Tourism stock price and COVID-19: medium-term relationship with passenger transport, hotel, and tour operator subsectors.

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COVID-19 has had a devastating effect on tourism in Spain, one of the world's biggest tourist destinations and also one of the first countries to face the consequences of the pandemic. Tourism stock prices showed high volatility at the beginning of the pandemic. However, we do not yet know whether this relationship has remained throughout the pandemic and the effect it has had on the main subsectors of tourism. Quantifying this relationship in the medium term makes it possible to predict the effect of the pandemic on the tourism sector stock market and to compare the impact on its different subsectors. A dynamic regression model has been developed to predict the stock price of the hotel, passenger transport, and tour operator subsectors in Spain, based on the evolution of COVID-19. Cumulative COVID-19 deaths have been confirmed to be a good predictor of abnormal stock price in the main tourism subsectors, affecting passenger transport more intensely than hotels or tour operators.

Keywords**:** COVID-19; abnormal stock price; Spain; tourism stock price; dynamic regression models.

1. Introduction

In March 2020, the World Health Organization decreed that COVID-19 should be classed as a pandemic. To contain the spread, governments implemented restrictions on mobility and mass gatherings, social distancing, closing public spaces, etc. (Dube et al. 2020; Liev, 2020a), which fully impacted the world's economy, with tourism being the most affected sector.

Mobility restrictions and perceived risk drastically reduced tourism demand, the effect of which was more intense in tourism-dependent countries (Novelli, et al., 2018). Therefore, since February 2020, negative year-on-year variation rates have been recorded, reaching falls of more than -90% in April, May, and June, and higher than -80% from October 2020 to May 2021. Globally, on average, international tourist arrivals fell by -73% in 2020 and -80% in the first half of 2021 (UNWTO, 2021).

In Spain, tourism is a strategic sector, accounting for 12% of its GDP and 13% of employment (Torres & Fernández, 2020). In 2019, it received more international tourists than any other country in the world, with 83.5 million, and recorded the second highest turnover in tourism, with 79.7 billion USD, which accounts for 16% of exports (UNWTO, 2021).

In addition, Spain was one of the first countries to face large outbreaks of the pandemic, which led to a nationwide lockdown for three months. Thus, activity in the sector was drastically reduced, coming to a total standstill from April to June 2020. On average, international tourist arrivals fell by -77% in 2020 and -74% in the first half of 2021, and it was not until the summer of this year that the decline dipped below -50% (UNWTO, 2021). This is due to the fact that, in countries that are strongly dependent on tourism, the tourism stock market has suffered the most as a result of the pandemic. Indeed, Gofran et al. (2022) advised against investing in the Spanish tourism sector during the pandemic.

Stock price fluctuations are usually attributed to exceptional events and circumstances (Chen & Siems, 2004), such as natural disasters, health crises or political instability (Nhamo, 2020), because of investor decisions, which are influenced by market sentiment (Ichev & Marinč, 2018). As for the stock market, COVID-19 has had a greater influence than any other infectious-contagious disease, especially in terms of tourism stock price, which reached levels of volatility comparable to those of the great crises of the last century and demonstrated low performance compared to other sectors (Baker et al., 2020; Daglis & Katsikogianni, 2022).

Therefore, it is important to know the magnitude of the pandemic and how damaging it is according to market and investor perceptions (Ru et al., 2020), whose expectations will influence companies' stock prices (Nhamo, 2020). Therefore, analysing the impact and predictive capacity of the evolution of the pandemic on the shares of certain tourism companies can help to minimise uncertainty and maintain investor confidence, thereby avoiding abrupt radical fluctuations that are extended over time, which will help to improve the response to the crisis (Chen et al., 2009).

The existing literature on the impact of COVID-19 on the tourism stock market, summarised in Table 2 in the literature review section, has focused on the short term, taking as a time horizon the initial outbreak of COVID-19. In fact, these studies demonstrated its devastating effect on tourism stock prices and highlight the concern that exists regarding the evolution of this relationship in the medium and long term (Sharma & Nicolau, 2020), considering that it will take six years, from the start of the pandemic, to return to normal levels in the sector (Carter et al., 2022). In addition, few authors have studied the impact of the health parameters of the pandemic on the tourism stock market (Liew, 2020b; Sharma & Nicolaw, 2020, Wu et al. 2020). Only Sharma and Nicolau (2020) showed the effect of the number of positive cases and deaths, but without determining the best predictor, and ignoring the fact that, at the start of the pandemic, when all these studies were carried out, the numbers of cases were not exact, and the real proportion of people infected was unknown (Ioannidis, 2020).

The research presented here was conducted in Spain, where previously only Gil-Alana and Poza (2022) and Gofran et al. (2022) have conducted impact studies of the pandemic on the tourism stock market, although in their case the time interval studied ended in mid May 2020, and they did not tie their findings in with health variables (Table 2).

Understanding the impact of the pandemic on the stock market is extremely important to counter the uncertainty generated in investor expectations (Nhamo et al. 2020; Ru et al., 2020). Furthermore, the interconnection between companies in different subsectors of tourism transmits the impact on the stock market from one subsector to another (Daglis & Katsikogianni, 2022), hence the importance of sector and sub-sector specific analyses.

The research presented in this paper is framed within this gap in the literature. Hence, the main objective of this research is to analyse and quantify the relationship between COVID-19 and the stock price of the three most important subsectors of tourism (hotels, tour operators, and transport) in Spain, in the medium term (14 months), developing prediction models and comparing this relationship of dependency.

The starting hypothesis for this research is divided into four sub-hypotheses:

H1. In the medium term, the number of deaths from COVID-19 is the best predictor for the stock price of the main tourism subsectors[1], rather than the number of cases.

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[1] Hotels, tour operators, and transportation.

H2. In the medium term, there is a significant, negative, and quantifiable relationship of dependency between the number of deaths from COVID-19 and the stock price of the main tourism subsectors.

H3. This relationship between the number of deaths and the stock price of the main tourism subsectors is maintained beyond the initial impact of the pandemic.

H4. The stock price of the transport subsector was the most severely affected by the evolution in the number of deaths due to COVID-19, followed by the hotel subsector, and finally tour operators.

The results of this research will guide decision makers and governments to make effective decisions in the medium term (Estiri et al., 2022), since the evaluation of risks resulting from unexpected health situations provides a foundation to formulate emergency risk and tourism planning strategies (Chen et al, 2022). Knowing the impact of the pandemic on the stock market evolution of key companies in the tourism sector allows them to direct financial aid and support, since their role is critical in the recovery and sustainability of the sector (Sharma & Nicolau, 2020).

In addition, it is very useful information for companies and investors, who should be aware of financial risks (Anim et al., 2021) when making decisions to maximise profits and minimise losses in global pandemic situations, protecting and anticipating stock market effects by diversifying their portfolio (Sharma & Nicolau, 2020).

2. Literature Review

COVID-19 is one of the infectious diseases that has caused the most deaths in recent times and has had a serious impact on the world economy (Ramelli & Wagner, 2020), forcing the governments of many countries to take restrictive measures regarding business activities and citizen mobility (Vila, 2020).

Since the start of the pandemic, stock markets around the world have reflected the impact of COVID-19, with very high volatilities (Bagão et al., 2020). The Standard & Poor's 500 index suffered a drop of 33.9% from 19 February 2020 to 23 March 2020. In Europe, the Euro Stoxx50 reduced its value by almost 40% between 20 January and 16 March 2020 (Vila, 2020). In Spain, the Ibex35 plummeted 65% in the same period (Madrid Stock Exchange, 2021).

Among the most affected economic sectors, tourism and passenger transport felt the effects of the pandemic very strongly (Clavellina, 2020), with tourist arrivals falling worldwide between 70% and 90% (UNWTO, 2021), as a result of travel restrictions, lockdowns, and general fear related to COVID-19, which significantly decreased the income and profitability of the tourism sector (Carter et al., 2022).

The stock prices of companies in the tourism sector were greatly affected by the pandemic, with sharp falls and extreme volatility (Sharma & Nicolau, 2020; Mazur, et al., 2020). Some companies lost up to 80% of their value in two weeks (Nhamo et al., 2020). The effect was similar, although much more significant, to other exceptional situations, such as terrorism and war (Chen, 2011; Chen & Siems, 2004; Lanouar & Goaied, 2019), epidemic diseases such as SARS[2]-2003 (Chen et al., 2007; Chen et al., 2009; Loh, 2006), or outbreaks (Kim et al., 2020) such as Ebola (Ichev & Marinč, 2018). Table 1 summarises the research conducted to date about the impact of infectious diseases and the tourism stock market.

(Table 1)

The SARS-2003 pandemic is considered the smaller-scale predecessor of COVID-19, and research carried out during this outbreak provided the basis for conducting the same analysis during COVID-19. SARS-2003 shocked the economy and tourism of the countries affected, more than other sectors (Chen et al., 2007; McKercher & Chon, 2004). In fact, tourism stock returns fell sharply after the announcement of the SARS-2003 outbreak, with abnormal returns remaining negative for a long period of time (Chong et al., 2010).

Different authors have analysed the behaviour of the different tourism subsectors during SARS-2003. Their findings highlight the fragility of the hotel sector (Chen et al., 2007; Chen et al., 2018), with the most significant negative average abnormal returns on the day of the SARS-2003 outbreak and increasing over time. This drop in profitability is associated not only with a decrease in the number of international tourists and, therefore, in hotel revenues, but also with the increase in the perceived risk of investments in hotel stocks (Chen et al., 2011). Loh (2006) focused on the transport sector, studying the volatility and returns of airline companies as a result of the effect of the SARS-2003 outbreak, which pushed down the share prices of most airlines, compared to the period before the event.

[2] Severe Acute Respiratory Syndrome

Table 2 summarises the research conducted to date about the impact of COVID-19 on the tourism stock market. As we can see, the work carried out previously has used databases from the start of the pandemic, during the initial outbreak of the disease.

(Table 2)

All of them agree in their conclusions, summarising that the first outbreak of COVID-19 negatively affected stock prices and returns in tourism above other sectors, showing extreme temporary volatility (Haroon & Rizvi, 2020; Liev, 2020a & 2020b; Mazur et al., 2021; Yiwei et al., 2022). Some of them, after applying regression models, even claim that the effect on the sector was explosive (Wang et al., 2022), with values declining faster and faster, after lockdown was imposed on Wuhan (Al-Awadhi, et al., 2020; Liev, 2020a and 2020b; Carter et al., 2022; Lin & Falk, 2022). This and the declaration of a global pandemic were the most analysed events (Nhamo et al., 2020), applying event study methodology, recording an 85% fall in tourism stock prices and a 20% drop in accumulated abnormal returns (Liev 2020a).

Liquidity fell for tourism markets, thereby reducing their efficiency (Gofran et al., 2022). This, along with volatility, solvency, and the size of tourism businesses are the variables that have driven cumulative abnormal returns during COVID-19 (Pandey & Kumar, 2022). The most productive tourism companies are those that reduced their returns, but their recovery was faster (Poretti & Heo, 2022). In addition, those with the highest financial leverage were the most affected (Carter et al., 2022). All this is a consequence of greater volatility in the financial markets, which has a more powerful effect for the sectors most affected by the events that took place during the pandemic (Haroon & Rizvi, 2020).

Some authors have explored this impact of COVID-19 on the stock market behaviour of tourism companies, by subsectors (Table 2). Companies in the transport, hotel, and leisure subsectors were the most affected by the initial declaration of the pandemic. Consequently, when comparing pre-pandemic values of the tourism subsectors' stock prices with those of the pandemic, a negative effect was confirmed (Sharma & Nicolau, 2020).

Transportation sectors performed significantly worse than the market during COVID-19, (Al-Awadhi et al., 2020; Lin & Frank, 2022, Nhamo et al., 2020), and were more affected than the hotel sector (Haroon & Rizvi, 2020; Poretti & Heo, 2022). The hotel sector experienced a dramatic decline, with a rapid descent of market capitalisation, falling more than 70%, and volatility levels above 20% (Mazur et al (2021). In the first phase of the pandemic, the air transport sector was the first to suffer the negative impact of COVID-19, followed by the hotel sector (Carter et al., 2022). Within the transport sector, cruises suffered the greatest losses (Nhamo et al., 2020; Sharma & Nicolau, 2020).

Tour operators also suffered the effect of the pandemic, with stock prices falling more quickly after the lockdown in Wuhan, reflecting losses of up to 55.1% (Liew, 2020b).

3. Data and methodology

In this research, the objective is to establish and quantify the relationships of dependency between the stock market prices of the most representative companies of the different tourism subsectors in Spain and the evolution of the COVID-19 pandemic, which can be used to predict the stock market performance of these companies.

3.1. Data

The time period spanned by the database used extends from the month in which the first cases and news related to the pandemic appeared up to when the vaccination process began to be implemented at a rate of 90 per cent[3] and at least 5% was fully immunised (Epdata, 2021). Therefore, the time frame spans from 1 February 2020 to 31 March 2021. This is a period of 14 months that will allow the analysis to be carried out in the medium term, going beyond the start of the pandemic and covering the period of its highest incidence in Spain, where the tourist companies analysed are listed.

The options considered and tested for the dependent variable and the explanatory variables were different, in order to develop the most reliable prediction model that would best define the relationship between the pandemic and the stock market behaviour of the main Spanish tourism companies.

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[3] Number of doses administered over those received.

In this study, for the dependent variable Y_t, the stock values of all the companies in the tourism sector that are listed on the Madrid Stock Exchange are considered. These are also the most important and representative of the subsectors that make up this industry: tour operators, hotels, and passenger transport. Therefore, the companies listed on Madrid Stock Exchange are Edreams Odigeo, S.A. (Edreams), Meliá Hotels International (Meliá), S.A., NH Hotel Group, S.A. (NH), Aena, S.M.E., S.A. (Aena) and International Consolidat Airlines Group (IAG). The potential dependent variables considered for modelling were:

(1) Companies' daily stock prices.

(2) Daily abnormal stock prices (ASP), calculated using the approach to measuring abnormal performance in a sector described by Brown and Warner (1985), applying the following formula for each day's values:

$$ASP_{jt} = C_{jt} - \overline{C}_j \qquad (1)$$

where ASP_{jt} is the abnormal listed price of stock j at time t, C_{jt} is the actual observed listed price of stock j at time t, and $\overline{C}_j$ is the average of the daily stock prices listed on stock index j during the (-30,-11) estimation period. $\overline{C}_j$ is calculated as follows (Chen and Siens, 2004):

$$\bar{C}_t = \frac{1}{20} \sum_{t=-30}^{-11} C_{jt} \qquad (2)$$

(3) Abnormal returns calculated using the adjusted average return method and using the following formula for the values of each day:

$$AR_{jt} = R_{jt} - \overline{R_J} \quad (3)$$

where AR_{jt} is the abnormal return of stock j at time t, R_{jt} is the actual observed performance of stock j at time t, and $\bar{R}_j$ is the average daily return of stock index j during the (-30,-11) estimation period. $\bar{R}$ is calculated as follows (Chen & Siens, 2004):

$$\bar{R}_t = \frac{1}{20} \sum_{t=-30}^{-11} R_{jt} \quad (4)$$

For the values of series X_t, four different variables for the behaviour of the COVID-19 pandemic have been considered, obtained through Spain's National Epidemiology Centre (Centro Nacional de Epidemiología, 2021): number of deaths per day, cumulative number of deaths, number of new cases daily, cumulative number of cases.

After the pertinent tests, described in the following subsection, the cumulative number of deaths was selected as the explanatory variable X_t (Figure 1), and for the dependent variable Y_t, the variables that yielded the best results were the ASP of Edreams, for the tour operator subsector, Melia for the hotel sector, and Aena for transport. Neither the values of NH nor those of IAG provided a conclusive model. In addition, for the purpose of homogeneity, it was convenient to use the same number of companies for each subsector. As a result, three of the five possible companies are considered, which means a sample that represents 60% of the population.

(Figure 1)

3.2. Methodology

To conduct this research, a descriptive analysis is carried out of the ASP behaviour of the tourism sector and the Ibex-35, as a reflection of market evolution, as well as each of the subsectors studied, reporting average, maximum, and minimum values, and linking them with circumstances and events of the pandemic.

For the statistical study, the classic regression model solved by the least squares method, widely used for fit and prediction in previous studies of stock prices, could not be applied. (Ichev & Marinč, 2018; Sharma & Nicolau, 2020). This was due to the fact that the observations of a series depend on their past values, so the resulting residuals εt would be auto-correlated. Therefore, the estimation of coefficient β is no longer the best possible measure, as some information is ignored in the calculation, and the t-test for the significance of the coefficient is incorrect. The Akaike information index (AIC) values adjusted models are no longer a good guide to the best prediction model, and the p-values associated with the coefficients will be excessively low. Therefore, some predictor variables appear to be relevant, but they are not really significant (spurious regression).

Considering the ARIMA models (Stram & Wei, 1986), as time series fit and prediction models, these take into account past observations without considering the inclusion of X_t series as explanatory covariates.

Therefore, DRMs offer a conjunction of the previous models (Bollerslev & Wooldridge, 1992). DRMs make it possible to determine the extent to which the current value of a variable depends on its previous values and to specify independent variables (Mateu-Svert et al., 2013).

The following equations show the exact formulation of a DRM, which has two error terms associated with it: η_t associated with the regression of Y_t over X_t, which is adjusted by an ARIMA (p,d,q) process, and the final error ε_t, obtained from the ARIMA fit, which is required to yield independent and identically distributed values.

$$Y_t = \alpha + \beta X_t + \eta_t,$$

$$\eta_t \sim ARIMA(p, d, q)$$

$$\eta_t \sim + \emptyset_1 \eta_{t-1} + \cdots + \emptyset_p \eta_{t-p} + \qquad (6)$$

$$+\theta_1 \epsilon_{t-1} + \cdots + \theta_q \epsilon_{t-q} +$$

$$+\epsilon_t$$

$$\epsilon_t \sim N(0; \sigma)$$

The maximum likelihood method has been used to estimate the described model, taking the values that make the observed series most likely to occur, since in this model the estimated parameters have a known distribution, or they can be associated with a hypothesis test to establish their influence on the model.

The series involved in a DRM must be stationary. If they are not, the coefficients obtained will not be consistent and/or significant estimates. To avoid this problem, you can convert non-stationary to stationary series using two methods: logarithmic transformation, which makes the dispersion more or less constant; or series differentiation, which helps to eliminate the tendency of a series, seeking stationarity in the mean. These transformations have been applied to the variables used. In practice, the stationarity of the series stock price is assured using the Dickey-Fuller test (Said & Dickey, 1984).

The second premise for the application of a DRM is that the errors are white noise, which means that εt behaves like a stochastic process taking random and independent values. In this study, the white noise condition is verified using the Ljung-Box test, which states in its null hypothesis that all autocorrelations in the series (up to a sufficiently high order) are null, which is equivalent to saying that the residuals are random and independent of each other (Ljung and Box, 1978).

A graphic representation of the autocorrelations ρ(k), orders 1, 2 ..., k, has been made, which is the so-called Bartlett Bands test (Bartlett, 1964), as a support for the Ljung-Box test (Bartlett, 1964), proving that, in a series of white noise, such autocorrelations should be placed within the band "−2/T, 2/T", with T being the size of the series.

Finally, to select the definitive model from the different correct explanatory models, based on its goodness-of-fit, the AIC statistic (Wagenmakers and Farrell, 2004) has been used, employing the criterion of the lowest AIC, since it takes into account the number of parameters to arrive at a good compromise between fit and prediction. The generic Root-Mean-Square Error (hereinafter RMSE) fit has been discarded (Chai

& Draxler, 2014) since the greater the number of parameters, the better it will fit the data, although it will gradually lose its predictive capacity and vice versa.

Over the course of this study, we have analysed and related time series two by two. Bearing this objective in mind, regression models between series are commonly used as if they were two statistical variables, but modified so that errors are not auto-correlating, which is why we have chosen the DRM methodology.

We chose not to use other statistical models that have been applied previously in the scientific literature, such as data panel models (Al-Awadhi et al. 2020; Topaloglu et al.; 2021) because in these models the time variable is usually considered a variable that divides the samples into a few categories, whereas in this study there is a very fine partitioning of time.

An event study approach was similarly ruled out because the aim of this study is to establish a model for predicting stock price according to health variables and how they have evolved over the course of COVID-19 whereas the objective of event study methodology (Uguedo, 2003) is to analyse whether there have been any abnormal returns in any of the financial assets of a company, in response to new information about an event (Liew, 2020a; Liu et al., 2020; Ofori-Boateng et al., 2021). Furthermore, the estimation periods used in the event study methodology are usually between 100 and 300 days, for studies with daily returns (Uguedo, 2003), so it would not be appropriate to use it in this study, since we are analysing the daily ASP of tourism companies over the course of 424 days.

4. Results

4.1. Descriptive Analysis

Figure 2 shows the evolution of the Ibex35 ASP and the tourism sector ASP throughout the period studied, which, in view of the data, reflects the evolution of the pandemic in Spain, with negative values in the periods of higher incidence of COVID-19, with variations in tourism ASP being more noticeable than those of the market.

In Figure 2, the negative impact of the start of the pandemic on the stock market values is very prominent, with a greater incidence in the case of tourism companies, reaching negative ASPs of -48%, when the market did not fall below -35.76 %.

The highest value for CA in the tourism sector was recorded in November 2020, when the pharmaceutical companies Pfizer, BioNTech and Moderna announced that their vaccines were more than 90% effective (Ansede, 2020; Ramón, 2020).

(Figure 2)

The evolution of the ASP of the tourism subsectors is shown in Figure 3. As we can see, the ASP of the three companies rises and falls at the same rate, in a more or less perceptible way.

Taking into consideration the data of the three companies, tour operators, with an average ASP of 2.41%, reflect more pronounced increases than the other subsectors and, in the case of negative values, it shows in a more pronounced way the initial impact of the pandemic, as well as the increase in numbers of COVID-19 infections in July and August 2020 (Figure 3).

The hotel subsector reflects an average ASP closer to zero (0.49%), showing worse values than the rest during periods of the highest incidence of COVID-19 in Spain in the spring, summer and autumn of 2020 and the winter of 2021.

The ASP of passenger transport shows positive and negative maximum values, generally less pronounced than the rest, with an average ASP of -0.63%, although not the closest to zero.

(Figure 3)

4.2. Statistical Analysis

The results obtained are detailed below, after applying the methodology described in the third section to establish the relationships of dependency between the time series of ASP for the subsectors of tour operators, hotels, and passenger transport (taken as explained variables Y_t and called ASP-tour-operators, ASP-hotels and ASP-transport, respectively) and the series that define the evolution of pandemic X_t, considered explanatory variables. This way, it is possible to demonstrate that there is a significant relationship of dependency between the series and it is also possible to quantify the strength of said relationship and establish a prediction model for ASP variables according to the evolution of the COVID-19 pandemic.

Table 3 shows the final result in detail. In all three cases, the functional form of the resulting dynamic regression models is the hypotheses that ensure their correct functioning: a) they were models with no lags, b) with predictive capacity for series of the type ASP, c) explained by the explanatory variable "cumulative deaths" on a logarithmic scale, d) based, in 2 out of the 3 cases, on differentiated series of order d=1.

(Table 3)

In all cases, the historical information for the stock price series is still relevant to explain the evolution of stock prices and cannot be dispensed with, since the pandemic effect does not cancel it out.

As we can see, the model is validated in all three cases by the Dickey-Fuller stationarity test, which yields a significant p-value at 95%, evidencing the effect that the pandemic has on the ASPs of the three companies. In this test, the p-value of the test should ideally be less than 0.05, and, for the three explanatory models, it yields a value of 0.01, so it is below the appropriate value; therefore, stationarity is established.

In addition, the Dickey-Fuller test establishes a lag=0, indicating that it is not necessary to take lagged predictors to obtain stationarity, and a d=1 indicating that the ASP-transport and ASP-hotels series must be integrated series of order 1, that is, the dynamic model is built on the differentiated series once.

In terms of the residuals, the Ljung-Box test indicates an excellent performance in the white noise hypothesis, with p-values greater than 0.05. Finally, the two measures of goodness of fit, AIC and DRM, both show that the models, from the smallest to the largest fit error, are for tour operators, hotels, and passenger transport.

The negative sign of the β coefficients is consistent with the effect of falling listed prices, as the impact of the pandemic increases. The values of β -20.086, β -0.511 and β -0.205 are interpreted as the change in units of the variables ASP-transport, ASP-hotels and ASP-tour-operators, respectively, caused by a one unit increase in the variable cumulative number of deaths. Hence, the so-called pandemic effect is different in the stock prices of each company: in the case of ASP-transport it is very significant at 99%, in the case of ASP-hotels it is significant at 95% and for ASP-tour-operators it is only significant at 90%.

In order to quantify these effects on the variables analysed, standardised coefficients must be used, that is, the coefficient estimated divided by its standard error, being -4.2718 for the passenger transport subsector, -2.2026 for the hotels subsector, and -1.9159 for the tour operator subsector. From all this, we can deduce that the passenger transport subsector reflects more than twice the pandemic effect than the hotels and tour operator subsectors, which show a similar effect.

Figure 5 shows the fit behaviour and how ASP-transport, ASP-hotels, and ASP-tour-operators move within confidence bands of 99%, 95% and 90%, respectively, for the adjusted value based on the explanatory variable of cumulative COVID-19 deaths.

(Figure 5)

In addition, the goodness of fit of the models designed is confirmed in Figure 5, showing that the actual values of the series ASP-transport, ASP-hotels and ASP-tour-operators, represented in the clouds of points, fit fairly well to the values predicted by the models dependent on the variable cumulative deaths from COVID-19.

(Figure 6)

To conclude, Figures 7, 8 and 9 graphically show the behaviour as white noise without correlation or dependence on the epsilon residuals of ASP-transport, ASP-hotels, and ASP-tour-operators.

As we can see, in both cases, the normal autocorrelations, with respect to “n” days before, and partial autocorrelations, with respect to -2 days, of the residuals are not significant, since they are placed within the Bartlett bands. Thus, the histogram can be approximated well enough through normal distribution, and the evolution of residuals over time does not show growth in mean or amplitude.

In the ASP prediction models developed for the three companies studied, the normal autocorrelations, with respect to “n” days before, and partial autocorrelations, with respect to -2 days, are located within the Bartlett bands, so they are considered not significant. In addition, the temporal evolution of these residuals does not show growth in mean or amplitude. We can state, therefore, that the histogram can be sufficiently well approximated by the normal distribution.

(Figure 7)

(Figure 8)

(Figure 9)

5. Discussion

The global tourism sector has been rocked by COVID-19. In Spain, this impact has been felt very intensely, as it is one of the most important tourist destinations in the world, and its economy depends largely on the service and tourism sectors (Gil-Alana & Poza, 2022; Gofran et al. 2022).

The literature review conducted (Carter et al., 2022; Chai; 2021; Lin & Falk, 2022; Mazur et al., 2021) stated that, at the start of the pandemic, the fall in the stock price of the tourism sector reflected its severity, and Sharma and Nicolau (2020) and Nhamo et al. (2020) highlighted the importance of being aware of the evolution of this relationship in the medium and long term, a contribution made by this research.

After an initial descriptive study, the conclusion reached is that, throughout the pandemic, and not only in its early phase, the ASP of the tourism sector has been much more affected by the evolution of the pandemic than the market itself, coinciding with the findings of Liev (2020b) and Cheng et al. (2007) regarding the SARS-2003 outbreak. In fact, research into SARS-2023 anticipated that a new epidemic could sink its stock values (Chen et al., 2007; Chen et al., 2018), and we have seen this in the study conducted here.

Thus, we have confirmed that the conclusions reached by Sharma and Nicolau (2020) and Mazur, et al. (2020), on the initial impact of the pandemic on the stock market behaviour of the tourism sector, also hold true in the medium term. This contradicts the findings of Gil-Alana &

Poza (2022), who stated that this impact is temporary and that it would disappear beyond the short term. It does, however, confirm the results of Gofran et al. (2020) who did foresee abnormal returns in the long term.

As for the study of health variables, Liew (2020b) established that variations in positive cases have an insignificant effect on tourism stock price. This research corroborates that the increase in the number of deaths from COVID-19 is the best predictor of stock price in the main tourism subsectors, with a negative relationship between the two variables (Sharma & Nicolau, 2020).

Transport has been the most seriously affected subsector by the pandemic in terms of its performance on the Spanish stock market, as stated by Carter et al., (2022) for the US, Lin and Falk (2022) for India, and Nhamo et al. (2020) and Poretti and Heo (2022), with a β value for DRM that is much higher than for the subsectors of hotels and tour operators, and with a significance level of 99%. In fact, the difference between the impact of the pandemic on the three subsectors analysed has been quantified, showing that the effect of the pandemic for passenger transport has been twice as serious as it has been for the other two subsectors analysed.

6. Conclusions

Following Pandey and Kumar (2022), who highlighted that future research should focus on studying the impact of the pandemic over the different stages through which it passes, over the course of the study presented here, we have achieved our intended purpose, analysing and quantifying the relationship between COVID-19 and the stock prices of the three most important subsectors of tourism in Spain, in the medium term, developing three prediction models for the ASP of these subsectors, using DRM.

It has been possible to validate the hypothesis of this research. Indeed, cumulative deaths from COVID-19 offer the best predictions of the stock price evolution of the tourism subsectors analysed in the medium term (H1). We have shown that the ASP of the transport, hotel, and tour operator subsectors are more volatile in the face of fluctuations in deaths from COVID-19, with an inverse relationship between the ASP of the three tourism subsectors and the cumulative number of deaths from the pandemic, so that there is a drop in the stock price as the impact of the pandemic increases (H2). Furthermore, this relationship extends over the medium term, from the beginning of the pandemic up to April 2021 (H3).

However, this pandemic effect is different depending on the subsector considered. The effect of the pandemic has been more than twice as serious for the transport subsector than it has for the other two subsectors analysed: it was found to be very significant for transport and simply significant for hotels, followed by tour operators (H4).

This research has also shown that the historical information of the ASP series is indeed very relevant to explain the evolution of prices, which is why it was not excluded in any of the three models, since the pandemic effect does not cancel it out.

The findings of this research are very useful and important for managers, governments, and investors, as they contribute to improving the decision-making process and who are very interested in having frameworks that help them make the most robust and effective decisions. “The risk assessment of unexpected natural disasters can provide the basis for policymakers and tourism operators to make risk emergency strategies and tourism planning" (Chen et al, 2022:319).

This research demonstrates and quantifies the medium-term impact of the coronavirus pandemic on the stock market of the different tourism subsectors. In this way, as it is an impact that goes beyond the short term, policymakers must carry out structural measures, not only temporary ones (Gil-Alana and Poza, 2022). For this, it is essential that they must have sufficient resources to provide monetary and fiscal stimuli so that the markets remain as stable as possible.

Governments must take quick, effective rational decisions to reduce the intensity of shock and minimize the economic losses, using the models developed here to anticipate the effects of the pandemic, and other similar situations, and to reduce market uncertainty, buoying investor and business confidence, and avoiding major changes in the stock price (Chen et al., 2009). They must focus on supporting the most affected industries, tourism being one of them and, within this, as shown here, passenger transport, followed by hotels and tour operators, stimulating the stock market liquidity of these subsectors and in this order of priority. The role of governments is to protect stock markets from major declines in future pandemics or epidemics.

Furthermore, stock prices represent future earnings potential, and investors perceive the pandemic as slowing down economic activity, worrying about their future income, therefore investors can also follow the figures for the death toll related to COVID-19 to make investment decisions, diversifying with assets in more secure, less volatile sectors, thus reducing the uncertainty they face. The prediction models presented here can serve as a guide for investors, who should avoid investment portfolios with shares of companies that are more vulnerable (transport subsector) to a suspicious development of the virus, or other similar ones, in the future. Instead, they should take the chance to buy dip after massive market decline when appropriate (Liew, 2020a), with great caution when making decisions in the short term.

One of the limitations of this study is its geographical scope, which focuses solely on Spain. Furthermore, it has not taken other control variables into account such as events and news stories related to COVID-19 or the characteristics of the environment. Another of the limitations is the possibility of having applied another methodology, such as event study.

Proposed future lines of research could expand the geographical scope of the study to other countries and compare results. Establishing control variables, such as events and news stories related to COVID-19, which would further hone the balance between fit and prediction, is another possible future strand of research. Finally, it would be interesting to apply other methodologies, such as event studies or the panel method, to validate the conclusions reached in this study.

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Table 1. Scientific literature analyzed on the relationship between infectious diseases and the tourism stock market.

	INFECTIOUS DESEASE	METHODOLOGY	GEOGRAPHICAL SCOPE	STOCK MARKET SCOPE/SECTOR
Chen (2011)	SARS-2003	Panel data regression	Taiwan	Hotel
Chen et al. (2007)	SARS-2003	Event study	Taiwan	Hotel
Chen et al. (2009)	SARS-2003	GARCH model	Taiwan	Tourism
Chen et al. (2018)	SARS-2003	Smooth time-varying co-integration analysis	Asia	Asian stock markets
Chong et al. (2010)	SARS-2003	Event Study	China	Pharmaceutical and tourism industries
Ichev & Marinč (2018)	Ebola	Event Study-regression model	USA	Multisector portfolio (with aviation and tourism)
Kim et al. (2020)	Avian flu, Swine flu, Bovine spongiform encephalopathy and Salmonella Infantis.	Event Study-regression model	USA	Restaurant industry
Loh (2006)	SARS-2003	Regression model	Canada, China, Hong Kong, Singapore and Thailand	Airline
Ru et al. (2020)	SARS-2003	Regression model	China	Stock indexes

Source: Authors' own

Table 2. Scientific literature analyzed on the relationship between COVID-19 and the tourism stock market.

	TIME FRAME	METHODOLOGY	GEOGRAPHICAL SCOPE	STOCK MARKET SCOPE/SECTOR
Al-Awadhi et al. (2020)	10/01/2020-16/03/2020	Panel data regression	China	Stock indexes and multisectoral analysis, differentiating air transportation and hotels
Carter et al. (2022)	15/02/2020-30/03/2020	Multivariate regression model and event study	USA	Airlines, restaurants, and hotels
Chai (2021)	01/04/2019-08/01/2020	Event study (case study)	China	Stock index and tourist company (Caissa Tourism)
Gil-Alana et al. (2022)	14/05/2018-14/05/2020	Fractional integration-regression model	Spain	Stock index and tourism
Gofran et al. (2022)	11/01/2020-10/05/2020	Event study and multivariate regression model	UK, Europe and Spain	Tourism and leisure
Haroon & Rizvi (2020)	01/01/2020-30/04/2020	Exponential GARCH models and Ordinary Least Square Regressions	USA	Stock indexes and multisectoral analysis, differentiating travel and hotels
Liew (2020a)	11/03/2019-14/04/2020	Event study	China	Tourism
Liew (2020b)	02/10/2019-27/03/2020	Regression model	USA	Tourism and travel: tour operators
Lin & Falk (2022)	01/06/2018-01/06/2020	Regression model.-Markov regime switching model	Nordic countries	Travel and leisure industry
Mazur et al. (2021)	01/03/2020-31/03/2020	Descriptive analysis	USA	Stock indexes and multisectoral analysis, differentiating hospitality
Nhamo et al. (2020)	19/02/2020-24/03/2020	Event study – descriptive analysis	Global	Tourism and Sports
Pandey & Kumar (2022)	06/09/2019-22/06/2020	Event study. Cross-sectional regression	India	Tourism
Poretti & Heo (2022)	01/01/2019-17/03/2020	Event study	Global	Tourism
Sharma & Nicolau (2020)	01/09/2018-31/03/2020	Autoregressive conditional heteroskedasticity model	USA	Hotel, airline, cruise and rental car industries
Wang et al. (2022)	04/01/2000-27/04/2020	Regression model. Sup augmented Dickey–Fuller (SADF) and SADF tests.	China	Tourism
Wu et al. (2020)	25/03/2019-10/07/2020	Event study and regression model	China	Tourism
Yiwei et al. (2021)	30/01/2019-06/11/2020	Multivariate GARCH-dynamic conditional correlation and wavelet coherence transform models.	China and USA	Stock indexes and tourism indexes

Source: Authors’ own.

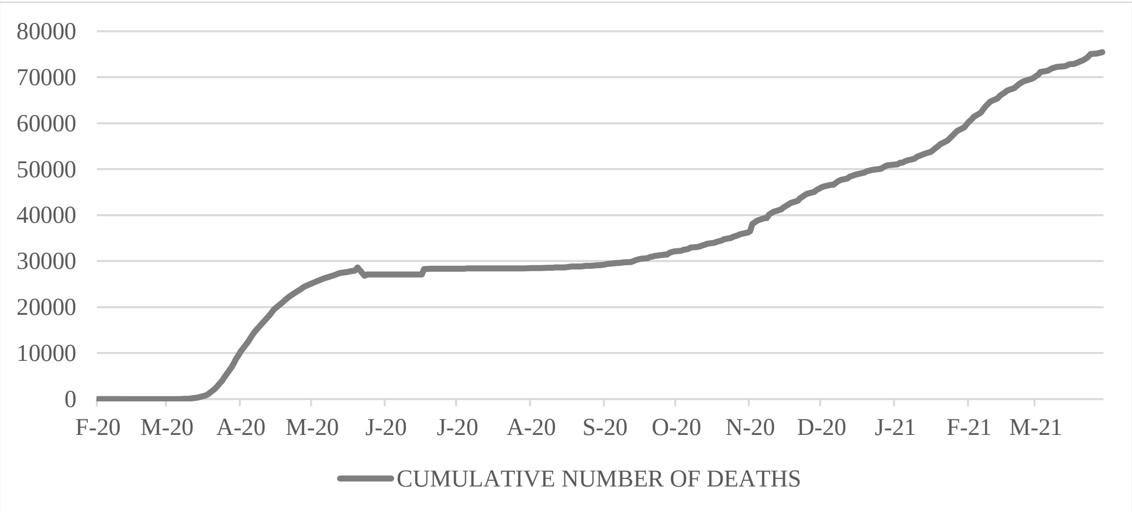
Table 3. Result of dynamic regression models

Model $Y = \alpha + \beta X + \eta$	Dickey-Fuller Test	Estimation Coefficients	AIC	RMSE	Ljung-Box Test
Y=ASP-transport X=$\log_{10}$(deaths+1) $\eta \sim$ ARIMA(2,1,1)	DF=-17.4 d=1 lag=0 p-value=0.01	Estimate Std. Error Z p-value ar1 0.605 0.151 4.00 0.000 *** ar2 0.165 0.065 2.54 0.011 * ma1 -0.599 0.145 -4.11 0.000 *** β -20.086 4.702 -4.27 0.000 ***	1660	3.88	Q* = 8.1, df = 6, p-value =0.2
Y = ASP-hotels X = $\log_{10}$(deaths+1) $\eta \sim$ ARIMA(4,1,2)	DF=-15.5 d=1 lag=0 p-value=0.01	Estimate Std. Error Z p-value ar1 0.971 0.150 6.4 0.000 *** ar2 -0.585 0.160 -3.6 0.000 *** ar3 -0.136 0.079 -1.7 0.087 ar4 0.254 0.058 4.3 0.000 *** ma1 -0.889 0.150 -5.9 0.000 *** ma2 0.675 0.142 4.7 0.000 *** β -0.511 0.232 -2.2 0.027 *	-88.44	0.20	Q* = 3.2, df = 3, p-value =0.4
Y = ASP-tour-operators X = $\log_{10}$(deaths+1) $\eta \sim$ ARIMA(2,0,1)	DF=-13.8 d=0 lag=0 p-value=0.01	Estimate Std. Error Z p-value ar1 1.931 0.031 61.9 0.000 *** ar2 -0.944 0.030 -30.8 0.000 *** ma1 -0.828 0.056 -14.5 0.000 *** interc -0.868 0.455 -1.91 0.057 β -0.205 0.107 1.90 0.057	-342.8	0.13	Q* = 5.6, df = 5, p-value =0.3

Source: Authors' own.

p-value: p<0.1; ∗ p<0.05; ∗∗∗ p<0.01

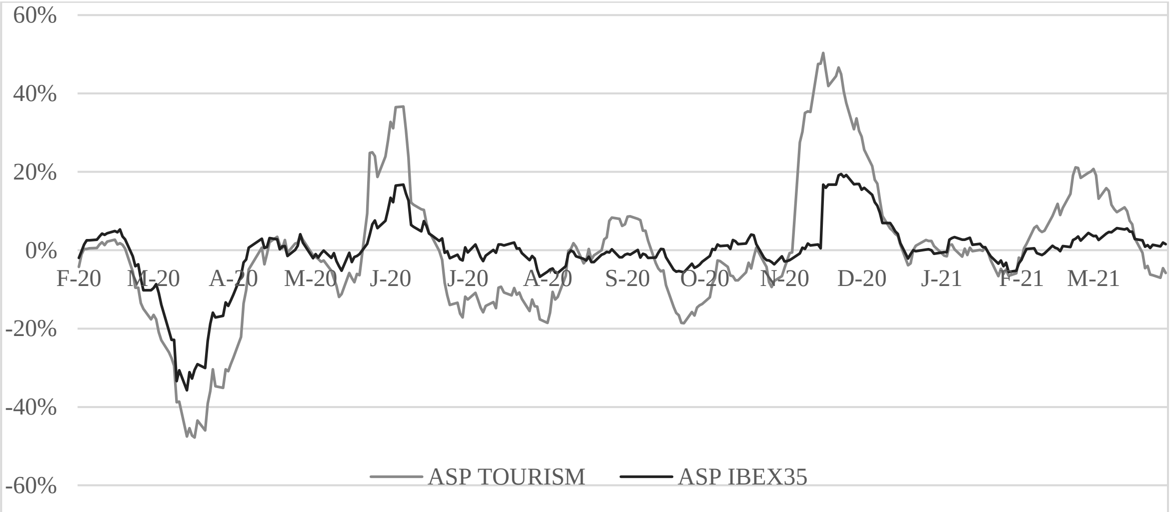
Figure 1. Cumulative number of deaths from COVID-19 (February/2020-April/2021)



Source: National Centre for Epidemiology (2021)[4].

[4] https://cnecovid.isciii.es/

Figure 2. Abnormal stock prices of the tourism sector and the Ibex35 (February/2020-April/2021)



Source: Madrid Stock Exchange (2021)[5].

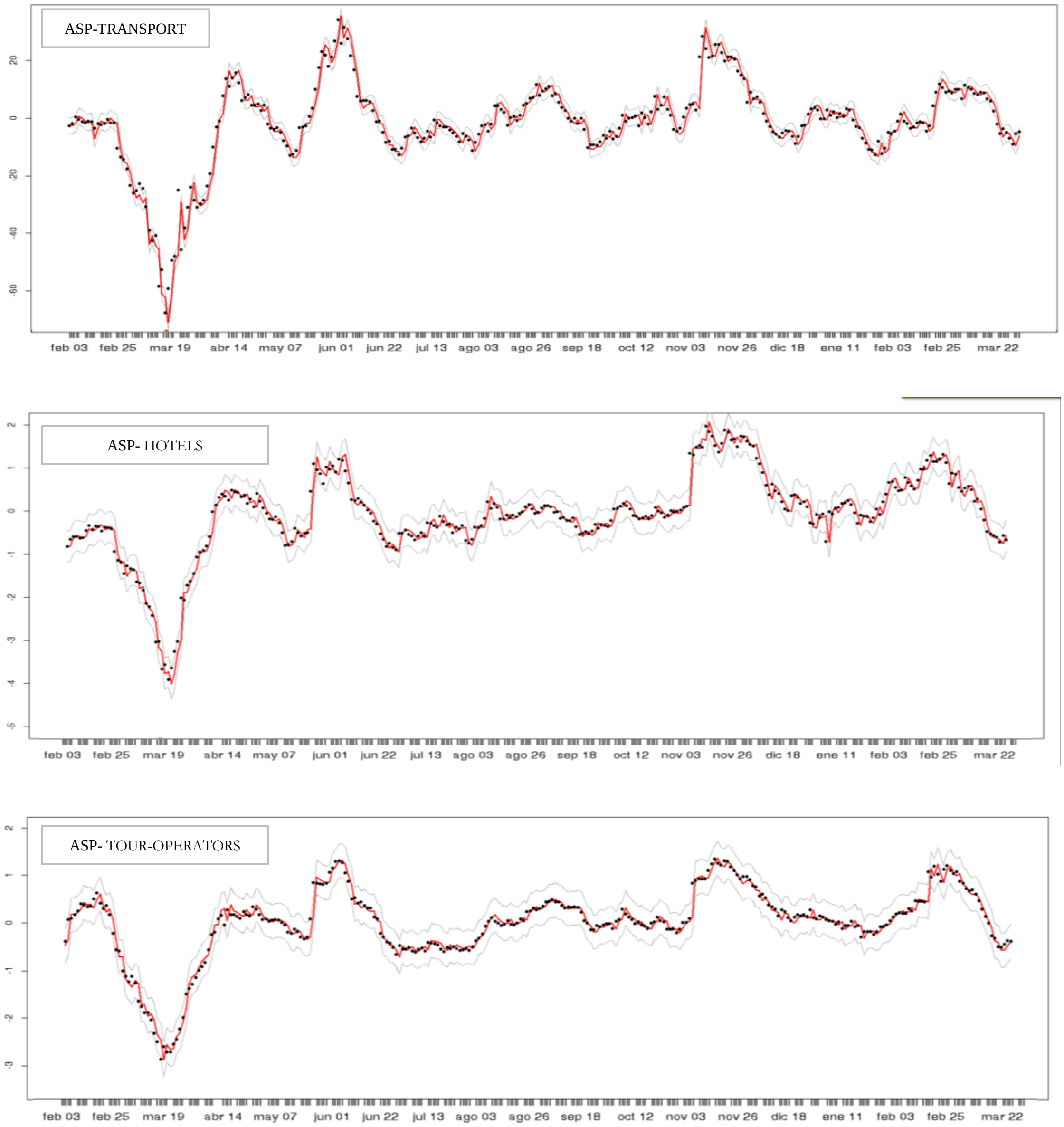
[5] https://www.bolsamadrid.es/esp/aspx/Empresas/Empresas.aspx

Figure 3. Abnormal stock prices of tour-operator, hotel and passenger transport subsectors (February/2020- April/2021)

Source: Madrid Stock Exchange (2021)[6].

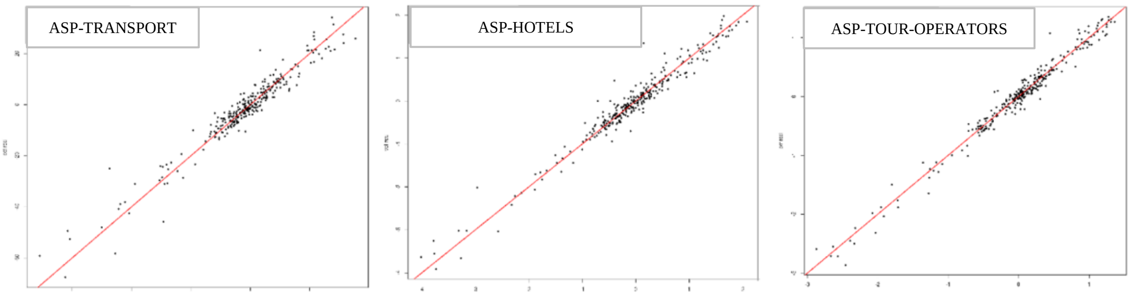
[6] https://www.bolsamadrid.es/esp/aspx/Empresas/Empresas.aspx

Figure 4. Fit of the ASP-transport, ASP-hotels and ASP-tour-operators according to the confidence band of the applied model



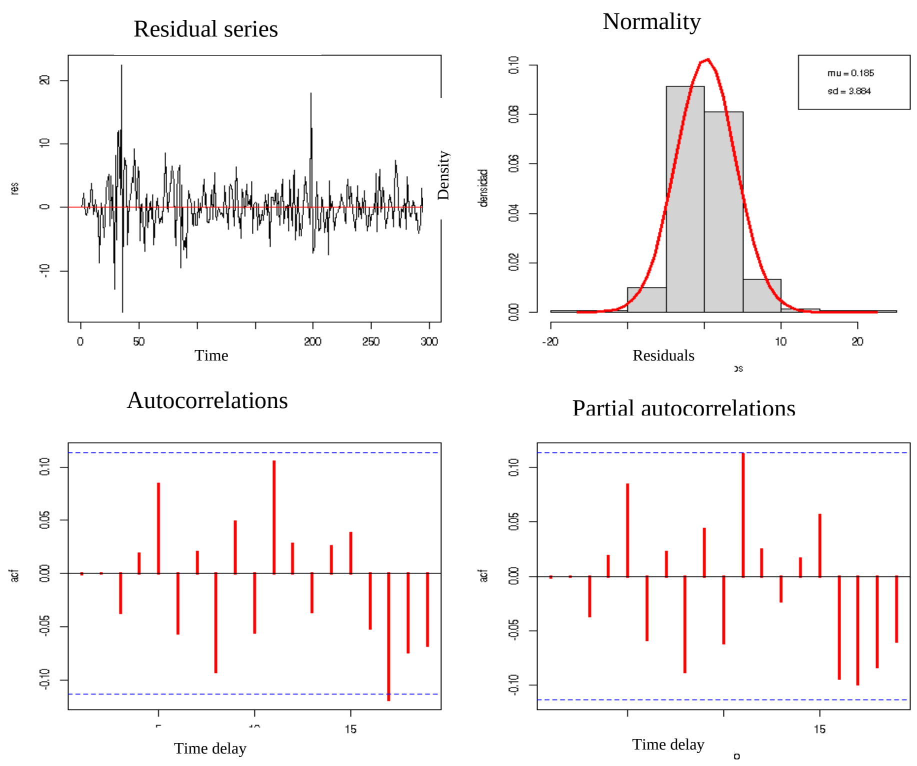
Source: Authors’ own.

Figure 5. Goodness of fit of the model designed to predict the ASP-transport, ASP-hotels and ASP-tour-operator.



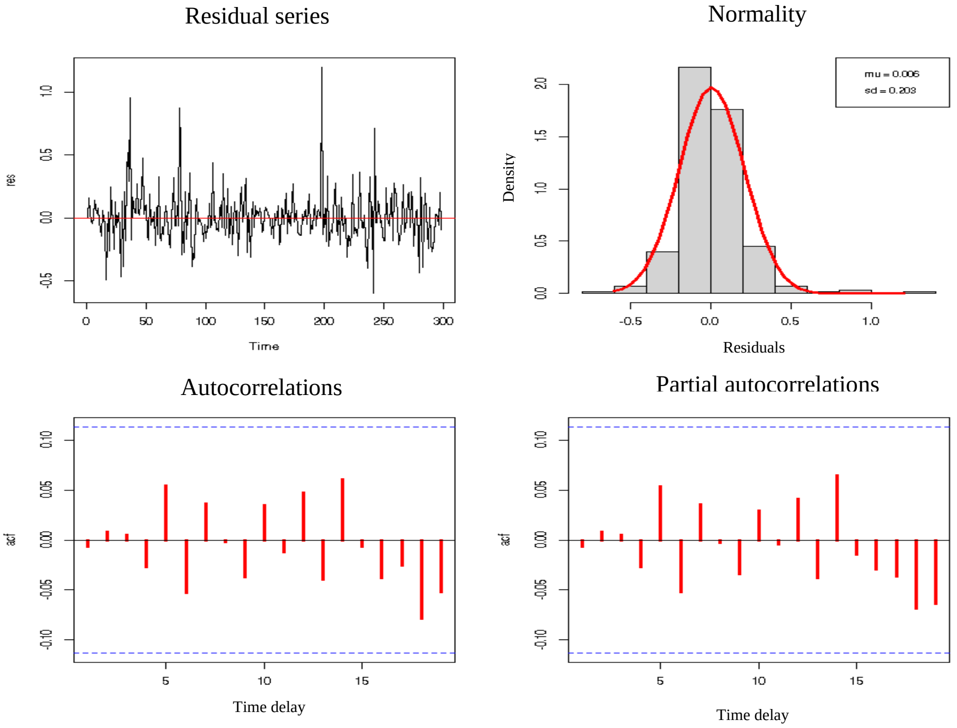
Source: Authors' own.

Figure 6. Residual series, normality, and autocorrelations of the ASP-transport against the variable cumulative number of COVID-19 deaths.



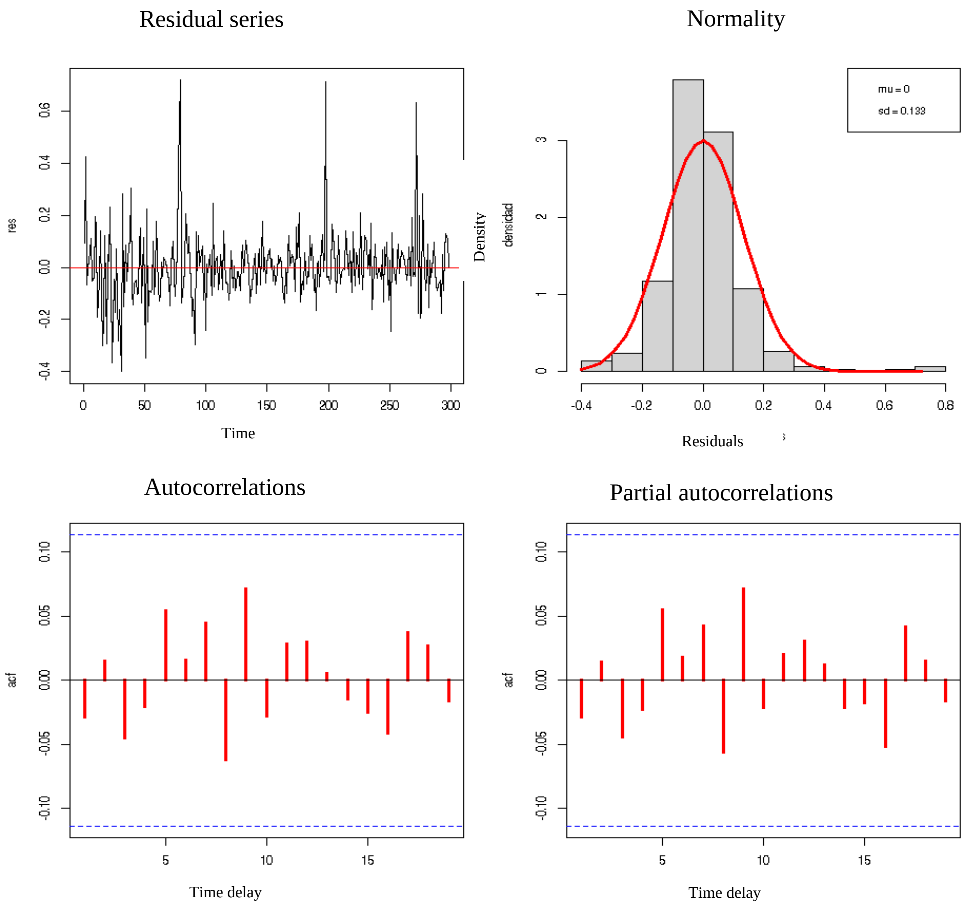
Source: Authors' own.

Figure 7. Residual series, normality, and autocorrelations of the ASP-hotels against the variable cumulative number of COVID-19 deaths.



Source: Authors' own.

Figure 8. Residual series, normality, and autocorrelations of the ASP-tour-operators against the variable cumulative number of COVID-19 deaths.



Source: Authors' own.