Impact of cohesion policy on air traffic evolution. A case study on European Union airports

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Extended Abstract

Aim

The objective of this research is to investigate the airport's passenger traffic from 2020 to 2025 using monthly data from the Eurostat database. The analysis examines the impact of the COVID-19 crisis and the subsequent recovery dynamics as found in traffic seasonality, operational efficiency indicators, airport clustering structures, passenger traffic forecasts, and the evolution of international traffic shares, complemented by a statistical description of the dataset. At the same time, performance indicators were developed to measure operational efficiency through cabin density, revealing which routes are in demand and thus, more profitable. Within this framework, the study also explores how the European Union cohesion policy (*Inforegio - The Future of Cohesion Policy*, n.d.) contributes to traffic evolution by supporting airport infrastructure development, enhancing regional connectivity, attracting new airlines, and reducing regional disparities through increased mobility to these areas. These effects are visible in several European regions, where cohesion policy investments have supported airport expansion and traffic growth. Relevant examples include the development of new regional airports and cargo facilities in Romania, as well as the strong seasonal traffic dynamics observed in tourism-dependent regions like Burgas in Bulgaria. This study contributes to the existing literature by linking air traffic volume with the regional development objectives sustained by the European Union through its cohesion policy.

Methodology

The dataset used for this research has been extracted and filtered from the Eurostat database (Eurostat, 2024) and contains information on the total number of passengers on board, the monthly number of commercial passenger air flights, and the number of national and international flights across more than 100 airports in 12 European countries.

Data preprocessing involved consolidating 52 initial datasheets, of which 27 were retained after conducting a completeness check. Only entries with more than 50% data availability were used to ensure consistency. Moreover, for 2025 data, additional validation rules were added to obtain a statistically relevant dataset.

The data analysis was performed in Python using several dedicated statistical libraries, such as *plotly.graph_objects* library (*Python API Reference for Plotly — 6.5.0 Documentation*, n.d.), which helps create graphical representations of the curated dataset.

Multiple metrics were selected for analysis, such as the correlation between costs and cabin density, and congestion according to seasonality (dividing the summer from winter traffic). This data was further used to create predictions for the period 2026-2030 using a Holt-Winters exponential smoothing model (Hyndman & Athanasopoulos, 2018), which accounts for level, trend, and seasonality. The Holt-Winters model was chosen for its suitability in modeling air passenger demand, accounting for trend dynamics and seasonal fluctuations.

For clustering purposes, Principal Component Analysis - PCA (Jolliffe & Cadima, 2016) was applied to reduce the dataset's dimensionality and capture the maximum variance in the data. This method was used to facilitate the identification of airport typologies and to mitigate multicollinearity among the selected indicators.

The methodological approach enables an objective assessment of potential traffic changes associated with the cohesion policy-supported airport development and enhancements to regional accessibility.

Results

Several metrics were calculated to represent the evolution of aviation traffic among the 12 selected European countries.

The first metric evaluates aircraft occupancy levels and indicates the financial impact of increasing cabin density.

The second metric identifies the airports with the most representative spikes during the summer, highlighting seasonality. This indicates the dependence of tourism-oriented regions on air accessibility. In this scenario, the airlines implemented dynamic boarding strategies, such as rear-door stair boarding, to avoid delays that would incur costs.

Figure 1 presents the evolution of estimated boarding costs and aircraft load factors. The descending trend began in March 2020, when COVID-19 restrictions were imposed across the European Union, and April 2020 marked the lowest point, with only 31 passengers per flight and a boarding cost of 1.597,42 euros. Starting in 2022, when COVID-19 restrictions were lifted, the trend was similar, and strong seasonality affects both passenger numbers and costs. For instance, in July 2022, each flight averaged 121 passengers and a boarding cost of 2.948,011 euros, while in January 2025, there were only 106 passengers per flight and a boarding cost of 2.722,534 euros.

The observed recovery rate suggests the resilience of European air transport demand, supported by cohesion policy investments aimed at restoring the regional connectivity lost during the COVID-19 disruption.

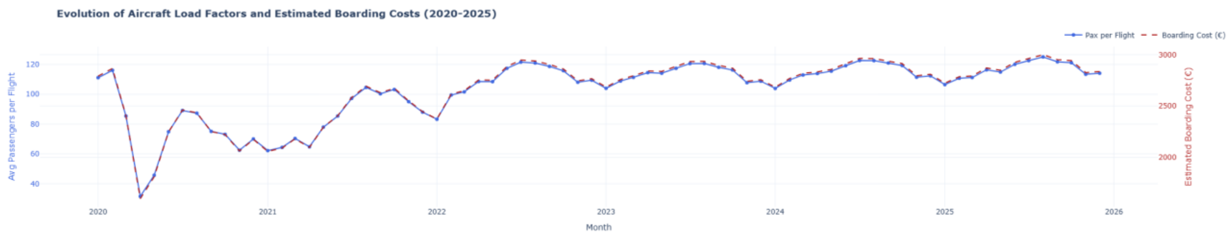

Figure 1. Evolution of Estimated Boarding Costs and Load Factors between 2020 and 2025

Figure 2 compares the most volatile and the most stable airports by seasonality. The airport that has the highest seasonality value is Burgas Airport in Bulgaria, where traffic concentration during summer months generates significant regional economic activity, while the most stable airport is Mariehamn airport, a small airport from a Finnish island called Aland, which has a constant number of flights and passengers, and due to the location, is very limited and restrictive for other airline companies to fly. The average monthly number of flights at Mariehamn airport is 170 in August, while in January it is 159. For Burgas, the average number of flights in January is only 40, while in August it is 1566, showing how strong the seasonality is at the Bulgarian airport. This strong contrast between the two airports illustrates the need to differentiate regional development paths within the EU, where cohesion policy plays an important role in sustaining tourism-dependent regions.

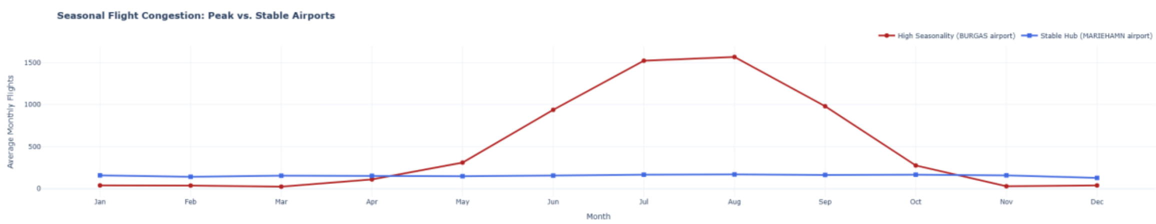

Figure 2. Seasonal Flight Congestion. A Comparison between Peak and Stable Airports

Figure 3 shows the evolution of international traffic share relative to the mean of 78.7% for the 2020-2025 period. Until March 2022, when COVID-19 restrictions were lifted, there were almost no periods that exceeded the average, except for January and February 2020, when there were no COVID-19 restrictions, and October 2021, which exceeded the average slightly. For the rest of the period, the average exceeded 80%, indicating that most passengers travel outside their home countries. The predominance of cross-border mobility aligns with the cohesion policy focused on territorial integration and the reduction of spatial isolation.

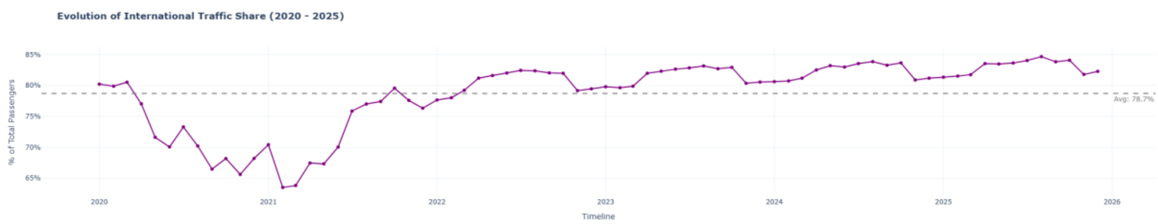

Figure 3. Evolution of International Traffic between 2020 and 2025

Figure 4 points out the evolution of passengers between 2026 and 2030 using the historical data. Seasonality was retained to more accurately estimate the number of passengers. The peak in predictions was registered in August 2030, when over 106 million passengers will travel, compared to 77 million in August 2025. The growth prediction indicates the need for investment in airport infrastructure to sustain the increase in passenger mobility, reinforcing long-term cohesion policy goals.

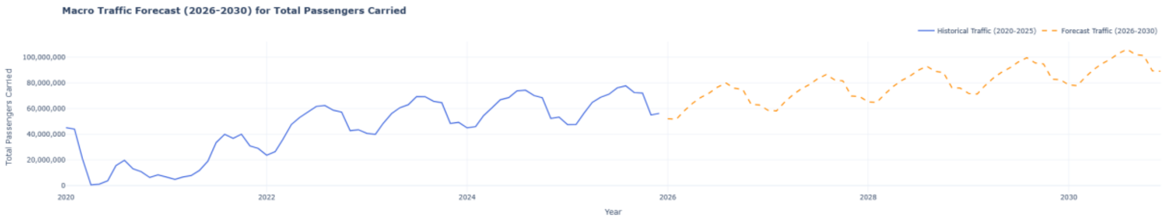

Figure 4. Macro Traffic Estimation between 2026 and 2030 for Ground Handling

Figure 5 presents the clustering of countries included in the analysis based on a similar number of passengers, COVID-19 drop ratio, recovery index, volatility level, and total passenger volume, resulting in 2 clusters. The first cluster contains the majority of the countries, such as the Netherlands, Bulgaria, Germany, Switzerland, Luxembourg, and Hungary, while the second cluster includes only two countries, Iceland and Slovakia, which had a high volume and recovery rate compared to the first cluster and a relatively small volatility and COVID-19 impact. These results highlight the heterogeneity of the recovery dynamics across EU countries, suggesting that cohesion policies may vary in results depending on the specifics of each country, such as economic structure and connectivity levels.

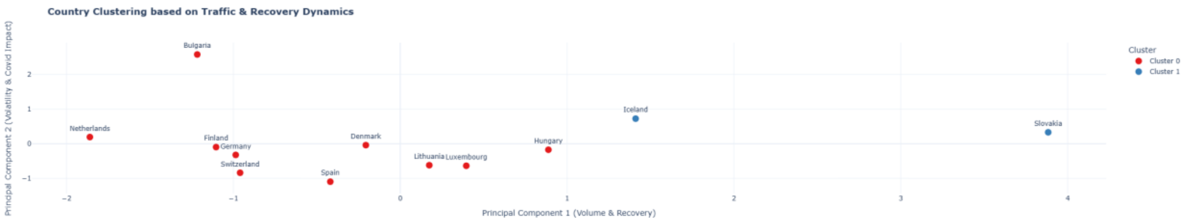

Figure 5. Countries Clustering based on Recovery Dynamics and Traffic

Figure 6 details the evolution of passenger traffic between 2026 and 2030, showing a positive trend while accounting for existing seasonality. For instance, the predicted number of passengers for the first cluster is approximately 79 million, while for the second cluster, it is almost 1.25 million for August 2026. In December 2030, the first cluster had 88 million passengers, while the second cluster had 1.2 million passengers, compared with 55 million for the first cluster and 0.6 million in December 2025. Those differences in forecasts across clusters indicate an uneven growth trajectory, underscoring the importance of more effective and continuous use of cohesion policy instruments to support disadvantaged regions.

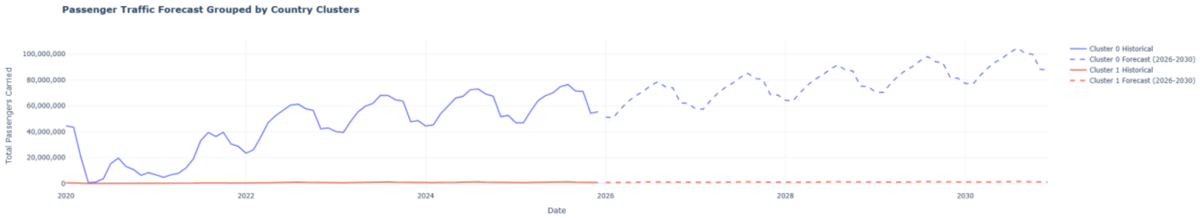

Figure 6. Passengers Traffic Prediction based on Country Clusters

Figure 7 provides an overview of the seasonality and operational efficiency for the airports. A total of five clusters have been defined based on the similarities. The first cluster comprises 65 airports, with a mean seasonality of 2.60, an average of 130 passengers per flight, and a recovery index of 1.66. The most representative airports included in the first cluster are: Geneva, Stuttgart, Sevilla, Ibiza, and Eindhoven.

The second cluster has 24 airports, with an average seasonality of 1.26, a mean of 45 passengers per flight, and a mean recovery index of 1.33. The most representative airports are: Aarhus, Melilia, Vaasa, Kuusamo, and Jyvaskyla.

The third cluster included 10 airports, which have an average seasonality index of 1.82, a mean passengers per flight of 141, and a mean recovery time of 1.85. The most relevant airports in the cluster are Madrid/Adolfo Suarez Madrid-Barajas, Amsterdam/Schiphol, Frankfurt/Main, Barcelona/El Prat, and Munich/Munich International Airport.

The second-to-last cluster describes only one airport, Erfurt-Weimar, with a seasonality value of 15.82, a mean passengers per flight of 157, and a recovery index of 49.58, showing the airport's development over the last five years.

The last cluster contains only one airport, Burgas, and has the highest seasonality ratio (49.96), a mean of 156 passengers per flight, and a recovery index of 1.46.

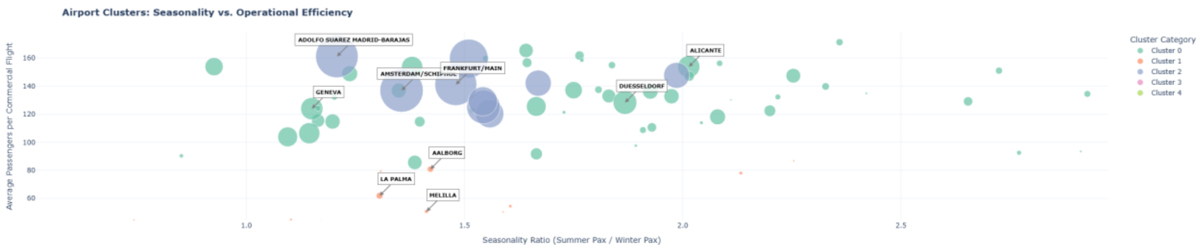

Figure 7. Airports Clusters: Comparison between Seasonality and Operational Efficiency.

Figure 8 shows the full overview of the airports, including the high seasonality values for Erfurt-Weimar and Burgas.

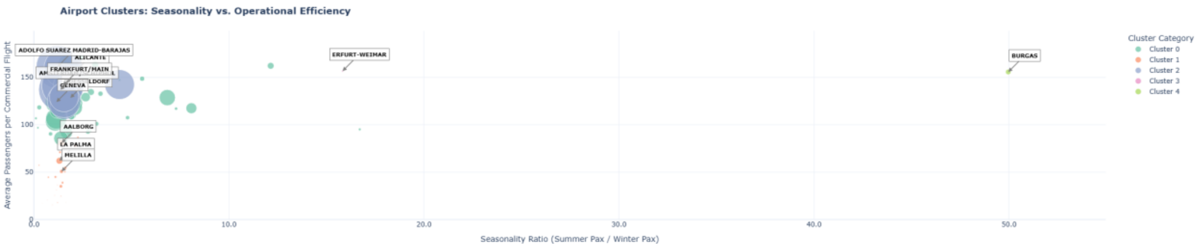

Figure 8. Airports Clusters: Comparison between Seasonality and Operational Efficiency Full Overview

Figure 9 shows a map of all airports included in the analysis, generated with Python using *geopy* library (*Geopy*, n.d.). In addition, the geographical distribution of the airports included in the analysis shows the coverage of cohesion policies aimed at enhancing connectivity across the European Union, bringing together central and bordering regions.

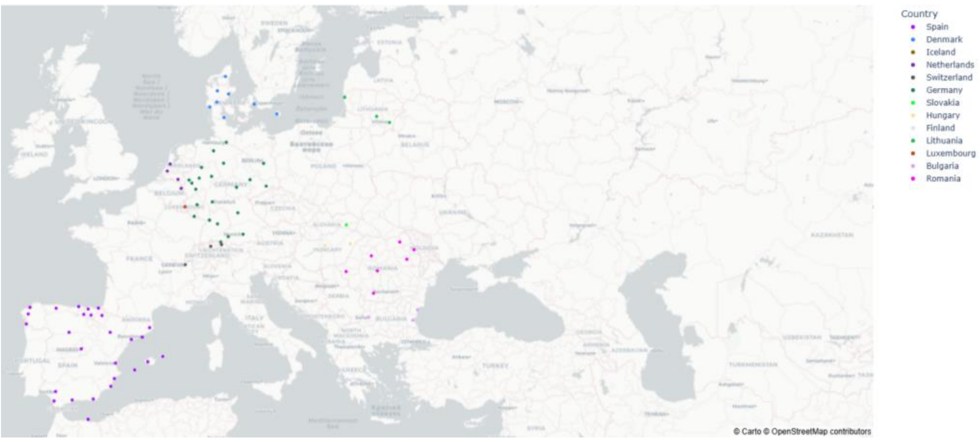

Figure 9. Map of Airports included in the analysis

Conclusions

The presented analysis shows a strong recovery in air traffic across European countries following the COVID-19 pandemic, with seasonal patterns and differentiated development trajectories. The results suggest that cohesion policy-supported investments contributed to improved regional access and helped air traffic recovery, particularly in touristic regions. Despite this, the high dependence on seasonal demand suggests uneven regional coverage across the EU airports considered. Future research should bring cohesion policy funding data to assess further the link between regional economic development and air transport growth.

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