), the airline industry has a high level of business risk, which has been severely exacerbated during the pandemic. Dube et al. (2021) reveal that the cost of borrowing for airlines has increased significantly with the emergence of COVID-19, threatening the survival of many airlines. This means that risk-averse investors may require higher risk premiums, which in turn drives down the price of risky assets (a flight to safety) (e.g., Baele et al., 2020). Dube et al. (2021) highlight that due to severe cash burn instigated by travel restrictions, rating downgrades, liquidation, and bankruptcy of several airlines have been observed in the industry around the world. As a result, there has been a need to support the sector with fiscal and monetary measures to ensure its survival prospects. Third, airlines based in most pandemic heat areas are likely to experience prolonged slow recovery periods. This could be attributed to anxiety and fear, which may force many to stay at home and not travel (e.g., Altig et al., 2020; Bae and Chang, 2021; Fetzer et al., 2020). Bae and Chang (2021) cite anxiety and fear as some of the biggest threats to the tourism and airline industry.

These three factors explain the cumulative negative abnormal return in the airline industry of 24.42% over the five-day period after the announcement found by Maneenop and Kotcharin (2020). This empirical evidence proves that the airline industry was not only one of the first industries to be affected by the COVID-19 pandemic but also one of the most economically affected.

2.3. Market impact of COVID-19 vaccines

If it is true that, for the reasons explained, there was a drop in airline stock returns with the emergence of COVID-19, it was expected that global stock markets react positively to announcements of the effectiveness of COVID-19 vaccines. A safe and effective vaccine would undoubtedly save lives. In response, investors are likely to update their beliefs regarding future economic growth. According to the hypothesis that investor sentiment affects stock market returns (e.g., Baker and Wurgler, 2006; Fetzer et al., 2020), the stock market is expected to respond immediately and positively to announcements of the effectiveness of COVID-19 vaccines, reflecting the fundamental changes in the net benefits for the society. Hong et al. (2021) highlight that asset valuation are highly sensitive to vaccine arrival rates. The arrival of a vaccine would shift the stock prices to pre-pandemic levels.

Existing studies on the impact of COVID-19 vaccines on stock markets analyse (*i*) the impact of COVID-19 vaccination on stock market volatility (Rouatbi et al., 2021); (*ii*) the stock market reactions to the start of human clinical trials for COVID-19 vaccine candidates (Chan et al., 2021); and (*iii*) the value of a cure (Acharya et al., 2020).

Rouatbi et al. (2021) provide evidence that COVID-19 vaccination contributes to stabilizing the global equity market. The impact of vaccination is relatively stronger in developed markets than in emerging ones. Acharya et al. (2020) develop an asset-pricing perspective to achieve the value of a cure by constructing a novel "vaccine progress indicator". They conclude that the value of a cure rises sharply when there is uncertainty about the frequency and duration of pandemics. Moreover, they estimate the exposure levels within each industry and investigate the impact of vaccine progress on a cross-section of industries. Industries that are exposed to the COVID-19 pandemic (as is the case of the airline industry) tend to see a higher positive impact as a vaccine is deployed soon. Chan et al. (2021) find that stock markets react positively, with an average increase of 15.2 basis points (bps), on the first day of clinical trials after controlling for the growth in COVID-19 cases and deaths as well as for investor sentiment. Moreover, the stock markets react more strongly when clinical trials progress to later phases. The abnormal return increases by 30.0 bps and 51.7 bps on the first day of phase 2 and phase 3 of human clinical trials of vaccine candidates, respectively. These results show that stock market reaction is even more substantial as vaccine development progresses to later phases.

2.4. COVID-19 vaccines: partially anticipated events and the innovation race

Scheppler et al. (2021) argue that the development of a vaccine is a lengthy and uncertain process which normally takes around 10–15 years before the vaccine could be produced on a large scale for the public. During this process, human clinical trials are arguably the key in determining the success (or failure) of the vaccine. Chan et al. (2021: 5) presents an industry report showing that "*only one-sixth of all vaccine candidates that have had human clinical trials during the period 2006–2015 obtained final approval for mass production*". Given the high failure rate of vaccine clinical trials, we believe it is pertinent to analyse the impact of the announcements of the effectiveness of COVID-19 vaccines on the stock market, in which, despite the possible anticipation of the event by investors, a positive and significant impact is expected due to the decline in investors' uncertainty associated with the existence of a cure for COVID-19.

Another important issue is the confidence that the population has in the cure provided by the vaccine. The vaccines developed in the US tend to generate a greater level of confidence (and perceived efficacy) in the public globally than vaccines developed in other countries, particularly in China, due to the US's dominant position in the global pharmaceutical industry and acquired reputation in terms of health research (e.g., Chan et al., 2021). Chan et al. (2021) show a heterogeneous reaction of the stock market to vaccines developed by pharmaceutical firms domiciled in the US, China, and other countries. The stock market reaction to human clinical trials for COVID-19 vaccines is higher for US-developed vaccines than non-US-developed vaccines.

The market reaction to the effectiveness of the COVID-19 vaccines depends on investors' perception of the likelihood of the event. The effect of the announcement of vaccine effectiveness could be smaller than the economic impact and the failure to find significant announcement returns may be explained by partial anticipation (e.g., Acharya et al., 1993). In our study, we analyse the impact of the announcements of the effectiveness of three vaccines on airline stocks. Given that these vaccines have successfully passed through several phases of testing, investors must have partially anticipated the event, and stock price changes on announcement of the effectiveness of the COVID-19 vaccines only partly reflect the overall economic effect. Furthermore, given that pharmaceutical companies had become embroiled in an innovation race (e.g., Gu, 2016), it was expected that the first market announcement of the effectiveness of the COVID-19 vaccines would have a greater impact on the stock market than subsequent announcements.

Gu (2016) highlights that the potential future cash flows associated with R&D projects are more likely to be extinguished in competitive industries because rivals could win the innovation race. In the case of COVID-19, this has not been the case, as no firm has an official capacity to vaccinate the entire world. However, it was expected that the first announcement of the effectiveness of the COVID-19 vaccines would have a greater impact on stocks, as it would significantly reduce investor uncertainty levels, a situation that was not expected to happen with the same magnitude in the following announcements.

2.5. Cross-sectional analysis of market impact

We evaluate the relation between the observed abnormal performance and a set of firm-specific and industry attributes considered important by previous studies. These attributes include size, leverage, liquidity, profitability, ownership and a dummy to control for low-cost carriers. Firm size is one of the firm-specific standard control variables (e.g., Ramelli and Wagner, 2020). The literature shows that firm size affects a firm's market power advantage, economies of scale, and financial performance in the end. Titman and Wessels (1988) note that large firms tend to diversify their businesses more efficiently and are less prone to bankruptcy. Recent studies on the impact of the COVID-19 pandemic on the stock market show that larger firms appear to be less affected by the pandemic than smaller ones (e.g., Heyden and Heyden, 2021; Huo and Qiu, 2020; Ramelli and Wagner, 2020; Xiong et al., 2020). Previous studies on the airline industry show a negative relationship between firm value and size (Malighetti et al., 2011) and a positive relationship between systematic risk and firm size (Lee and Jang, 2007). Lee and Jang (2007) state that small airline firms tend to be less exposed to systematic risks owing to their relatively low operating costs. In addition, smaller companies have taken advantage of this pandemic crisis to find new opportunities as major carriers stopped flying the less profitable routes. In short, airlines tend to present a higher risk that is not reflected in a higher market valuation. Thus, the impact of the COVID-19 pandemic on the airline industry has been unpredictable.

Ding et al. (2020), Heyden and Heyden (2021), Huo and Qiu (2020), Ramelli and Wagner (2020), and Xiong et al. (2020) state that leverage tends to affect firm performance during economic downturns. Given the high anxiety of investors, Ding et al. (2020) highlight the negative moderating role of leverage, where increases in a firm's leverage under external shock signals a potential increase in business risks. As the pandemic depressed sales by firms, they were forced to seek liquidity to cover costs. According to Almeida et al. (2004) and Bates et al. (2009), liquidity acts as a precautionary buffer against adverse shocks. Ding et al. (2020) also stress the importance of access to credit during the pandemic. Firms with higher profitability and greater access to credit tend to experience less severe stock price declines than less profitable firms with less access to credit. This issue is especially important in the case of the airline industry. As Dube et al. (2021) note, with the onset of the COVID-19 pandemic, the cost of borrowing for airlines increased significantly due to the downgrade of their firm credit ratings (a large number reached junk status). This fact contributed to the liquidation of many airlines.

Like Malighetti et al. (2011), we include two variables related with ownership: (*i*) ownership concentration – cumulated ownership of the three main shareholders, and (*ii*) a dummy to control for state ownership. Previous studies (e.g., La Porta et al., 2002) state that when a few shareholders tightly hold a firm control, it is better they focus on value maximization. Malighetti et al. (2011) argue that since the airline industry is a very dynamic industry, strategic decisions must be taken with speed and decisiveness, and this is more likely to be true in a stable concentrated ownership framework. Regarding the state ownership dummy, the literature shows that when the main shareholder is the state or another public entity, the market perceives those objectives different from value maximization may be pursued by the management (e.g., Pedersen and Thomsen, 2003).

Finally, as in Malighetti et al. (2011), we include in the cross-sectional analysis a dummy to control for the low-cost effect. Flouris and Walker (2005) note that a low-cost carrier business model, from the perspective of investors, provides an airline firm with significantly more financial and operational flexibility than full-service airlines. They state that low-cost airlines tend to be more resilient and react to a changing environment more quickly than conventional airlines for three reasons: (*i*) they have a lower and more variable cost structure; (*ii*) they have a lower breakeven load factor; (*iii*) the high migration of business and leisure travellers from full-service airlines to low-cost airlines. Malighetti et al. (2011) show a statistically positive effect between airline value and the low-cost dummy. This result validates the idea that low-cost carriers may get a higher valuation in the stock market than traditional airlines.

3. Research hypotheses

3.1. We evaluate the following hypotheses

The declaration of COVID-19 as a global pandemic by the WHO was associated with a significant negative airline stock market reaction.

A significant negative airline stock market reaction is consistent with the asset-pricing perspective, reflecting those investors believe that the COVID-19 pandemic destroys value for listed firms. In fact, the asset-pricing perspective states that the market value of a firm's shares tends to decrease when there is an expectation of a decline in the firm's prospective cash flows and/or an expectation of an increase in discount rates.

[H2.1] The announcements of the effectiveness of COVID-19 vaccines are associated with a positive market reaction in the airline industry.

[H2.2] The announcement of the effectiveness of the Pfizer–BioNTech COVID-19 vaccine (the first to successfully complete vaccine trials) was associated with a more positive and greater market reaction in the airline industry than the announcements for other COVID-19 vaccines.

A significant positive market reaction was expected in the airline industry, this expectation is consistent with the asset-pricing perspective and the investor sentiment hypothesis. According to these theories, the announcements of the effectiveness of the COVID-19 vaccines might have immediately and positively affected the airline stock market returns, reflecting the fundamental changes in the net benefits for the society. It was expected that the first announcement of the effectiveness of the COVID-19 vaccines would have a greater impact on airline stocks, given the innovation race competition effect and the significant reduction in investor uncertainty levels.

Abnormal returns vary across events and airline firms and are driven by firm-specific characteristics.

Significant differences in the cross-section of abnormal returns are evidence in favour of arguments that predict the observed effects to be associated with differential benefits across airline firms, depending on the specific characteristics of the firms.

4. Data selection and the event study methodology

4.1. Data

We use the dates of the declaration of COVID-19 as a global pandemic (March 11, 2020) and of the announcements of the effectiveness of the Pfizer–BioNTech (November 9, 2020), Moderna (November 16, 2020) and AstraZeneca (November 23, 2020)[1] vaccines in the US as event dates to compute abnormal returns (ARs). The data used in the event study was collected from different sources. Airline stock returns were obtained from Datastream and computed using the total return index.

The selection of listed airline firms was obtained through the following steps. First, we selected all listed aviation firms in the world. Only firms whose activity is airlines were considered for the analysis.[2] The initial sample included 69 listed firms around the globe. Second, we eliminated 10 airline firms that have low liquidity in the stock market. The list of 59 listed airlines used for the analysis is presented in Appendix I. The US and China, with 11 and 7 listed airlines respectively, are the most represented in the table, where more than 30% of the total airlines are listed in these two markets.

For the multiple analysis, we use seven firm-specific variables: size, ownership concentration, liquidity, leverage, ROA, a low-cost dummy, and a state ownership dummy. The first five variables are calculated from the 2019 year-end accounting Fig. 3 or obtained from the airlines' annual reports available on their websites. The last two variables were collected from the International Civil Aviation Organization (ICAO). We use the low-cost carriers[4] and government-owned[5] airline lists compiled by the ICAO in the construction of the two dummy variables. Panel 5 of Table 1 provides the descriptive statistics of the control variables in our dataset.

4.2. Event study methodology

The event study methodology has been the standard method of measuring stock price reaction to some announcement or events since it was introduced by Fama et al. (1969). The literature shows that event studies have been used for two major reasons: (*i*) to test the stock market efficiency, and (*ii*) to examine the impact of some events on stock markets. The usefulness of this methodology depends on a set of assumptions that must be guaranteed so that the results do not appear biased (e.g., Brown and Warner, 1980, 1985). These authors highlight three assumptions that must be correctly taken into account in event studies: (*i*) markets are efficient—if this is true, then any financially relevant information that is newly revealed to investors will be quickly (instantaneously) incorporated into stock prices; (*ii*) events are unanticipated—the market previously did not have information on the event; (*iii*) there are no confounding effects from other events—it is possible to isolate the effects of one event from the effects of other events. As highlighted by Brown and Warner (1980, 1985), when these assumptions are assured, the event study method is a powerful tool, allowing the investigator to infer the significance of an event. This methodology is not free of problems. Sample size is a concern because the test statistics used in the event study framework is based on normality assumptions associated with large samples. da Graça and Masson (2012) demonstrate that the tests used in these studies are typically less powerful than they could be.

To measure the magnitude of stock price reaction to the emergence of COVID-19 and the announcements of the effectiveness of the vaccines, we use the standard abnormal returns technique based on the market model.[6] We calculate the normal rate of returns as follows:

$$E(R_{it}) = \widehat{a_i} + \widehat{b_i}\, R_{mt} \tag{1a}$$

where $E(R_{it})$ is the expected return rate of airline stock i on the trading day t; R_{mt} is the country's total return market index, and a_i and b_i are the regression coefficients of the daily return rate and the market return rate, respectively, of the airline stock i.

We use the dates of the declaration of COVID-19 as a global pandemic (March 11, 2020) and of the announcements of the effectiveness of Pfizer–BioNTech (November 9, 2020), Moderna (November 16, 2020) and AstraZeneca (November 23, 2020) vaccines in the US as event dates to compute abnormal returns (ARs), which are obtained by finding the difference between the observed returns of stock i on day t and the expected return generated by the market model as follows:

$$AR_{it} = R_{it} - E(R_{it}) \tag{2}$$

Like Heyden and Heyden (2021), we use the last 200 trading days of the year 2019 as our estimation window. By cumulating the ARs over a particular time interval, we obtain the cumulative abnormal returns (CARs) as follows:

$$CAR[t_1, t_2] = \sum_{t_1}^{t_2} AR_t \tag{3}$$

In the present study, $t_1 = -1$ and $t_2 = 1$ or 5. In analysing the impact of the announcements of the events on the stock market, two different time intervals for the CARs are considered: [−1,1] and [−1,5]. The descriptive statistics for the CARs are shown in Panels 1–4 of Table 1.

We use both parametric and non-parametric tests to assess the statistical significance of average abnormal returns. The parametric test statistics examined are the Brown and Warner (1980, 1985), without crude dependence adjustment. The non-parametric test statistic is the sign test. For more details about the tests, see Serra (2004).

4.3. Cross-sectional analysis

To estimate the impact of the firm-specific characteristics on the cross-sectional variation of abnormal returns, we evaluate the following equation by ordinary least squares (OLS):

$$CAR_i = \beta_0 + \beta_1 \ln(SIZE_i) + \beta_2 OWN_i + \beta_3 LIQ_i + \beta_4 TLEV_i + \beta_5 ROA_i + \beta_6 LCD_i + \beta_7 STO_i + \varepsilon_i \tag{4}$$

where CAR_i are the cumulative abnormal returns of airline firm i, $SIZE_i$ is the total assets (natural logarithm of total assets, millions of euros) of airline firm i, OWN_i is the cumulated ownership of the three main shareholders (%) of airline firm i, LIQ_i is the ratio of current assets to total assets (%) of airline firm i, $TLEV_i$ is the ratio of total debts to total assets (%) of airline firm i, ROA_i is the ratio of operating income to total average assets (%) of airline firm i, LCD_i is a dummy variable that takes the value 1 for low-cost carriers and 0 otherwise, STO_i is a dummy variable that takes the value 1 if the main owner is the state or another public entity and 0 otherwise, and ε_i is an i.i.d. (independent and identically distributed) error term. The reason for choosing these control variables and their expected effect on the stock market are explained in

[1] The timeline of COVID-19 developments in 2020 can be found here: https://www.ajmc.com/view/a-timeline-of-covid19-developments-in-2020.

[2] There are some firms, whose activity is airports & air services or travel services, which were not considered for the analysis.

[3] An identical procedure was adopted by Heyden and Heyden (2021).

[4] Available here: https://www.icao.int/sustainability/Documents/LCC-List.pdf.

[5] Available here: https://www.icao.int/sustainability/SiteAssets/Pages/Eap_ER_Databases/FINAL_Airlines%20Privatization.pdf.

[6] For more details, please see MacKinlay (1997) and Serra (2004).

Table 1
Descriptive Statistics of CARs and Control Variables and Results of Abnormal Returns Tests This table presents descriptive statistics of CARs and control variables and the results of abnormal returns tests. All figures of control variables are calculated from the 2019 year-end accounting figures. CAR_i are the cumulative abnormal returns for airline firm i for event window [-1; 1]; [-1; 5]; $SIZE_i$ is the total assets (natural logarithm of total assets, millions of Euro); OWN_i is the cumulated ownership of the three main shareholders (%); LIQ_i is the ratio of current assets to total assets (%); $TLEV_i$ is the ratio of total debt to total assets (%); ROA_i is the ratio of operating income to total average assets (%); LCD_i is a dummy variable that takes the value 1 for low-cost carriers and 0 otherwise; STO_i is a dummy variable that takes the value 1 if the main owner is the state or another public entity and 0 otherwise. θ_1 and τ_1 are the *p-values* of Brown and Warner (1980, 1985) *t*-test statistics and *z*-statistic for the sign test, respectively (see Serra, 2004; for more details). *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Variable	Mean	SD	25th perc.	Median	75th perc.	θ_1	τ_1
Panel 1: COVID as a Global Pandemic: March 11, 2020							
CAR [-1,1]	−7.94%	10.12%	−12.99%	−5.90%	−1.77%	0.007***	0.009***
CAR [-1,5]	−24.65%	26.41%	−45.05%	−17.69%	−6.15%	0.002***	0.006***
Panel 2: Pfizer, BioNTech COVID-19 Vaccine Results: November 9, 2020							
CAR [-1,1]	14.43%	10.74%	8.54%	12.08%	18.30%	0.005***	0.007***
CAR [-1,5]	17.29%	15.10%	7.69%	13.59%	22.26%	0.012**	0.018**
Panel 3: Moderna COVID-19 Vaccine Results: November 16, 2020							
CAR [-1,1]	5.23%	5.99%	1.96%	4.20%	8.02%	0.065*	0.081*
CAR [-1,5]	7.55%	9.71%	1.74%	6.79%	12.27%	0.090*	0.105
Panel 4: AstraZeneca COVID-19 Vaccine Results: November 23, 2020							
CAR [-1,1]	4.80%	7.85%	0.16%	1.42%	7.25%	0.143	0.155
CAR [-1,5]	3.12%	6.91%	−0.80%	1.89%	5.61%	0.170	0.183
Panel 5: Control Variables							
Size (SIZE)	€15,065 ml	€25,610 ml	€2,994 ml	€5,926 ml	€19,602 ml		
Ownership Concentration (OWN)	47.2%	24.6%	25.6%	46.4%	63.5%		
Liquidity (LIQ)	24.0%	12.1%	16.3%	21.6%	28.6%		
Total Leverage (TLEV)	40.8%	18.6%	28.0%	39.4%	52.6%		
Return on Assets (ROA)	2.0%	4.7%	−0.1%	2.4%	5.2%		
Low-Cost Dummy (LCD)	32.2%	47.1%	0	0	1		
State Ownership (STO)	25.4%	43.9%	0	0	0.5		

section 2.5. Equation (3) will be estimated for the following two announcements: (*i*) the declaration of COVID-19 as a global pandemic by the WHO, and (*ii*) announcement of the effectiveness of the Pfizer–BioNTech, COVID-19 vaccine.

Equation (3) can suffer from specification problems if unobservable country characteristics that influence airline stock returns are ignored. As an example, we have the aid provided by the state to airlines, which vary significantly from country to country. Other unobservable country-related characteristics tend to influence the market returns of airline firms. We use clustered robust standard errors to solve this problem. We group the standard errors by country and consider intra-cluster correlations or unobserved country heterogeneity in the equation. According to Wooldridge (2003), this procedure is equivalent to modelling country-specific random effects for the intercept.

5. Results

5.1. Abnormal return

Panels 1–4 of Table 1 show the cumulative abnormal returns due to the four announcements analysed in this study. We observe a negative and statistically significant stock price reaction to the declaration of COVID-19 as a global pandemic. The parametric and non-parametric tests show a level of statistical significance of 1%.

We also evaluate the impacts of the effectiveness of COVID-19 vaccines in the US on airline stock prices. The results are in line with the expectations, i.e., the existence of a positive impacts on the stock market due to the announcements. These results are consistent with investor sentiment and asset-pricing hypotheses, since it was expected that the stock market would respond immediately and positively to the announcements of the effectiveness of the COVID-19 vaccines, reflecting the fundamental changes in the net benefits for the society (e.g., Hong et al., 2021).

As explained above, given that these vaccines have successfully passed through several phases of testing, investors must have partially anticipated the event, and stock price changes on announcement of the effectiveness of the COVID-19 vaccines only partly reflect the overall economic effect. In fact, the effects of the announcements of the effectiveness of the vaccines on the stock market could be smaller than the economic impact, which is explained by investor partial anticipation (e.g., Acharya et al., 1993).

The results also show that the announcement of the effectiveness of the Pfizer–BioNTech, COVID-19 vaccine (the first to successfully complete vaccine trials) was associated with a more positive and greater market reaction in the airlines industry than the announcements for other COVID-19 vaccines in the US. The innovation race competition effect and the greater reduction in investor uncertainty levels explain the higher stock market impact of the announcement of the effectiveness of the Pfizer–BioNTech vaccine announcement, compared to the other two vaccines.

In short, the results obtained for the airline CARs lead us to reject the null of no significant aggregate market reaction to the WHO declaration of COVID-19 as a global pandemic and announcements of the effectiveness of COVID-19 vaccines in the US. As expected, the WHO declaration of COVID-19 as a global pandemic was associated with a negative and significant impact on stock prices. In turn, the announcements of 'cures' for the disease were associated with positive impacts on stock prices, with the first of these announcements showing a greater stock market impact than the other two announcements.

5.2. Cross-sectional analysis

We regress the cumulative abnormal returns (CAR[-1,1] and CAR [-1,5]) against the set of firm-specific variables as proposed by the empirical specification in Equation (4). Table 2 shows the results.

Our results show that the effect of liquidity is positive and statistically significant; this is consistent with the perspective that liquidity represents a premium that purchases investor insurance against risks that are otherwise hard to hedge (e.g., Ramelli and Wagner, 2020). This finding is in line with that of Ramelli and Wagner (2020) and supports the perspective of liquidity as a precautionary buffer to adverse shocks (Almeida et al., 2004; Bates et al., 2009). Concerning ROA, the results are not statistically significant. This is in line with the finding of Heyden and Heyden (2021). These authors also found no statistical significance for the variable profitability in their study.

The coefficient associated with the variable *OWN* is positive and

Table 2
Cross-Sectional Analysis of CARs for the Global Airline Industry This table presents OLS estimates of the impact of the announcement of COVID-19 as a global pandemic by World Health Organization (WHO) and Pfizer, BioNTech COVID-19 Vaccines Effectiveness Results on CARs for the global airline industry. Panel 1 reports the market reactions of COVID-19 declaration as a global pandemic by WHO. Panel 2 and Panel 3 presents the market reactions of Pfizer, BioNTech COVID-19 vaccine results. In Panel 2 the variables are calculated from the 2019 year-end accounting figures. In Panel 3 the variables are calculated based on 2020 interim accounting figures. The dependent variables are the airline CARs for two different time windows: [-1,1] and [-1,5]. $SIZE_i$ is the total assets (natural logarithm of total assets, millions of Euro); OWN_i is the cumulated ownership of the three main shareholders (%); LIQ_i is the ratio of current assets to total assets (%); $TLEV_i$ is the ratio of total debt to total assets (%); ROA_i is the ratio of operating income to total average assets (%); LCD_i is a dummy variable that takes the value 1 for low-cost carriers and 0 otherwise; STO_i is a dummy variable that takes the value 1 if the main owner is the state or another public entity and 0 otherwise*, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Country-clustering robust errors are used (in parentheses).

	Panel 1: COVID-19 as a Global Pandemic		Panel 2: Pfizer, BioNTech COVID-19 Vaccine Results		Panel 3: Pfizer, BioNTech COVID-19 Vaccine Results	
	[-1,1]	[-1,5]	[-1,1]	[-1,5]	[-1,1]	[-1,5]
Constant	−0.116 (−0.834)	−0.130 (−0.901)	0.362 (1.183)	0.440 (1.444)	0.331 (0.980)	0.215 (1.025)
Ln(SIZE)	0.010** (2.289)	0.030** (2.271)	−0.011** (−2.200)	−0.015** (−2.148)	−0.010* (−2.011)	−0.012** (−2.582)
OWN	0.081** (2.222)	0.345*** (3.549)	0.126 (1.767)	0.216** (1.925)	0.176*** (3.273)	0.153** (2.481)
LIQ	0.064** (2.203)	0.551*** (2.699)	0.184** (2.481)	0.257** (2.422)	0.142** (2.340)	0.267** (2.444)
TLEV	−0.244*** (−5.330)	−0.700*** (−4.002)	0.361** (2.255)	0.430** (2.319)	0.252** (2.180)	0.344** (2.203)
ROA	0.205 (1.488)	0.369 (1.588)	0.257 (1.577)	0.586 (1.555)	0.123 (1.382)	0.171 (1.275)
LCD	0.124** (2.221)	0.137** (2.307)	0.075** (2.180)	0.067** (2.211)	0.057** (2.189)	0.063** (2.285)
STO	−0.144** (−2.201)	−0.161** (−2.301)	−0.186** (−2.533)	−0.158** (−2.288)	−0.136** (−2.206)	−0.150** (−2.540)
Adj. R^2	0.282	0.317	0.279	0.341	0.285	0.364

statistically significant. This result is consistent with relevant results in the literature. Given the dynamism of the airline industry, strategic decisions need to be taken with speed and decisiveness, and this is more likely to be true in a stable concentrated ownership framework (e.g., La Porta et al., 2002; Malighetti et al., 2011). Regarding the state ownership dummy (*STO*) coefficient, the results show a negative and significant impact on airline abnormal returns. This negative relation between state ownership and price impact may be a reflection of the idea that when the main shareholder is the state or another public entity, the market anticipates that value maximization will not always be the focus of management (e.g., Pedersen and Thomsen, 2003).

Empirical evidence from Heyden and Heyden (2021) and Ramelli and Wagner (2020) show that investor concerns about debt could have reversed after the onset of the COVID-19 pandemic. Our results show this behaviour. In Panel 1 (COVID-19 as a global pandemic), the *TLEV* variable presents a statistically significant negative coefficient; in Panel 2 (Pfizer–BioNTech, COVID-19 vaccine effectiveness), the coefficient is positive and statistically significant. This change in the sign of the *TLEV* variable may be explained as follows. When COVID-19 was declared a global pandemic by the WHO, airline firms with higher debts tended to be more penalized by investors, given the foreseeable negative impact of the pandemic on sales and access to credit (e.g., Opler and Titman, 1994). But with the first announcement of the effectiveness of the COVID-19 vaccines, there was a reduction in uncertainty about finding a cure for the disease, leading to a change in investor sentiment and an increase in industry sales. Thus, airline debt was no longer the main constraint in terms of financing.

The variable *SIZE* has a behaviour similar to the variable *TLEV*—a coefficient with different signs in Panel 1 and Panel 2. The variable *SIZE* shows a positive and statistically significant coefficient in Panel 1. This result is explained by the literature as showing that larger firms appeared to be less affected by the COVID-19 pandemic than smaller ones (e.g., Heyden and Heyden, 2021; Huo and Qiu, 2020; Ramelli and Wagner, 2020; Xiong et al., 2020). Titman and Wessels (1988) note that large firms tend to diversify their businesses more efficiently and are less prone to bankruptcy. Despite the high indebtedness of airline firms and its negative impact on stock prices, we should not forget that most governments immediately signalled to financial markets that they would not let the industry collapse due to its economic importance (e.g., Abate et al., 2020; Dube et al., 2021). In our opinion, it was passed to market the idea that existed for big banks, which are firms too important to fail. In Panel 2, the variable *SIZE* presents a negative and statistically significant coefficient. This result can be explained by the fact that major airline carriers were forced to focus only on profitable routes, enabling new business opportunities for smaller firms. Lee and Jang (2007) obtain a similar result following the effects of the terrorist attacks of September 11, 2001, where smaller firms took advantage of this crisis to find new opportunities as major carriers handed over the less profitable routes.

Finally, regarding the variable *LCD*, we find a positive and statistically significant coefficient. The literature shows that for several reasons already mentioned above, low-cost airlines tend to be more resilient and react to a changing environment more quickly than conventional airlines. This greater resilience to crises comes from the greater financial and operational flexibility of low-cost airlines vis-à-vis full-service airlines (e.g., Flouris and Walker, 2005). Our result validates the idea that low-cost carriers may get a higher valuation by the stock markets than traditional airlines.

5.3. Robustness check

To prove the robustness of our findings, we conduct additional analysis of the announcement of the effectiveness of the Pfizer–BioNTech COVID-19 vaccine in the US. As highlighted by Abate et al. (2020), most governments have prioritized maintaining air transport connectivity in order to protect economic activity and jobs. State aid to airlines raises doubts about the appropriateness of the pre-COVID-19 data used in cross-sectional regressions in Panel 2 of Table 2 for vaccine announcement analysis. For example, due to state aid and bailouts, the ownership structure and indebtedness of airlines had already changed when vaccines were announced to be effective. According to the IATA, the global airline debt had increased by $220 billion by the end of 2020, where state aid accounted for between 1% (Latin America) and 25% (North America) of airline operating revenues in2019.[7]

We evaluate Equation (4) for the seven variables, using the most recent data for many of the control variables to draw any relevant explanatory power from them. The control variables are calculated based on interim accounting figures for the year 2020. Panel 3 of Table 2 provides the results, which are consistent with the results of the original analysis in Panel 2 of Table 2.

[7] For more information see https://www.iata.org/en/iata-repository/publications/economic-reports/government-aid-and-airlines-debt/. On this issue, we would like to acknowledge the comments received from one of the reviewers.

6. Conclusions

This paper has analysed whether the declaration of COVID-19 as a global pandemic by the WHO and announcements of the effectiveness of COVID-19 vaccines in the US were associated with significant stock market reaction in the airline industry. According to the asset-pricing perspective and the investor sentiment hypothesis, a negative and significant impact on stock prices was expected due to the WHO declaration of COVID-19 as a global pandemic. Based on these same theoretical models, it was also expected that the announcements of 'cures' for COVID-19 would lead to positive impacts on airline stock prices. These expectations are validated by the empirical results.

Furthermore, our empirical results show that the announcement of the effectiveness of the Pfizer–BioNTech COVID-19 vaccine (the first to successfully complete vaccine trials) in the US was associated with a positive and greater market reaction than the announcements for other COVID-19 vaccines. The innovation race competition effect and the greater reduction in investor uncertainty levels explain the higher stock market impact of the Pfizer–BioNTech vaccine announcement, compared to the announcements for the other two vaccines. We interpret this finding as being supportive of rational valuation and partial anticipation. The market reaction seemed to only partly reflect the overall perceived economic benefit of these mega-events.

Finally, this study provides insights into which firm-specific characteristics emerged as value drivers in the airline industry with the emergence of COVID-19. Our results show that low-cost carriers and non-state-controlled airline firms with past characteristics of greater liquidity and size, ownership concentration, and less leverage were more resilient to stock declines as a result of the emergence of COVID-19 than other airline firms. However, the leverage and size variables are positive and negative respectively for the cross-sectional analysis of the CARs for the announcement of the effectiveness of the Pfizer–BioNTech COVID-19 vaccine in the US.

Our findings have important implications for airline management and governments. Here, we look at the lessons learnt and how these can be used to prepare for future crises. The first lesson is that collaboration and coordination are essential to crisis management. Few industries are as global as aviation. This means that the airline industry requires international consensus, rules, frameworks, and collaboration to move forward. Consistent passenger procedures between origin and destination airports are vital in case of a future crisis. Governments and airlines worldwide must have a holistic view of the crisis and regularly update crisis measures as information and situations change. As highlighted by the National Academies of Sciences et al. (2022: 48) "*if those measures are not standardized and they are not harmonized, it will be difficult to get air travel back up and recovery back up, especially internationally*". The second lesson is that partnerships are a key factor. Partnerships have always been a key factor to crisis management and recovery. However, the COVID-19 pandemic has further highlighted the necessity of partners between the public and private sectors in the travel and tourism industry when defining crisis management responses. Strong relationships and regular communication between key stakeholders before a crisis occurs facilitates a holistic crisis response when it is needed. Third lesson: government support is fundamental to crisis management and recovery (e.g., Czerny et al., 2021). Government support measures are fundamental to crisis management, given that most airlines lose their ability to earn income in the event of a crisis. It is essential that governments have crisis preparedness plans that include financial support for the most severely affected sectors, as is the case with the aviation industry during the COVID-19 pandemic. Fourth lesson: airline firms should implement more flexible systems, as they tend to be more innovative and resilient to crisis. In terms of innovation, it is important that aircraft designs take into account passenger security and safety. The acceleration of digitalization is another prominent feature of this crisis (e.g., National Academies of Sciences et al., 2022). This acceleration will prevent some of the problems experienced by communities in the recent pandemic crisis. Finally, it is important to improve the quality of management decisions in the sector (e.g., Tisdall and Zhang, 2020). In addition to highlighting the importance of adequate tools in terms of resource management and cost management, the COVID-19 crisis has shown the need to incorporate the black swan theory in risk measurement models. Models based on conventional finance theories may underestimate the probability of black swans, since they incorporate the random walk and Gaussian distributions (e.g., Mandelbrot and Hudson, 2007). As highlighted by the authors, the chance of unexpected events is greater than the predictions of these models. This fact requires the employment of appropriate approaches in risk measurement that consider the stylized facts of asset returns, such as volatility clustering, long memory, and fat tails.

The timely implementation of these lessons would ensure that airlines do not go bankrupt, as well as reduce financial aid granted by states, in future crises. Our results also call for strong support from states in the search for a cure for future contagious diseases. Finally, airlines should seek to be more resilient to possible contagion events in the future. Airline firms must pay greater attention to debt and liquidity ratios to avoid bankruptcy when COVID-19-like events arise. As this article has made clear, these financial variables, when well-managed, can mitigate the negative effects of future black swan events and external shocks in the airline industry.

While our study provides insightful implications, it is important to keep in mind its limitations. A key ingredient in an event study involves the date(s). Regarding the emergence of COVID-19, we make use of the official date of the declaration of the disease as a global pandemic by the WHO, i.e., March 11, 2020. Other studies look at the impact of other important different dates related to COVID-19 (e.g., Ashraf, 2020a, Ashraf, 2020b; Heyden and Heyden, 2021), such as: (*i*) the date of the first COVID-19 confirmed case in the country; or (ii) the date of the first COVID-19 death in the country. Regarding key data on COVID-19 vaccines, we use a single date for each vaccine: when the vaccine effectiveness was announced as against the dates of vaccine trials. This choice is justified by the fact that vaccine development is a lengthy and uncertain process that generally takes around 10–15 years to complete before the vaccine can be mass-produced for public use (e.g., Chan et al., 2021). Despite the fact that the start of each phase marks a milestone in vaccine development because it (*i*) indicates the successful completion of the previous phase and (*ii*) boosts people's belief that the vaccine has a higher likelihood of progressing to the next stage, industry statistics show that only one-sixth of all vaccine candidates that undergo human clinical trials obtain final approval for mass production (Chan et al., 2021). Therefore, a more significant impact is to be expected when the vaccine is accepted by the regulators for mass population vaccination. We are aware that the magnitude of the impact of the emergence of COVID-19 and vaccine effectiveness announcements was influenced by the chosen dates.

Further studies may want to explore the impact of vaccinations on other industries and other asset classes, such as corporate bonds or currencies.

CRediT author statement

António Martins: Conceptualization; Methodology; Software; Formal Analysis; Writing – original draft; Writing – review & editing. **Susana Cró:** Conceptualization; Data Curation; Resources; Formal Analysis; Writing – original draft.

Declaration of competing interest

None.

Acknowledge

This paper is financed by Portuguese national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., projects numbers UIDB/

00685/2020 and UIDB/04007/2020.

Appendix

Appendix I. Sample of Publicly Listed Airlines Companies

This table reports the list of global airlines companies publicly listed analysed in the present study. For each one, the country where the company's headquarters is located is presented.

Companies Publicly Listed			
Airline Company	Headquarters	Airline Company	Headquarters
1. Air Canada	Canada	31. Icelandair Grp.	Iceland
2. Air China	China	32. InterGlobe Aviation	India
3. Air France-KLM	France/Netherlands	33. International Consolidated Airlines Grp. (IAG)	UK
4. Air New Zealand	New Zealand	34. Japan Airlines	Japan
5. Air Asia Berhad	Malaysia	35. Jeju Air	South Korea
6. Alaska Air Grp.	US	36. JetBlue Airways	US
7. Allegiant Travel	US	37. Jin Air	South Korea
8. American Airlines	US	38. Korean Air Lines	South Korea
9. ANA Holdings	Japan	39. LATAM Airlines	Chile
10. Avianca Holdings	Colombia	40. Mesa Air Grp.	US
11. Azul	Brazil	41.Nok Airlines	Thailand
12. Bangkok Airways	Thailand	42. Norwegian Air Shuttle	Norway
13. Cathay Pacific Airways	Hong Kong	43. Pegasus	Turkey
14. China Airlines	Taiwan	44. Aeroflot – Russian Airlines	Russia
15. China Eastern Airlines	China	45. Qantas Airways	Australia
16. China Express Airlines	China	46. Ryanair	Ireland
17. China Southern Airlines	China	47. SAS AB	Sweden
18. Controladora Vuela Compañía de Aviación	Mexico	48. Shandong Airlines	China
19. Copa Holdings	Panama	49. Singapore Airlines	Singapore
20. Delta Air Lines	US	50. SkyWest	US
21. Deutsche Lufthansa	Germany	51. Southwest Airlines	US
22. easyJet	UK	52. SpiceJet	India
23. El Al Israel Airlines	Israel	53. Spirit Airlines	US
24. EVA Airways	Taiwan	54. Spring Airlines	China
25. Finnair Oyj	Finland	55. Thai Airways International	Thailand
26. Garuda Indonesia	Indonesia	56. Turkish Airlines	Turkey
27. Gol Linhas Aéreas Inteligentes	Brazil	57. T'Way Air	South Korea
28. Grupo Aeroméxico	Mexico	58. United Airlines	US
29. Hainan Airlines	China	59. Wizz Air	Hungary
30. Hawaiian Airlines	US		

References

Abate, M., Christidis, P., Purwanto, A.J., 2020. Government support to airlines in the aftermath of the COVID-19 pandemic. J. Air Transport. Manag. 89, 101931.

Acharya, S., 1993. Value of latent information: alternative event study methods. J. Finance 48 (1), 363–385.

Acharya, V.V., Johnson, T., Sundaresan, S., Zheng, S., 2020. The value of a cure: an asset pricing perspective. NBER. *Working Paper No. 28127*.

Alfaro, L., Chari, A., Greenland, A.N., Schott, P.K., 2020. Aggregate and firm-level stock returns during pandemics. Real Time. *NBER Working Paper No. 26950*.

Almeida, H., Campello, M., Weisbach, M.S., 2004. The cash flow sensitivity of cash. J. Finance 59 (4), 1777–1804.

Altig, D., Baker, S., Barrero, J.M., Bloom, N., Bunn, P., Chen, S., Davis, S., Leather, J., Meyer, B., Mihaylov, E., Mizen, P., Parker, N., Renault, T., Smietanka, P., Thwaites, G., 2020. Economic uncertainty before and during the COVID-19 pandemic. J. Publ. Econ. 191, 104274.

Ashraf, B.N., 2020a. Economic impact of government interventions during the COVID-19 pandemic: international evidence from financial markets. J. Behav. Exp. Fin. 27, 100371.

Ashraf, B.N., 2020b. Stock markets' reaction to COVID-19: cases or fatalities? Res. Int. Bus. Finance 54, 101249.

Bae, S.Y., Chang, P.J., 2021. The effect of coronavirus disease-19 (COVID-19) risk perception on behavioural intention towards 'untact' tourism in South Korea during the first wave of the pandemic (March 2020). Curr. Issues Tourism 24 (7), 1017–1035.

Baele, L., Bekaert, G., Inghelbrecht, K., Wei, M., 2020. Flights to safety. Rev. Financ. Stud. 33 (2), 689–746.

Baker, M., Wurgler, J., 2006. Investor sentiment and the cross-section of stock returns. J. Finance 61 (4), 1645–1680.

Baker, S.R., Bloom, N., Davis, S.J., Kost, K., Sammon, M., Viratyosin, T., 2020. The unprecedented stock market reaction to COVID-19. Rev. Asset Pricing Stud. 10 (4), 742–758.

Bates, T.W., Kahle, K.M., Stulz, R.M., 2009. Why do US firms hold so much more cash than they used to? J. Finance 64 (5), 1985–2021.

Brown, S.J., Warner, J.B., 1980. Measuring security price performance. J. Financ. Econ. 8 (3), 205–258.

Brown, S.J., Warner, J.B., 1985. Using daily stock returns: the case of event studies. J. Financ. Econ. 14 (1), 3–31.

Button, K., 1996. Liberalising European aviation: is there an empty core problem? J. Transport Econ. Pol. 30 (3), 275–291.

Campbell, J.Y., 2000. Asset pricing at the millennium. J. Finance 55 (4), 1515–1567.

Chan, K.F., Chen, Z., Wen, Y., Xu, T., 2021. COVID-19 vaccines: saving lives and the global stock markets. Available at: SSRN 3785533(https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3785533. .

Chang, C.P., Feng, G.F., Zheng, M., 2021. Government fighting pandemic, stock market return, and COVID-19 virus outbreak. Emerg. Mark. Finance Trade 57 (8), 2389–2406.

Czerny, A.I., Fu, X., Lei, Z., Oum, T.H., 2021. Post pandemic aviation market recovery: experience and lessons from China. J. Air Transport. Manag. 90, 101971.

da Graça, T., Masson, R., 2012. More power to you: properties of a more powerful event study methodology. Rev. Account. Finance 11 (2), 166–183.

Ding, W., Levine, R., Lin, C., Xie, W., 2020. Corporate immunity to the COVID-19 pandemic. NBER. *Working Paper No. 27055*.

Donthu, N., Gustafsson, A., 2020. Effects of COVID-19 on business and research. J. Bus. Res. 117, 284–289.

Dube, K., Nhamo, G., Chikodzi, D., 2021. COVID-19 pandemic and prospects for recovery of the global aviation industry. J. Air Transport. Manag. 92, 102022.

Economist, 2012. The Ineluctable Middlemen. The Economist.

Fama, E., 1991. Efficient capital markets: II. J. Finance 46 (5), 1575–1617.

Fama, E.F., Fisher, L., Jensen, M., Roll, R., 1969. The adjustment of stock prices to new information. Int. Econ. Rev. 10 (1), 1–21.
Fetzer, T., Hensel, L., Hermle, J., Roth, C., 2020. Coronavirus perceptions and economic anxiety. Rev. Econ. Stat. 1–36.
Flouris, T., Walker, T.J., 2005. The financial performance of low-cost and full-service airlines in times of crisis. Can. J. Adm. Sci. Rev. Canad. Sci. Adm. 22 (1), 3–20.
Forsyth, P., Guiomard, C., Niemeier, H.M., 2020. Covid− 19, the collapse in passenger demand and airport charges. J. Air Transport. Manag. 89, 101932.
Gu, L., 2016. Product market competition, R&D investment, and stock returns. J. Financ. Econ. 119 (2), 441–455.
He, P., Sun, Y., Zhang, Y., Li, T., 2020. COVID–19's impact on stock prices across different sectors—an event study based on the Chinese stock market. Emerg. Mark. Finance Trade 56 (10), 2198–2212.
Heyden, K.J., Heyden, T., 2021. Market reactions to the arrival and containment of COVID-19: an event study. Finance Res. Lett. 38, 101745.
Hong, H., Wang, N., Yang, J., 2021. Implications of stochastic transmission rates for managing pandemic risks. Rev. Financ. Stud. (Forthcoming).
La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R., 2002. Investor protection and corporate valuation. J. Finance 57 (3), 1147–1170.
Lee, J.S., Jang, S.S., 2007. The systematic-risk determinants of the US airline industry. Tourism Manag. 28 (2), 434–442.
Liu, M., Choo, W.C., Lee, C.C., 2020. The response of the stock market to the announcement of global pandemic. Emerg. Mark. Finance Trade 56 (15), 3562–3577.
MacKinlay, A.C., 1997. Event studies in economics and finance. J. Econ. Lit. 35 (1), 13–39.
Malighetti, P., Meoli, M., Paleari, S., Redondi, R., 2011. Value determinants in the aviation industry. Transport. Res. E Logist. Transport. Rev. 47 (3), 359–370.
Mandelbrot, B., Hudson, R.L., 2007. The Misbehavior of Markets: A Fractal View of Financial Turbulence. Basic Books, New York, NY.
Maneenop, S., Kotcharin, S., 2020. The impacts of COVID-19 on the global airline industry: an event study approach. J. Air Transport. Manag. 89, 101920.
Mazur, M., Dang, M., Vega, M., 2021. COVID-19 and the March 2020 stock market crash. Evidence from S&P1500. Finance Res. Lett. 38, 101690.
McQueen, G., Roley, V.V., 1993. Stock prices, news, and business conditions. Rev. Financ. Stud. 6 (3), 683–707.
National Academies of Sciences, Engineering, and Medicine, 2022. Flying in the COVID-19 Era: Science-Based Risk Assessments and Mitigation Strategies on the Ground and in the Air: Proceedings of a Workshop. The National Academies Press, Washington, DC. https://doi.org/10.17226/26426.
Narayan, P.K., Phan, D.H.B., Liu, G., 2021. COVID-19 lockdowns, stimulus packages, travel bans, and stock returns. Finance Res. Lett. 38, 101732.
Opler, T.C., Titman, S., 1994. Financial distress and corporate performance. J. Finance 49 (3), 1015–1040.
Pagano, M., Wagner, C., Zechner, J., 2020. Disaster Resilience and Asset Prices. Discussion Paper, CEPR.
Pedersen, T., Thomsen, S., 2003. Ownership structure and value of the largest European firms: the importance of owner identity. J. Manag. Govern. 7 (1), 27–55.
Ramelli, S., Wagner, A.F., 2020. Feverish stock price reactions to COVID-19. Rev. Corporate Fin. Stud. 9 (3), 622–655.
Rouatbi, W., Demir, E., Kizys, R., Zaremba, A., 2021. Immunizing markets against the pandemic: COVID-19 vaccinations and stock volatility around the world. Int. Rev. Financ. Anal. 77, 101819.
Salisu, A.A., Vo, X.V., 2020. Predicting stock returns in the presence of COVID-19 pandemic: the role of health news. Int. Rev. Financ. Anal. 71, 101546.
Scheppler, L., De Clercq, N., McGoldrick, M., Dias, J., 2021. Regulatory harmonization and streamlining of clinical trial applications globally should lead to faster clinical development and earlier access to life-saving vaccines. Vaccine 39, 790–796.
Serra, A.P., 2004. Event study tests: a brief survey. Gestão. Org-Revista Electrónica de Gestão Organizacional 2 (3), 248–255.
Suau-Sanchez, P., Voltes-Dorta, A., Cugueró-Escofet, N., 2020. An early assessment of the impact of COVID-19 on air transport: just another crisis or the end of aviation as we know it? J. Transport Geogr. 86, 102749.
Tisdall, L., Zhang, Y., 2020. Preparing for 'COVID-27': lessons in management focus–an Australian general aviation perspective. J. Air Transport. Manag. 89, 101922.
Titman, S., Wessels, R., 1988. The determinants of capital structure choice. J. Finance 43 (1), 1–19.
Tretheway, M.W., Markhvida, K., 2014. The aviation value chain: economic returns and policy issues. J. Air Transport. Manag. 41, 3–16.
Wooldridge, J., 2003. Cluster-sample methods in applied econometrics. Am. Econ. Rev. 93, 133–138.
Xiong, H., Wu, Z., Hou, F., Zhang, J., 2020. Which firm-specific characteristics affect the market reaction of Chinese listed companies to the COVID-19 pandemic? Emerg. Mark. Finance Trade 56 (10), 2231–2242.
Yong, H.H.A., Laing, E., 2021. Stock market reaction to COVID-19: evidence from US firms' international exposure. Int. Rev. Financ. Anal. 76, 101656.