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# International Passenger Traffic at the Hellenic Airports: Impact of the COVID-19 Pandemic and Mid-Term Forecasting

**Stavroula P. Kitsou [1], Nikitas Spiros Koutsoukis [2], Panos Chountalas [3] and Nikolaos P. Rachaniotis [4,*]**

1 Hellenic Civil Aviation Authority, 16777 Athens, Greece; vdkitsou@gmail.com
2 Department of Political Science & International Relations, School of Social & Political Sciences, University of Peloponnese, 20132 Corinth, Greece; nkoutsou@uop.gr
3 Department of Business Administration, University of Piraeus, 18534 Piraeus, Greece; pchountalas@gmail.com
4 Department of Industrial Management & Technology, University of Piraeus, 18534 Piraeus, Greece
* Correspondence: nraxan@unipi.gr; Tel.: +30-210-414-2148

**Abstract:** The aviation industry in the COVID-19 pandemic era (caused by the SARS-CoV-2 pathogen) is practically starting from scratch as significant losses have been recorded since the outbreak in December 2019. This paper focuses on the study of the available historical operational data (provisional and final) of international passenger traffic to and from the Hellenic airports. The data originated from the official state statistics agency (Hellenic Civil Aviation Authority, HCAA). A forecasting model was developed to provide an estimation of the international passenger traffic at the Hellenic airports from August to December 2021. Through this analysis, the severe impact of two lockdown events and how they will affect the expected recovery rate of air travel is demonstrated. From this perspective, some first conclusions can be drawn about the expected recovery of international air travel to the growth rates of the 2019 pre-pandemic levels.

**Keywords:** COVID-19; Hellenic airports; international passenger traffic; time series forecasting



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## 1. Introduction

The worldwide aviation industry is going through an unprecedented downturn as the COVID-19 pandemic has affected more than 170 countries and caused losses of billions of dollars since December 2019 [1]. In spring 2020, more than 7000 airplanes were grounded as flight operations were paralyzed, airports were closed to air travel (leisure and business), routes were cancelled and seldom rescheduled, and the air borders of many states closed. The passenger demand for air travel with major airlines was reduced to historically low volume or to zero all over the world because of the pandemic, while to contain the virus governments imposed non-pharmaceutical interventions (NPIs), including a general restriction on non-essential flights and/or restrictions on flights to and from specific countries. Airlines worldwide were forced to readapt their schedules and planning to deal with the forthcoming challenges. The escalated crisis in air transportation, clearly much worse than the Global Financial Crisis of 2008–2009, grew to a catastrophe within weeks, leading many airlines around the globe to bankruptcy, an inability to settle their debts, and personnel lay-offs.

Since air transportation has been proved to be directly related to the universal propagation of COVID-19 [2], this paper proposes a quantitative forecasting model for identifying the impact on international passenger traffic to and from the Hellenic airports. It aims to contribute to the better organizational knowledge of how COVID-19 presents a threat, specifically for the Hellenic air transportation industry, and to provide a useful mid-term forecasting tool for international passenger traffic at Hellenic airports. A reliable forecasting tool applicable to the aviation industry will contribute to less operational uncertainty, better planning, and risk-aware decision making. The remainder of this paper is structured as follows: In Section 2 the existing literature regarding forecasts and the impact assessment of COVID-19 on international flights is recorded. In Section 3 the methodology and the developed model are presented. In Section 4 the forecasting results are presented for all Hellenic airports that accept international flights and separately for Athens International Airport (AIA). In Section 5 the limitations of the present analysis along with the suggestions for future research are noted, and Section 6 concludes the paper.

## 2. Literature Review

The failure of most developed countries to successfully manage the pandemic crisis and stop its momentum, along with the suspension, restriction, and limitation of international flights, has impacted passenger confidence and trust in safe air travel [3,4], hindering the expected recovery of global passenger traffic and increasing uncertainty about the new "normal". The aviation industry, having suffered a period of deep uncertainty and severe shock, will not recover in the short term, and the experts' estimates are for a recovery period that varies from 4 to 6 years as far as capacity is concerned.

More specifically, on the one hand, academic studies have shown that recovery will vary significantly, presenting shorter estimated recovery periods for some regions and longer ones for others. The more optimistic forecasting scenario for Europe estimates a recovery within 2 years, i.e., by mid-2022, and the less optimistic forecasting scenario estimates a recovery within 6 years, i.e., by 2026, which, if verified, will make it the longest recovery period ever recorded [5]. The consequences have been more severe in international markets than in domestic ones, as the latter retained some activity, at least until the nationwide lockdowns in March 2020 [6].

On the other hand, initial assessments in technical reports from the International Air Transport Association (IATA)—which represents 290 airlines that provide 82% of the world air traffic operations—state that world passenger traffic will recover to pre-pandemic levels in 2023 [7]. According to the IATA, the year 2020 was "the worst year in history for air travel demand", recording a decrease of 65% compared to 2019. Regarding international passenger demand in 2020, a decrease of 75.6% compared to 2019 was recorded. Nevertheless, the IATA's forecast for 2021 refers to a rise in demand of 50.4% compared to 2020, noting the danger of a continuous decline and ongoing recession if the national restrictions continue because of SARS-CoV-2 emerging variants and associated risks [8].

Moreover, according to the Airports Council International (ACI World) [9,10], the most recent estimates regarding international passenger traffic show a decrease of more than 6 bn passengers by the end of 2020 (a decline of 64.2% in global passenger traffic). A volume of 2.2 bn passengers are expected to be transported in the first semester of 2021 and 3.5 bn passengers in the second semester of 2021. Furthermore, ACI, using 2019 as reference year, estimates that airport traffic in several areas of the planet could return to pre-pandemic levels from year 2023 onwards, while some regions will recover at a slower pace. In addition, in a five-year forecast international passenger traffic worldwide is estimated to vary in growth, with a 3.5% rise for Asia-Pacific, a 3.1% rise for Latin America, and a smaller growth that varying from a 1.2 to 1.9% rise for North America, Europe, Middle East, and Africa. These projections consider the ongoing effects of the pandemic, new variants of the virus, the wide availability of vaccines, etc. It is expected that these parameters will continue having a negative influence on the recovery speed, at least in the short term [11].

The above estimations were enhanced by the European Commission's "Report COM 2020/558" [12], which maintained that the decline of passenger traffic in the European Economic Area (EEA) will probably continue in the imminent future, based on the relevant EUROCONTROL "Aviation Recovery Factsheet" of 27 April 2020, among other sources [13]. On 4 November 2020, EUROCONTROL published a five-year forecast of the European air traffic for the period 2020–2024. Using three scenarios, full recovery to 2019 levels was forecasted for 2024 (best case scenario), 2026 (most likely scenario), and 2029 (worst case scenario), depending, on the one hand, on the effectiveness and availability of the vaccines and, on the other hand, on the regained confidence of the traveling public. All three scenarios considered risks such as a global second and third wave of COVID-19 and its impact on the global economy [14]. On 28 January 2021, EUROCONTROL presented two new mid-term draft forecasting scenarios for the recovery of European air traffic up to June 2021, with 2019 as the base year. According to these available forecasts, the best case scenario predicted minor recovery by June 2021, with the traffic reaching approximately 45% of the 2019 levels. The worst case scenario did not foresee any improvement for the second quarter of 2021 and stated that the traffic would be at 30% of the 2019 levels [15].

The impact of the COVID-19 pandemic on world aviation, and inevitably on the Hellenic air transportation industry, was the stimulus for the present analysis. The total loss of air connectivity nationwide [2], along with the loss of a variety of important economic benefits of air transportation [16], are problems worth examining in Greece. Moreover, the IATA's estimations of 10 December 2020 [17] and the December 2020 "Impact of COVID-19 on European Aviation and Economies" [18], specifically for Greece, noted an impact of 76% on passenger traffic.

Time series models are often used for air traffic flow forecasting [6]. Given the pandemic dynamics and deviating from existing research on international air traffic that focuses on long-term forecast horizons, in this research a mid-term forecast horizon of 5 months was utilized for the projection of international traffic in Greece (August to December 2021). The forecasting model is a triple exponential smoothing model with linear trend, multiplicative seasonality (Holt–Winters Model), and special events. The outcome illustrated the impact on and the losses of the Hellenic aviation industry in pax traffic volumes.

## 3. Methodology

Figure 1 maps all Hellenic FIR/UIR airports (Flight Information Region/Upper Information Region) [19], where the airports with international transportation are presented by , the airports with domestic transportation are presented by , and the communal airports are presented by . The 29 commercial Hellenic service airports that handle international transportation are presented with a color distinction.

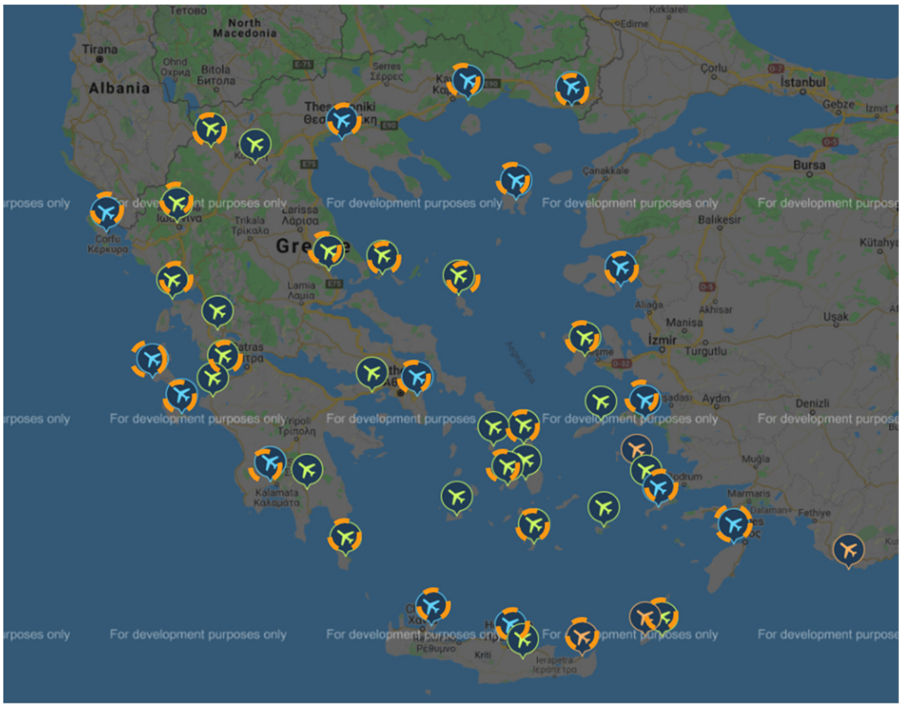


**Figure 1.** Map of Greece with the 29 Hellenic airports with international pax traffic (Source: HCAA [19]).

First, the 29 Hellenic airports that accept international passenger traffic were examined. Athens International Airport (AIA) is presented separately, as it is the biggest airport in Greece in magnitude and traffic volume and one of the model airports in its category Europe-wide [20].

We used the monthly international passenger traffic, i.e., pax figures from arrival and departure operations, including scheduled [21] and non-scheduled flights of the 29 Hellenic airports that handle international traffic, without considering the cargo flights or mail flights. The available data covered January 2017 (period 1) to July 2021 (period 55). The data origin was the Statistical Section of the Organization and Development Division of the Hellenic Civil Aviation Authority (HCAA) [22,23].

In selecting the forecasting methodology, an associative model would have been high risk. International passenger traffic undeniably depends on flows of tourism, which since December 2020 have been related to the vaccination rates for COVID-19 in countries of origin. However, vaccination of the world population is still incomplete (as of 6 September 2021, only 27.9% of the world population was fully vaccinated), and there is uncertainty regarding the long-term effectiveness of the vaccines against the emerging SARS-CoV-2 variants. Moreover, the NPIs imposed in both the countries of destination and the countries of origin may have unpredictable effects. Therefore, for the mid-term forecast desired in this paper, a time series model seemed suitable [21,24].

The forecasting methodology was selected from the widely applicable exponential smoothing family [25] in order to take into account the obvious seasonal patterns in international passenger traffic in Greece, as well as the trend in patterns capturing the growth of the Greek market [26]. More specifically, a triple exponential smoothing model with linear trend and multiplicative seasonality (Holt–Winters Model) [27–33] and decomposition was selected, since the seasonal pattern of air traffic is actually multiplicative in real life conditions, i.e., the time series forecasting equation is the product—and not the sum—of the seasonal component. The Holt–Winters Model can effectively handle the dynamic time series that represent trend and seasonal features by decomposing them into their components. The Holt–Winters method has previously been used in mid-term forecasting for air traffic, performing well [34].

The objective was to develop a mid-term forecasting model for international passenger traffic to and from the Hellenic airports (August to December 2021, i.e., period 56 to period 60), given the impact of the first three waves of the COVID-19 pandemic on international transportation, the first and second nationwide lockdowns, the local lockdowns in various areas of the mainland and the islands, and other restrictive measures [22].

In order to achieve the best forecasting outcome [33], first, the data were "de-seasonalized" using multiplicative decomposition [35] to yield the new smoothed values in the time series. The forecasting was initiated with the adaptation of the model to the actual data, the parameters' calibration process, and the assessment of the accuracy of the selected forecasting method. Then, the forecasting model was applied to the aforementioned period of 5 months.

The Multiplicative Method was used for the decomposition, under the following generic expression [28]:

$$X_t = S_t \times T_t \times C_t \times N_t \tag{1}$$

where $t$: is the time period

$X_t$: is the actual observation at the time period t,

$S_t$: is the seasonality component,

$T_t$: is the trend component,

$C_t$: is the cyclical component,

$N_t$: is the Irrelevant component or Noise.

The Multiplicative Decomposition Method was chosen as more suitable, instead of the Additive Method, because the available historical data from January 2017 to December 2019 indicated that there was an increasing trend in seasonal variation, year after year. Consequently, a factor that affected the changes per season, in strong seasonal patterns, was evident. In multiplicative seasonality, its variations are proportional to the volume of the data figures, i.e., they depend on the increase or decrease in the time series data values. This signifies that seasonal variations will be higher if the trend follows an incremental pattern [24].

In the multiplicative model, the seasonal component is defined as the quotient of every value of the time series over the average of the values for a 12-month period. The de-composition is defined as (de-seasonalized values):

$$D_t = \frac{X_t}{S_t}. \tag{2}$$

The calibration of the baseline component, the trend, and the initial seasonal factors was performed using the observations of 2017, i.e., the first 12 months. More specifically, the baseline component $U_0$ is calculated using the following formula:

$$U_0 = \frac{(X_1 + X_2 + \cdots + X_{12})}{12}. \tag{3}$$

The initial value of trend $T_0$ was set equal to 1 ($T_0 = 1$) [31].

The initial values for the Seasonal Components $S_i$, $i = 1, \ldots, 12$ are calculated by the formula:

$$S_i = \frac{X_i}{U_0}. \tag{4}$$

If $h$ is the forecasting horizon, $F_{t+h}$ is calculated by the following formula:

$$F_{t+h} = (U_t + h \times T_t) \times S_{t-12+h} \tag{5}$$

where:

$$U_t = U_{t-1} + T_{t-1} + \frac{\alpha \times e_t}{S_{t-12}}, \tag{6}$$

$$S_t = S_{t-12} + \frac{\gamma \times e_t}{U_{t-1} + T_{t-1}}, \tag{7}$$

$$T_t = T_{t-1} + \frac{\alpha \times \beta \times e_t}{S_{t-12}}. \tag{8}$$

For the smoothing constants $\alpha$, $\beta$ and $\gamma$ the following inequalities apply:

$$0 \leq \alpha \leq 1, 0 \leq \beta \leq 1 \text{ and } \alpha + \gamma < 1. \tag{9}$$

Parameters $\alpha$, $\beta$ and $\gamma$ values minimize the mean square error (MSE) during the calibration [24].

The baseline component is de-seasonalized and revised every time by a proportion $\alpha$ of the de-seasonalized forecast error. In this way, the coefficient $\alpha$ smooths and revises the baseline, the coefficient $\beta$ smooths and revises the trend, and the seasonality component varies by the proportion $\gamma$ of the quotient of the forecast error over the de-seasonalized baseline component of the related period.

The imposition of a general nationwide lockdown due to the outbreak of the COVID-19 pandemic is mentioned in the present research as a Special Event. Special Events are defined as unusual variations of the variable's values, either positive or negative, during some time periods owing to factors of the internal or/and the external environment [36,37]. The negative impact of the Special Event [38] takes into consideration the de-seasonalized Data $D_t$ and especially the de-seasonalized value of the period that precedes the Special Event ($D_{t0}$) and the period that follows ($D_{t0+n+1}$), where $n$ is the number of the periods that the Special Event lasted, itself included. The smoothed values $D'_t$ of the de-seasonalized periods of the Special Event are provided by the formula:

$$D'_t = (t - t_0) \times \frac{D_{t_0+n+1} - D_{t_0}}{n+1} + D_{t_0}. \quad (10)$$

The Special Events in the current analysis were the two (2) nationwide lockdowns imposed in March 2020 and in November 2020. For the first lockdown, the first Special Event started in period 39 (March 2020) and its duration was four periods ($n$ = 4). The previous period was the 38th and the next was the 43rd. For the second lockdown, the second Special Event started in period 47 (November 2020), and its duration was six periods ($n$ = 6). The previous period was the 46th and the next was the 53rd. The impact (%) for the time period of the Special Event is calculated by the formula [39]:

$$I_t(\%) = \left(D_t - D'_t\right) \times \frac{100}{D'_t} \quad (11)$$

For the calculation of the goodness of fit of the forecasting model, the mean absolute percentage error (MAPE) and the median absolute percentage error (MdAPE) were used [39].

## 4. Results

First of all, the suggested triple exponential smoothing model was applied to international commercial passenger traffic from and to the 29 commercial Hellenic airports that handle international traffic for the time period of January 2017 (period 1) to July 2021 (period 55). Next, the airport with the highest international traffic volumes in Greece, i.e., the Athens International Airport (AIA), was analyzed separately.

To calculate the percentage change or rate of change, historical data for two time periods were needed. The change (in absolute value) that occurred between these two periods was calculated by the following formula [40]:

$$Rate\ of\ change = \left(\frac{Value_{later\ period}}{Value_{earlier\ period}} - 1\right) \times 100 \quad (12)$$

### *4.1. Results on a National Level*

The international pax air traffic descriptive statistics are presented in Table 1. In Figure 2, four box plots were generated to represent the distribution of the 29 Hellenic airports' international passenger traffic for the years 2017 to 2020. There were no outliers or extremes.

**Table 1.** Descriptive statistics of international pax air traffic in Greece, January 2017 to July 2021. (The descriptive statistics for the 29 Hellenic International airports were graphed with the KNIME Analytics Platform. All measures were calculated directly from the data sets).

| Min | Mean | Median | Max | Std. Dev. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| 9260 | 2,821,609 | 1,495,570 | 8,192,215 | 2,576,714 | 0.8036 | −0.7805 |

For the total international pax traffic at the 29 Hellenic airports during the 54 time periods (from January 2017 to July 2021), the forecasting model yielded results that coincided, in general, with the actual traffic up to February 2020 (period 38). The low value of the mean absolute percentage error (5.16%) from period 13 to period 38 indicated that the model fit the historical data very well and provided a highly accurate forecast (Figure 3). Moreover, the low value of the MdAPE (7.5%) to July 2021 indicated that half of the absolute percentage errors in the forecasting period were less than 7.5%.

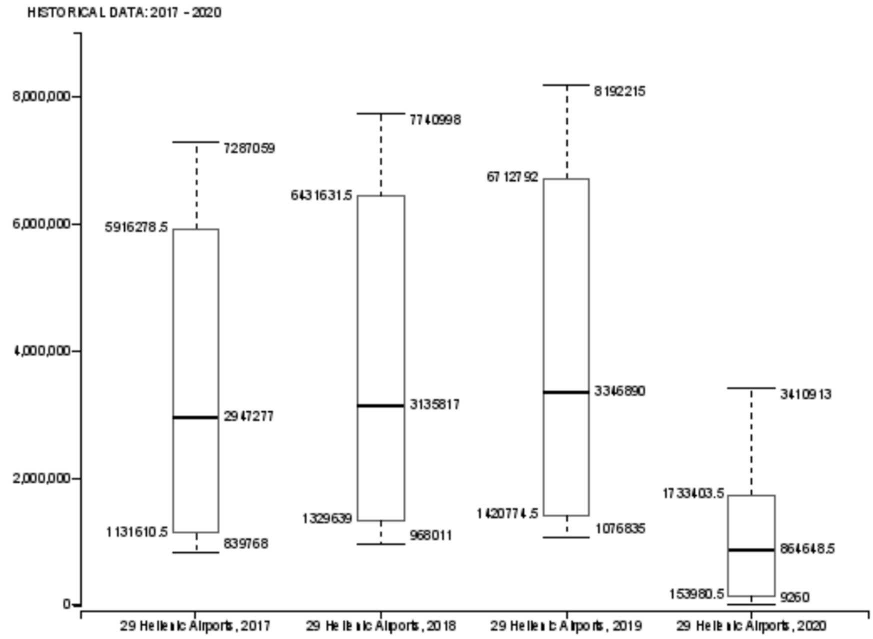


**Figure 2.** Box plots for annual international pax air traffic in Greece from 2017 to 2020. (The box plots for the 29 Hellenic International airports were drawn with the KNIME Analytics Platform. All measures (median, quartiles) were calculated directly from the data sets).

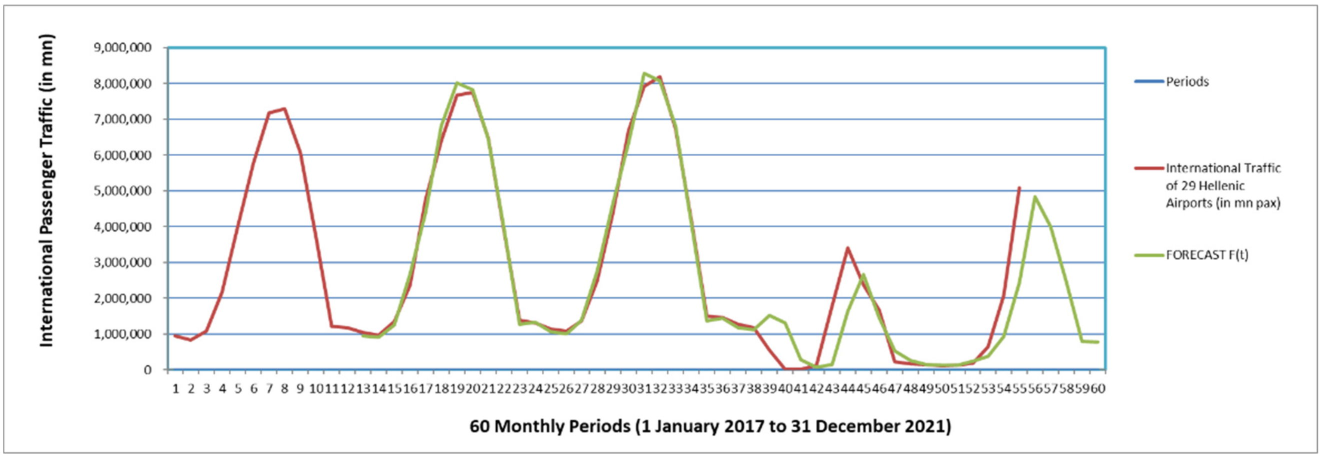


**Figure 3.** Model fitting and forecast for international pax air traffic in Greece.

Seasonality had a constant pattern. The coefficient $\gamma$ that controlled seasonality was low ($\gamma = 0.1$), meaning that the seasonal component was unlikely to change several periods ahead, and that the smoothed values were closer to the actual data points. The low level of $\gamma$ implied a high level of $\alpha$ ($\alpha = 0.89$) and yielded a line that changed fast. Coefficient $\alpha$ determined the weight assigned to the observations: as the $\alpha$ value was nearer to 1 than 0, the method showed a preference for the most recently observed values, not for the forecasted values, and it "forgets" easily. The trend illustrated whether the international passenger traffic slope would move upwards or downwards. Coefficient $\beta$ controlling trend was very low ($\beta = 0.001$) and indicated that data had a mid-term trend. It should be noted that in the present triple exponential smoothing the coefficient values for trend ($\beta$) and for seasonality ($\gamma$), both having very low levels, did not indicate a lack of trend or seasonality. They simply showed that the initial values for trend and seasonality were almost precise or very close to a "ready to use" updated level (baseline).

The highest forecast absolute percentage errors appeared in period 39 (first nationwide lockdown in mid-March 2020) and period 47 (second nationwide lockdown on 7 November 2020). These extreme variations were linked to major changes in the calculated patterns and the overthrow of the running order of the estimating process, obviously because of the various massive restrictive measures that were imposed and the Notice To Airmen (NOTAMs) being in effect, at both national and international levels, as the world reacted to the first, second, and third waves of the COVID-19 pandemic. More specifically, the first Special Event (first nationwide lockdown) had vast negative consequences, with the impact calculated to be 85.6%. The second Special Event (second nationwide lockdown) also had negative consequences, with the impact calculated to be 82.35% of the already low pax volumes (Figure 4).

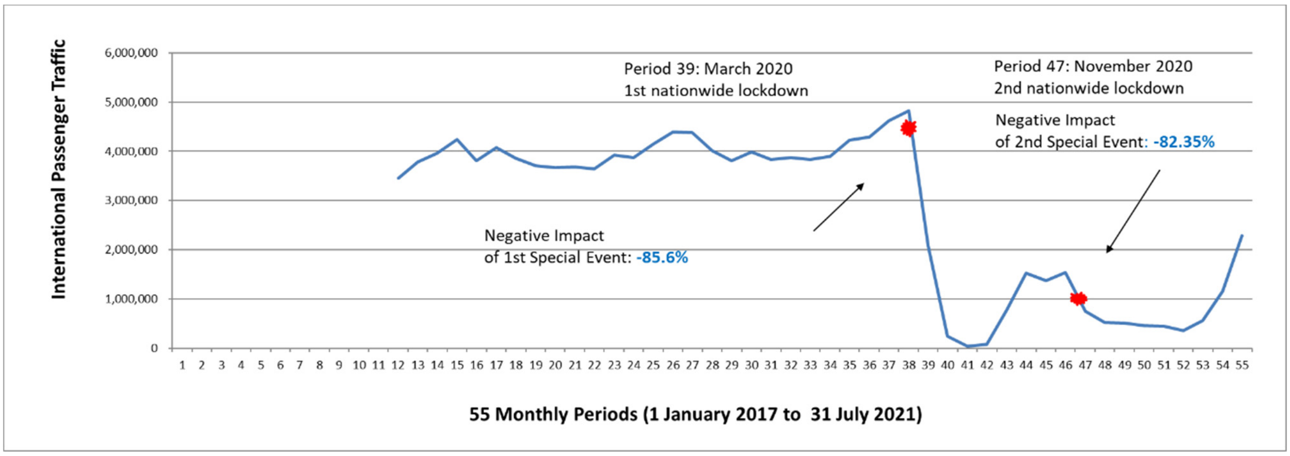


**Figure 4.** Special Events' impact on international pax air traffic in Greece.

The proposed model suggested that, based on the available data and compared to the 2019 levels, the percentage change in pax traffic in Greece averaged a 64.15% decrease for all of 2020 and a decline of 82.18% since the first nationwide restrictive measures were imposed. The rate of change (Figure 5) compared each month in 2020 and 2021 to the corresponding month in 2019 (pre-COVID-19 era). It was encouraging that, since February 2020, the first positive signs in the rate of change appeared in April 2021 and onwards, and an improvement was evident, implying a significant recovery for the remainder of the summer period ahead. The MAPE for the first 7 months of 2021 increased to 24.38% because of the traffic increase since April.

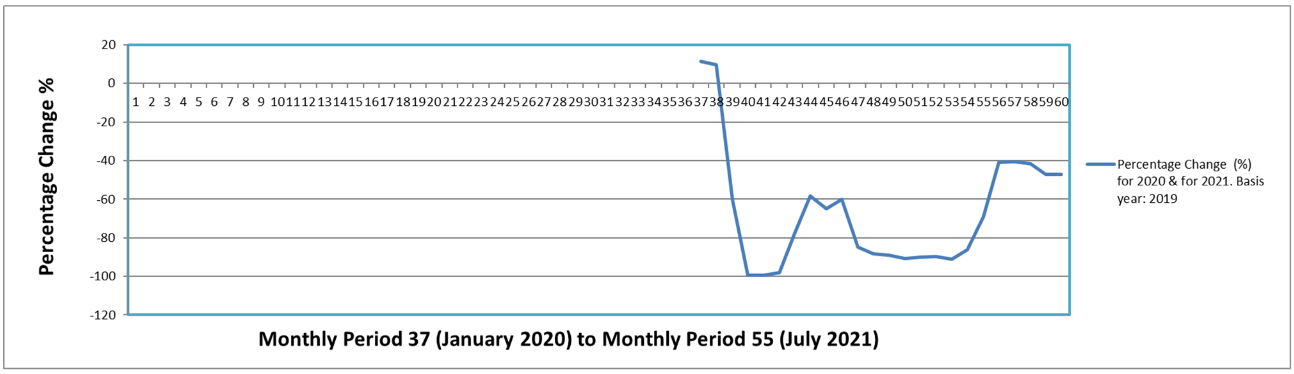


**Figure 5.** Rate of change for international pax air traffic in Greece.

To summarize, the international passenger traffic in Greece was impeded for the entire 2021 spring season and did not show significant signs of recovery but looked promising in the mid-term summer season. Compared to 2019, the first quarter of 2021 was practically lost, but the second quarter seemed less severely hit, and the same optimistic projection applied to the third quarter, as the calculations indicated a significant recovery pace. On a month-to-month basis, a reliable upturn in traffic was expected during the summer months, but the figures seemed to decline around the end of the year. Moving toward autumn was a challenge. In the mid-term the recovery to 2019 levels would take longer than desirable as the rate was unlikely to increase dramatically or keep a constantly high rate. It seemed that the overall decline in passenger traffic would not be temporary, and travel demand in the country would not return to the previous normal level at a fast rate. Smaller regional Hellenic airports, privately or publicly owned, under the present conditions, are facing issues of survival without government financial support [41]. Losing smaller airports means losing connectivity and several important wider economic benefits of air transportation, and this applies not only to Greece but to Europe and the rest of the world.

### *4.2. Results for Athens International Airport (AIA)*

AIA's international pax traffic descriptive statistics are presented in Table 2. In Figure 6, four box plots were generated to represent the distribution of the AIA's international pax traffic from 2017 to 2020. There were no outliers or extremes.

**Table 2.** Descriptive statistics of international pax traffic in AIA, January 2017 to July 2021. (The descriptive statistics for AIA were graphed with the KNIME Analytics Platform. All measures were calculated directly from the data sets).

| Min | Mean | Median | Max | Std. Dev. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| 8636 | 1,018,943 | 1,032,606 | 2,118,792 | 594,419 | −0.0699 | −0.9395 |

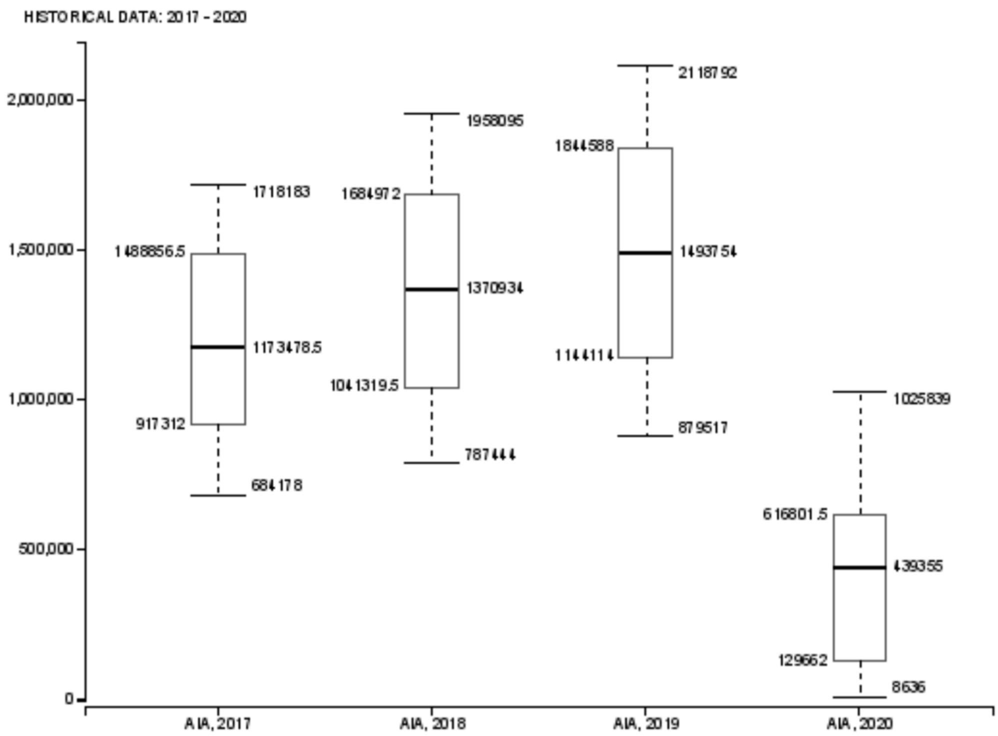


**Figure 6.** Box plots for annual international pax traffic in AIA from 2017 to 2020. (The box plots for AIA were drawn with the KNIME Analytics Platform. All measures (median, quartiles) were calculated directly from the data sets).

For Athens International Airport (AIA) the forecasting model yielded results that coincided in general with the actual international traffic data up to February 2020 (period 38).

The low value of the mean absolute percentage error (2.99% from period 13 to period 38) indicated that the model fit the historical data very well and provided a highly accurate forecast (Figure 7). Moreover, the low value of the MdAPE until July 2021 (3.49%) indicated that half of the absolute percentage errors were less than 3.49%.

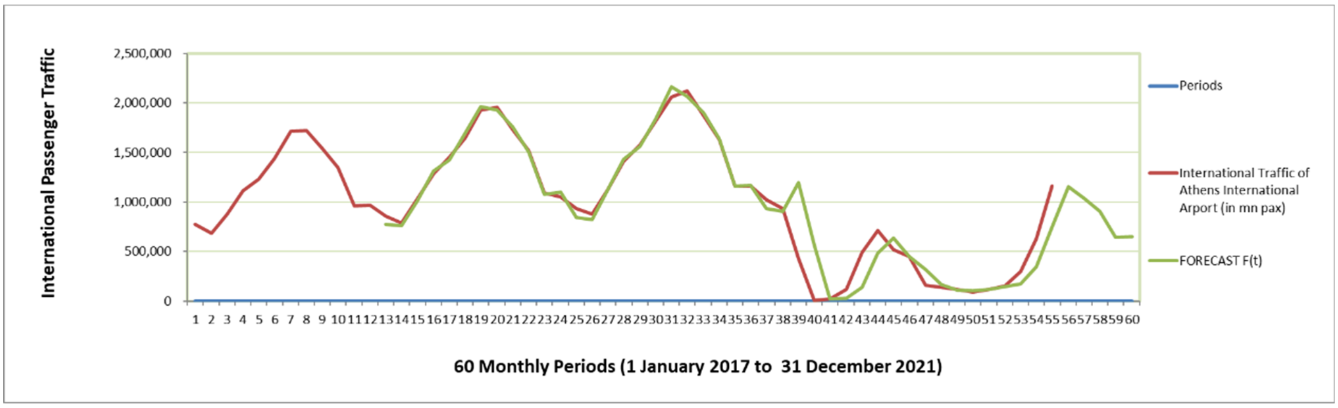


**Figure 7.** Model fitting and forecast for international pax traffic in AIA.

Seasonality had a constant pattern. Coefficient $\gamma$ that controlled seasonality was low ($\gamma = 0.1$), which meant that the seasonal component was not likely to change several periods ahead, and that the smoothed values were closer to the actual data points. The low level of $\gamma$ implied a high level of $\alpha$ ($\alpha$ = 0.89) and yielded a line that changed fast. Coefficient $\alpha$ determined the weight assigned to the observations: as the $\alpha$ value was nearer to 1 than 0, the method showed a preference for the most recently observed values, not to the forecasted values, and it "forgets" easily. The trend illustrated whether the international passenger traffic slope would move upwards or downwards. Coefficient $\beta$ controlling trend was very low ($\beta$ = 0.001) and indicated that data had a mid-term trend.

AIA was one of the two Hellenic international airports that opened their gates on 15 June 2020 under the partial lifting of the restrictive measures. Moreover, AIA applied effective strategies in order to gain a competitive advantage, like offering smart discounts to its travelers. Nevertheless, the passenger numbers handled by AIA had deviations. The highest forecast absolute percentage errors appeared in period 39 (first nationwide lockdown in mid-March 2020) and period 47 (second nationwide lockdown on 7 November 2020). More specifically, the first Special Event had severe negative consequences with the impact calculated to be 67.30%. The second Special Event also had negative consequences with the impact calculated to be 54.17% of the already low pax volumes (Figure 8).

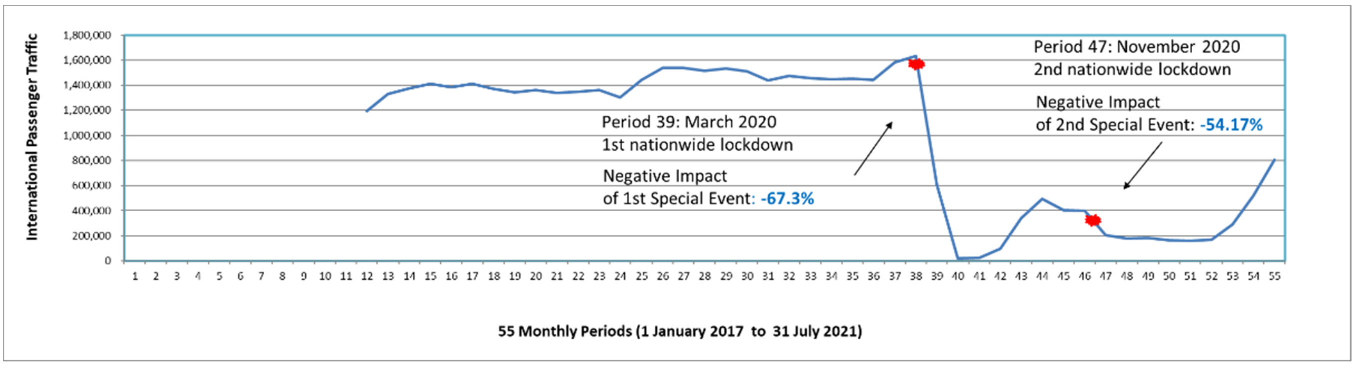


**Figure 8.** Impact of Special Events on international pax traffic in AIA.

The rate of change (Figure 9) compared each month in 2020 and 2021 to the corresponding month in 2019 (pre-COVID-19 era). Based on the forecasted values, the rate of change varied from a decline of 88.43% to 44.3% and seemed to improve in the months ahead. For the last five months of 2021 the percentage change was on average a 44.67% decrease, indicating further improvement. It was encouraging that, since February 2020, the first positive signs in the rate of change appeared in April 2021 and beyond, and an improvement was evident, implying a significant recovery for the remainder of the summer period ahead. The MAPE for the first 7 months of 2021 increased to 21.27% owing to the traffic increase since April.

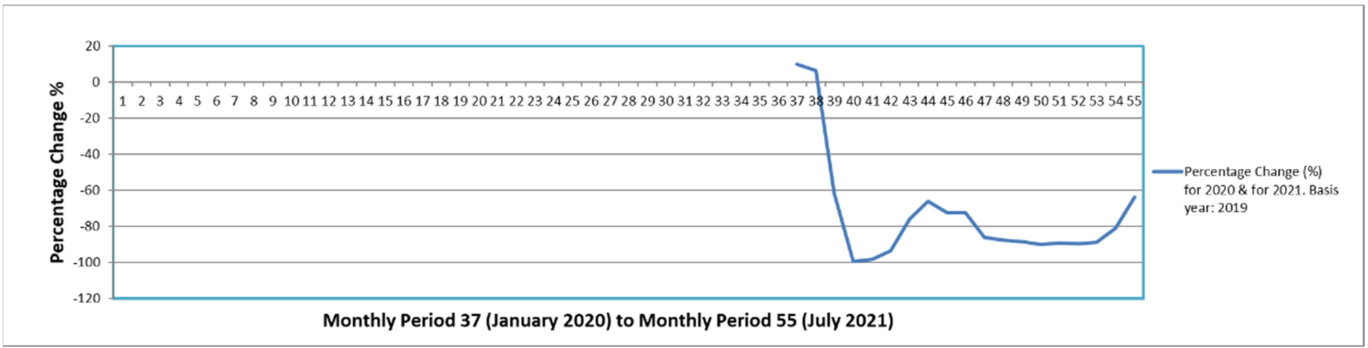


**Figure 9.** Rate of change for international pax traffic in AIA.

To summarize, although international passenger traffic in Athens International Airport was impeded for the entire spring season, the summer season looked promising. Compared to 2019, the first quarter of 2021 was practically lost, but the second quarter was much better, and there was a significant upturn during the summer season. Autumn was challenging, and the figures declined around the end of the year. It seemed that the overall decline in passenger traffic would not be temporary and travel demand would not return to the previous normal level at a fast and constantly high rate.

## 5. Discussion

According to the HCAA, the historical statistical data are categorized as operational provisional and final and are published on its official website as open source information. As mentioned in the "Air Traffic Statistics Quality Review" [26] of the HCAA, the provisional statistical data have a deviation of 1.0–1.5% from the final statistical data, and they are withdrawn from the website of HCAA as soon as the final data are officially published. Regarding the historical data so far and the time of the present analysis, the periods from January 2017 to June 2020 included official and final historical operational data, while the observations from July 2020 until July 2021 represented provisional observations subject to change. This deviation is undoubtedly a limitation for the present research, and it will be interesting to re-apply the proposed model, in due time, once all available data are final. Apart from that, there were no other assumptions about the data sets that were used and analyzed.

The effect of the NPIs, including flight restrictions resulting in almost empty flights and zero passenger traffic, was a very difficult to forecast for the abnormal situation that affected countries, national health systems, and economies throughout the planet [42,43]. A general restriction on non-essential flights, with the exception of repatriation flights for the citizens who live abroad, special purpose flights (sanitary, humanitarian, technical landings, state/ferry/emergency/military/firefighting/Frontex flights), and mail/cargo flights (especially to supply the national health system with pharmaceutical and hygiene materials and equipment for the prevention, control and suppression of COVID-19), would have been unthinkable in the past. The negative impact of the second Special Event, when more data become available, should be recalculated at its true dimensions.

This paper is useful for future analysis because the systematic observation and recording of strictly data-driven statistical analysis can lead to more integrated conclusions and results. The forecasting method for the present analysis used raw historical data of pax volumes without analyzing the qualitative aspects of passengers as customers of the aviation sector. As air travel passengers have different quality requirements and needs as customers [43], a more focused and in-depth analysis should be undertaken for future research, using forecasting in specific target groups and considering the deviations in pax behavior and habits of the aviation sector's customers.

The present analysis can be extended in time and thus provide useful insights for any party concerned. Moreover, it can be applied to a number of sectors and activities related to the air aviation industry to estimate the extent they were impacted by COVID-19. For instance, the cargo and mail traffic presented increased activity levels during the crisis, and this phenomenon can be further investigated and analyzed using the same methodology, where the Special Event impact would be positive in this case. To serve aviation sector stakeholders, the same methodology and forecasting model can also be applied—apart from the present analysis—to a single airport or any group of airports, a specific route or a group of routes, any country or block of countries, a specific region or regions, etc.

## 6. Conclusions

The COVID-19 pandemic affected the whole planet, with unprecedented levels of global systemic risk and a plethora of immeasurable and unparalleled consequences. A basic reason for the severe and extended losses was the pandemic's effect on global interconnection through air transportation. The present research and its outcomes may help in drawing useful conclusions regarding what will be henceforth the "day after" for air transportation, concerning the strategic planning, the new business models, the new approaches, the establishment of emergency or contingency plans for similar situations and the specialized and targeted recovery plans per area of operations. The forecast may serve the enterprises, organizations, and other entities that operate in the Hellenic air transportation industry in planning for the more efficient exploitation of their resources (manpower, material, equipment/installations, time/energy spent, economic resources), for the improvement of their operations (aiming at cost reduction), and for increasing brand loyalty and reputation, etc.

The proposed mid-term forecasting methodology is novel, since, for the first time in the aviation sector, it calculated the impact of Special Events, which up to now was only used in stock markets indexes and business planning strategies. It illustrated an improved international passenger traffic for 2021 at the commercial Hellenic airports that handle international traffic. The percentage change showed how deeply the international connectivity of the Greek air transportation system was affected by the COVID-19 pandemic. Travel demand in the country will depend on endogenous factors like the national response to and handling of the fourth wave of the COVID-19 pandemic that began in July 2021, along with the building of passenger trust and confidence in safe air traveling, as well as on exogenous factors like the international traveling public's uncertainty over the pandemic and the countries' coordinated (or not) vaccination strategy. As noted in the analysis, the road to recovery of air traffic to pre-pandemic levels is a slow process. While air traffic dropped abruptly owing to the lockdowns, it did not recover as swiftly as one might expect once the restrictions were lifted. By extrapolation, this implied that events causing an abrupt reduction of air traffic have a slow recovery and the air traffic industry should adjust their risk management strategy to cater to such "black swan" events. Despite the obvious differences, this halt in air traffic bears similarities to the effects of 9/11 on the air industry. At the time of writing, the effects of COVID-19 remain to be seen, and hopefully the industry will recover as swiftly as it was taken by surprise.

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