



The Impact of the COVID-19 Pandemic on the Aviation Sector in Poland

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Agnieszka Barczak

West Pomeranian University of
Technology in Szczecin, Szczecin,
Poland

Email: agnieszka-barczak@zut.edu.pl

Air transport in Poland in 2009–2019 was characterized by dynamic and stable growth in passenger numbers and passenger operations. The COVID-19 pandemic, which broke out in 2020, led to unprecedented disruptions in the sector's operations and interrupted its previous growth path. As a result, there was a need to assess the extent to which actual passenger flows in 2020–2024 deviated from the level that could have been achieved in the absence of the pandemic. The aim of the study was to assess the level of passenger flows in air transport in Poland in 2020–2024 by comparing actual values with forecasts based on data from 2009–2019. Two variables were analyzed: the number of passengers and the number of passenger operations. Based on historical data, exponential trend models were estimated, which were then used to make forecasts for 2020–2024, assuming no pandemic.



The fit of the models was also assessed and forecast errors were determined. The analysis revealed significant discrepancies between the forecast and actual values for 2020–2021, confirming the strong and sudden impact of the pandemic on the aviation sector. In subsequent years, a gradual market recovery was observed, but by 2024, the levels resulting from the pre-pandemic trend had not been fully achieved. At the same time, high determination coefficients and low forecast errors indicate the correctness of the models used and their usefulness in assessing the scale of deviations from the non-pandemic scenario. The results obtained allow us to conclude that the COVID-19 pandemic has caused a permanent disruption to the previous growth trajectory of air transport in Poland, and that the process of returning to the long-term trend is gradual and incomplete within the analyzed time horizon.

Keywords: air transport, COVID-19 pandemic, forecast, number of passengers, number of passenger operations.

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has shaken the entire world, leading to unpredictable changes in various sectors of the economy. In Poland, the first confirmed cases of infection were reported on March 4, 2020, which initiated a series of measures aimed at limiting the spread of the virus (Barczak, 2022). In response to the growing number of cases, the Polish government introduced restrictions that had a significant impact on air traffic in the country.

On March 14, 2020, Poland closed its borders to foreigners, which immediately restricted air traffic, and the effects of this were felt throughout the country (Wasowska et al., 2021). A day later, on March 15, the government suspended all international flights, which had disastrous consequences for the transport sector (Wasowska et al., 2021; Barczak, 2021). In the following weeks, as the pandemic spread, further restrictions were introduced, such as a total ban on foreign aircraft landing at Polish airports, effective from March 31, 2020. Although air connections with selected countries began to be gradually restored from June 16, 2020, numerous restrictions remained in place to protect public health and prevent the spread of the virus (Sun et al., 2023).

These restrictions had a drastic impact on air traffic in Poland. In 2020, the number of passengers served by Polish airports fell by approximately 70% compared to 2019 (Heiets et al., 2021; Olaganathan, 2021). Airlines such as LOT were forced to suspend many connections, which resulted in significant financial losses. Many airlines declared bankruptcy, and many others went into survival mode, putting the future of the sector in question. It is also worth noting that the impact of the pandemic on the aviation sector had repercussions on the economy, particularly in the tourism industry, which is closely linked to air transport (Gössling et al., 2021).

In the context of the long-term effects of the pandemic, experts note that many airlines have had to adapt their business models to the new reality. Increased interest in domestic travel and changes in passenger preferences may lead to lasting changes in the industry (Hoszman & Zagrajek, 2025). In addition, the pandemic has accelerated digitization processes in the aviation sector, affecting the way passengers book tickets and use air services (Shiwakoti et al., 2022).

When analyzing the future of air transport in Poland, there are many indications that the sector will have to address new challenges, such as maintaining sanitary standards and rebuilding passenger confidence (Zawojaska & Siudek, 2021; Florido-Benítez, 2023; Ochyra et al., 2024; Huderek-Glapska & Antczak, 2025). The long-term impact of the pandemic on national economies and global supply chains cannot be overlooked either, as air transport plays a key role in these processes (Chowdhury et al., 2021).

In summary, the COVID-19 pandemic has affected air traffic in Poland in a way that has permanently changed the face of the sector. The restrictions introduced, the significant drop in passenger numbers, and the need to adapt to the new reality are challenges that require detailed analysis and adaptation on the part of all market participants (Heiets & Xie, 2021). As the world emerges from the crisis caused by the pandemic, it will be crucial to understand these changes and their impact on the future of air transport in Poland.

Therefore, the aim of this study is to assess the level of passenger traffic in air transport in Poland in the years 2020–2024. This will allow us to examine whether the number of passengers and the number of passenger operations have reached the values that would have occurred in the absence of the COVID-19 pandemic. To achieve this, a forecast for 2020–2024 was prepared based on data from 2009–2019, specifying the number of passengers and passenger operations that should have been handled during this period if the pandemic had not occurred.

Air transport in Poland and the COVID-19 pandemic

The COVID-19 pandemic has had a drastic impact on air transport around the world, including in Poland. As the world began to adapt to the new reality, the issue of rebuilding the aviation sector became a key topic in public debate and among decision-makers. In Poland, after significant declines in passenger numbers and connections, a process of returning to normalcy began, which required rethinking operational strategies and adapting to new market conditions.

In the first half of 2021, the Polish aviation market faced many challenges. High levels of uncertainty related to the pandemic, changing travel regulations, and shifts in passenger preferences were key factors that affected the pace of recovery (Barczak, 2023). Carriers had to adapt their fleets and route networks to meet new market demands (Olaganathan, 2021).

Data published by the Civil Aviation Authority shows that in 2021, Polish airports began to see a gradual increase in passenger numbers. In the summer of 2021, the number of travelers increased by 60% compared to 2020, but was still 30% lower than in 2019 (Passenger transport..., 2022). As vaccinations became widespread and travel restrictions were eased, carriers began to restore connections, which contributed to further growth in passenger numbers.

In the face of a changing market, airlines in Poland introduced new strategies adapted to current conditions. Many of them focused on the development of domestic and regional connections, which was aimed at rebuilding passenger confidence and increasing the availability of air services. The growing importance of flexibility in bookings and ticket refund policies was key to attracting passengers in difficult times (Ochyra et al., 2024; Sulik, 2025).

Technology has also played a significant role in the process of returning air transport to its pre-pandemic state. The introduction of digital solutions, such as mobile booking and check-in apps, as well as passenger health monitoring systems, has contributed to increased comfort and safety during travel (Serrano & Kazda, 2020). New technologies have also enabled carriers to better manage their fleets and optimize routes, reducing operating costs (La et al., 2022).

Case and Methodology

Statistical data published by the Civil Aviation Authority covering the years 2009–2024 were used to analyze the development trends in the number of passengers served in domestic and international traffic – regular and charter – and the number of passenger operations in domestic and international traffic – regular and charter – at airports in Poland. Data for the years 2009–2019 were used in the first instance to determine trend functions using an analytical method, enabling the dynamics of the phenomenon under study to be described and its future directions of development to be determined.

In order to assess the fit of time series models to empirical data, the coefficient of determination (R^2) and the coefficient of variation (V_s) were used. These indicators allowed for the assessment of the quality and reliability of the models and their predictive usefulness. Based on the obtained functions, forecasts were made for the number of passengers and the number of passenger operations for the years 2020–2024.

The obtained forecasts were verified using the mean prediction error according to the formula:

$$S_T^P = \sqrt{\left(\frac{(T-\bar{t})^2}{\sum_{t=1}^n (t-\bar{t})^2} + \frac{1}{n} + 1\right) Se^2},$$

where:

T – period number for which the forecast is made,

Se^2 – variance of the residual component determined using the formula:

$$Se^2 = \frac{\sum_t (y_t - \hat{y}_t)^2}{n - m - 1},$$

where:

n – number of observations,

m – number of explanatory variables.

This error indicates the average deviation between the actual observed values of the explanatory variable in the forecast period and the forecast values.

The verification was supplemented using the relative ex ante forecast error, which is calculated using the following formula:

$$\eta_t = \frac{s_T^P}{y_T^P} \cdot 100\%,$$

where:

y_T^P is the value of the forecast obtained.

This error is used to determine the accuracy of the forecast. The lower its value, the less error there is in the forecast (Barczak, 2025).

Forecasts for air traffic in Poland in the context of COVID-19

Time series models were used as the forecasting method. The exponential ($y_t = \alpha e^{\beta t}$) trend function was found to be the best fit for the actual data. The estimated functions, together with the goodness-of-fit measures, are presented in Table 1.

Table 1. Number of passengers served and passenger operations – trend functions

Variable	Trend function	R ²	V _s
Number of passengers	$\hat{y}_t = 16292569.4850e^{0.0969t}$	0.9796	5.38%
Number of passenger operations (PAX)	$\hat{y}_t = 212936.7723e^{0.0520t}$	0.9125	6.05%

Based on the estimated functions, forecasts were made for the number of passengers served and passenger operations at airports in Poland. Table 2 presents the results obtained together with the error values of the estimated forecasts.

Table 2. Forecast of the number of passengers and passenger operations (PAX) at airports in Poland

Variable	Forecast					
	Forecast errors	2020	2021	2022	2023	2024
Number of passengers		52117936	57420946	63263538	69700615	76792666
	S_T^P	1959840	2039867	2128469	2224623	2327393
	η_t	3.76%	3.55%	3.36%	3.19%	3.03%
Number of passenger operations (PAX)		397421	418633	440978	464516	489310
	S_T^P	21298	22168	23131	24176	25293
	η_t	5.36%	5.30%	5.25%	5.20%	5.17%

Based on the analysis, it can be concluded that the forecasts obtained for both passenger numbers and passenger operations (PAX) are characterized by a low level of forecast error, which indicates their high reliability. In the case of passenger numbers, the relative forecast errors (η_t) for 2020–2024 range from 3.03% to 3.76%, while for the number of flight operations they range from 5.17% to 5.36%.

Low relative error values and their systematic decrease in subsequent years indicate a good fit of the trend functions used to the empirical data and the stability of the forecasting process. In addition, the error levels are within the limits commonly accepted in economic and transport analyses, which confirms the possibility of using the developed models for forecasting.

The results obtained therefore allow us to conclude that the proposed trend models can be a reliable tool to support the analysis of future air transport development, while maintaining caution in the event of sudden changes in the external environment.

A comparison of actual and forecast values allows for an assessment of the accuracy of the trend models used and the degree of consistency between the forecasts and the observed empirical data. This comparison also makes it possible to identify the scale of deviations between the forecasts and the actual development of air transport in the analyzed period (Figure 1–2).

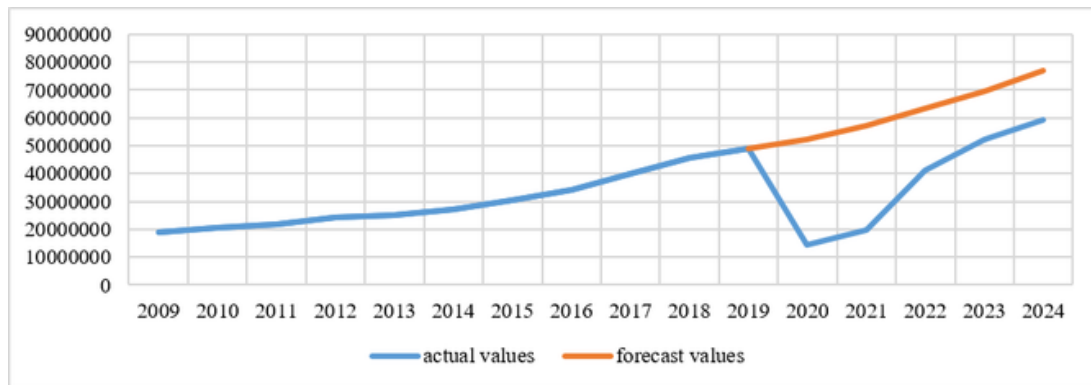


Figure 1. Comparison of actual and forecast values – number of passengers

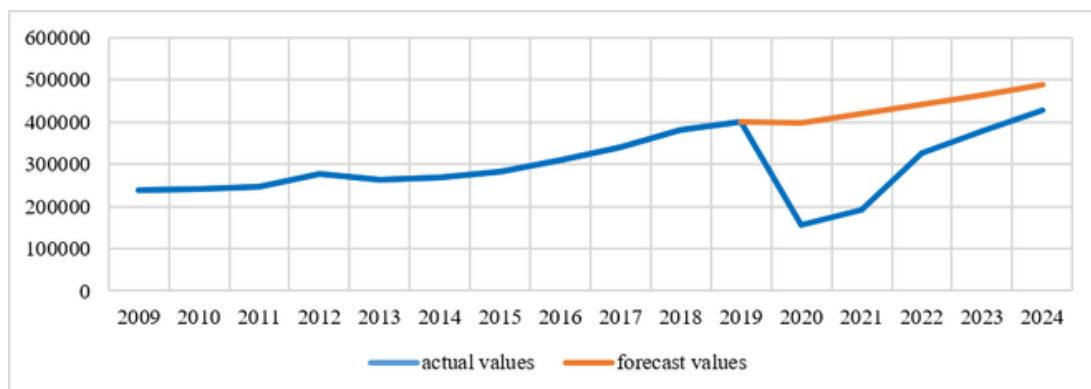


Figure 2. Comparison of actual and forecast values – number of passenger operations

To better illustrate the differences between actual and forecast values, Table 3 presents a comparison of the two.

Table 2. Summary of differences between actual and forecast values

Years	Number of passengers		Number of PAX operations	
	Number	%	Number	%
2020	37569815	27.91%	241572	39.22%
2021	37772749	34.22%	227703	45.61%
2022	22274416	64.79%	113596	74.24%
2023	17476810	74.93%	84751	81.76%
2024	17602398	77.08%	62366	87.25%

An analysis of the differences between the forecasted and actual passenger numbers in air transport in 2020–2024 indicates a significant overestimation of demand in the post-crisis period. In all the years analyzed, the actual number of passengers served was significantly lower than the forecast values, confirming the long-term impact of the COVID-19 pandemic on the aviation sector.

In 2020–2021, the absolute differences exceeded 37 million passengers per year, and the relative scale of underestimating the actual effects of the pandemic was very high. In 2020, the actual number of passengers was only about 28% of the forecast value, reflecting a sharp collapse in demand and the limited ability of forecasting models to take into account sudden systemic shocks such as border closures and lockdowns.

In the following years, i.e. 2022–2024, a gradual improvement in the situation and a systematic reduction in the relative difference between forecasts and actual data can be observed. The increase in the forecast fulfillment rate from 64.8% in 2022 to over 77% in 2024 indicates the recovery of the aviation market and the adaptation of passenger behavior to the new conditions of air transport. At the same time, the continuing significant absolute difference (approx. 17–18 million passengers) suggests that the return to the pre-pandemic growth path is slower than originally assumed.

An analysis of the differences between the forecasted and actual numbers of passenger operations in air transport in 2020–2024 shows significant discrepancies, particularly evident in the first years after the outbreak of the COVID-19 pandemic. In all the years analyzed, the actual number of operations was lower than the forecasted values, confirming the strong and long-lasting impact of the health crisis on the functioning of aviation infrastructure.

The scale of the differences was particularly large in 2020–2021. In 2020, the actual number of passenger operations was only about 39% of the forecast value, which was a consequence of massive flight cancellations, administrative restrictions, and border closures. Despite a partial recovery in 2021, the share of actual operations in forecasts rose only to 45.6%, indicating continued uncertainty and the market's limited ability to quickly return to previous levels of operational activity.

A clear recovery process in the sector can be observed in the period 2022–2024. In 2022, the actual number of passenger operations already reached over 74% of the forecast value, which indicates a gradual restoration of flight networks and an improvement in demand. This trend continued in subsequent years – in 2023, the level of forecast fulfillment rose to 81.8%, and in 2024 to 87.3%, confirming the growing stabilization of the market and increased operational efficiency of airports and carriers.

In summary, the COVID-19 pandemic has had an unprecedented impact on global air transport, including the Polish market (Sun et al., 2022). As the world began to return to normal, it became crucial to understand how these events would affect the future of air traffic in Poland. The pandemic has also changed passengers' expectations in terms of health and safety. Carriers have had to adapt their services to meet new requirements, which may affect their marketing strategies and customer satisfaction levels (Pereira et al., 2023; Kim & Lee, 2022). Technology plays an important role in the recovery process; the development of mobile applications for booking and check-in, as well as the implementation of digital and contactless solutions, have become standard in airline operations (Shiwakoti et al., 2022).

Forecasts for air traffic in Poland indicate a slow but steady recovery process that will require flexibility and innovation on the part of carriers. The aviation market in Poland was expected to return to pre-pandemic levels by 2025, but changes in passenger preferences and new health regulations have had and will continue to have a significant impact on the sector's development.

Conclusions

The results confirm the thesis that the COVID-19 pandemic was a long-term structural shock rather than a short-term disruption in demand. Forecasting models based on historical trends proved insufficient in conditions of high uncertainty, regulatory changes, and permanent changes in passenger preferences.

At the same time, the gradual reduction in the percentage difference between 2022 and 2024 indicates a process of market adaptation, including:

- adjusting carriers' offerings to reduced demand,
- restructuring route networks,
- rebuilding passenger confidence,
- increasing flexibility in the aviation sector.

The results indicate that passenger operations responded to the effects of the pandemic in a more flexible manner than the total number of passengers. This means that carriers restored the number of flights relatively faster than aircraft occupancy, which may have been due to the need to maintain continuity of flight schedules, slot commitments, and to adjust supply to changing health regulations.

At the same time, persistent differences between forecast and actual values suggest that the forecast models did not fully take into account structural changes such as:

- a reduction in the frequency of long-haul flights,
- an increase in the importance of domestic and regional connections,
- optimization of fleet utilization through larger aircraft or flight consolidation.

The future of air transport in Poland will depend on many factors, including the stability of the health situation, the progress of vaccinations, and changing passenger expectations. Forecasts indicate that a full return to pre-pandemic levels may take several years, but the key factor will be the flexibility and adaptability of carriers to the changing market (Dube et al., 2021; Ochyra et al., 2024).

In summary, the return of air transport in Poland to its pre-pandemic state is a complex process that requires the adaptation of operational strategies and the introduction of innovative solutions. Passenger growth and a new approach to fleet management are key elements in the recovery of the aviation sector in Poland.

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