

Forecasting the Development of Passenger Air Transportation: Regional Aspect

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Abstract

This article examines the influence of external factors on air passenger transportation, a key component of tourism. Factors such as military conflicts, epidemics and large-scale international events can both stimulate growth in passenger traffic and cause sharp declines. Methodologically, the study is based on the analysis of statistical data for 2012–2024 on the volume of passenger air transportation, with further spatial aggregation of data and the construction of trend models for 2022–2025 for airports in countries bordering Ukraine. The results indicate a transformation of air services associated with the displacement of logistical, evacuation, and migration routes. The forecast models suggest that high activity will persist at these regional airports in the short to medium term, even if the security situation partially stabilises. The study highlights both negative and positive changes in the spatial restructuring of aviation infrastructure in Central and Eastern Europe, with an emphasis on the role of peripheral airports under new conditions of population mobility.

Keywords

dynamics of passenger air transportation; tourism; external factors; regional transformations; forecasting.

Introduction

Over the past five years, passenger air travel has undergone profound transformations, directly affecting not only the aviation industry but also tourism as a global economic sector. The COVID-19 pandemic was an unprecedented shock to global tourism, as border closures, travel restrictions and lockdowns led to a sharp decline in international tourist flows. In 2020, global tourism returned to 1990s levels, and airports lost passengers en masse, turning from vibrant hubs into almost empty facilities.

After the gradual recovery from the pandemic, growing demand for travel has presented new challenges for airports, which are dealing with staff shortages, logistical disruptions and changing expectations among travellers regarding safety, hygiene and the digitalisation of services. Automated screening systems, biometric technologies and contactless services have become the norm, especially at tourist-friendly airports (Prymak et al., 2020). However, the war in Ukraine has added another dimension of instability, namely the suspension of air traffic over Ukraine, which has not only changed routes but also affected tourism flows in Eastern Europe. Tourists have

reoriented towards the western regions of the European Union (EU) or have chosen domestic tourism. This has also led to a redistribution of air traffic, the growing role of alternative transport hubs, and increased integration of aviation with rail and road transport. There has also been a significant redistribution of air passenger flows, in particular through the transfer of a substantial share of Ukrainian passenger traffic to European airports located near the Ukrainian border. Such changes have had a significant impact on the operation of border airports in Poland, Slovakia, Hungary, Romania, Lithuania, Latvia and Moldova, initially due to evacuation and humanitarian flights and, over time, due to the growth of tourist flows from Ukraine and increased offers from tourism sector stakeholders.

In response, the tourism industry in Europe has begun to integrate more closely with the aviation industry, with many regions focusing on sustainable tourism by combining air routes with the development of local tourism infrastructure, convenient ground connections, and digital services for travellers (Şahin, 2024). The role of medium-sized and regional airports is growing, and these airports have begun to actively promote themselves as 'gateways' to local tourist destinations that were previously less popular but now meet the demand for less mass tourism and more sustainable travel experiences.

Airlines are also adapting their routes to changes in tourism demand, focusing on seasonal destinations that ensure a stable flow of tourists and on cooperation with regional administrations to promote specific destinations. Tourist flows have become more flexible and dynamic, with a greater emphasis on online booking, short trips, and multimodal routes, where air travel is only one component of the journey. Thus, the modern travel model in Europe increasingly reflects a new paradigm that is adaptive, decentralised and focused on safety, sustainability, and passenger comfort, in which tourism and aviation strategies are developing in close interaction.

The main problem addressed in this study is the need to assess the impact of external factors, in particular military conflicts, on the structure of regional passenger air transportation. The closure of Ukrainian airports has led to a significant redistribution of passenger traffic between neighbouring European hubs, which, in turn, has affected infrastructure development and the economies of border regions. The study also contributes to understanding how local and global events affect transport systems and economies over time and provides recommendations for aviation and tourism stakeholders to adapt to changing conditions, which should be considered in strategic development. The results can be used for further planning of transport infrastructure, adaptation of aviation logistics flows, and assessment of the long-term impact of the war on tourism.

Literature review

The relationship between air transport and tourism, as well as the impact of global crisis events on this interaction, has been actively studied in the scientific literature over the last decade. In particular, many authors emphasise that air mobility is a key factor in the development of international tourism and the economy (Graham et al., 2010; Forsyth, 2023), and that changes in the availability of air transport can significantly affect the tourist attractiveness of regions. According to Šauer et al. (2021), this may represent a key strategic perspective for ensuring further growth of the industry. The COVID-19 pandemic became a powerful catalyst for rethinking the role of airports in the tourism system (Abate et al., 2020), triggering numerous studies assessing the economic impact of travel restrictions (Dimitriou & Sartzetaki, 2022; Melgar et al., 2024) and the adaptation of infrastructure to new conditions. Dimitriou and Sartzetaki (2022) highlight the importance of developing local airports as indicators of regional growth, as they contribute to improving transport accessibility, stimulating economic activity, attracting tourist flows, and enhancing the competitiveness of regions in tourism and logistics.

At the same time, there is growing interest in sustainable tourism in the context of regional aviation development. Researchers consider the implementation of multimodal transport solutions as a strategic response to environmental challenges (Čižiūnienė et al., 2022), as well as a way to integrate airports into tourist routes with minimal environmental impact (Pagliarin & Marks, 2025). Of particular interest are studies that analyse the role of regional airports in the decentralisation of tourist flows and the development of remote areas (Olariaga, 2021; Komornicki & Goliszek, 2023),

which has gained renewed relevance in light of military conflicts and changes in transport chains in Eastern Europe. The approach proposed by Olariaga (2021) highlights the need for state support and development, as this contributes to improving transport accessibility and activating socio-economic processes in the regions.

The war in Ukraine has had a significant impact not only on the country itself and its internal processes, but also on neighbouring countries (Bocquillon et al., 2024). It has been a critical factor in transforming the region's aviation and tourism landscape, in particular by highlighting the inter-relationship between security, mobility, and economic sustainability in a global context. Ostroumov et al. (2025) draw attention to the fact that the war in Ukraine has significantly transformed the airspace architecture of the Eurasian region, leading to the loss of direct connections on key trans-continental routes and reducing the efficiency of air transport. This has created a need for new air traffic management strategies, greater system flexibility, and a rethinking of the safety and economics of air transport in high-risk zones. Accordingly, this requires in-depth research into changes in Ukraine's aviation industry and regional developments, taking into account security challenges, the restructuring of transport and logistics chains, the redistribution of passenger flows, and new conditions for integration into the European aviation space.

This article aims to assess regional transformations in air passenger flows at EU airports bordering Ukraine in the context of military conflict, to determine the influence of external geopolitical and crisis-related factors on their dynamics, and to develop forecasting models to assess the prospects for the development of regional aviation infrastructure under geopolitical change.

To achieve this aim, a quantitative analysis of statistical data from selected airports and official EU statistics on air passenger flows for 2012–2024 was conducted. The data were aggregated on a territorial basis to identify airports bordering Ukraine, and spatial analysis was used to identify trends and changes in the geography of passenger flows.

The study analysed the dynamics of passenger traffic at 11 airports: Rzeszów, Lublin, Kraków, Warsaw and Katowice (Poland); Košice (Slovakia); Debrecen (Hungary); Suceava (Romania); Chişinău (Moldova); Vilnius (Lithuania); and Riga (Latvia). The analysis period covers 2012–2024, with the aim of identifying changes in the structure of air traffic and assessing the volume of Ukrainian passenger traffic that could be redistributed, based on both observed statistical data and forecast values for 2025.

Trend models and time series were used to forecast the further development of passenger traffic. The forecast was carried out according to two scenarios: an optimistic one based on the dynamics of 2012–2019 (before the impact of COVID-19) and a pessimistic one considering the pandemic years 2020–2021 and their consequences. The forecast values for the number of passengers at each airport for 2022–2025 were calculated by extrapolating trends under both scenarios. The selected linear trend model represents a parsimonious specification appropriate for medium-term scenario-based extrapolation.

The use of simple linear models of the form $Y = aX + b$ is justified by their ability to produce realistic forecast values. The application of more complex mathematical relationships may provide better indicators of model adequacy; however, it often leads to less reliable forecasting results.

The adequacy of the regression models used to forecast expected passenger flows was evaluated using the F-test. The paper presents only a selection of the obtained results; specifically, the discussion of modelling and forecasting passenger flows for each of the analysed airports is included only partially. Nevertheless, the results of assessing the statistical significance of each model vary substantially depending on the length of the time series and the study periods included. Model diagnostics included R^2 values, t-statistics for the slope coefficient, the standard error of regression, and visual inspection of residuals to detect non-random patterns. Ninety-five per cent confidence intervals were calculated for the projected values. For example, the statistics for total airport traffic for 2012–2019 allow the construction of a model with a high degree of adequacy ($R^2 = 0.96$, $F = 2.36E-05$). However, the inclusion of the COVID-19 years in the time series sharply reduces the statistical significance of the estimates.

Forecasting accuracy was assessed through an ex post comparison of projected values with actual published passenger statistics. In most cases, observed values were within or close to the range defined by the pessimistic and optimistic scenarios, indicating the directional adequacy of

the trend-based projections. Particular attention was paid to 2022 as a structural turning point. Following the outbreak of the full-scale war in Ukraine, airport operations within the country were completely suspended, which led to a substantial redistribution of passenger flows towards airports located in neighbouring countries. The objective of the forecasting procedure was not short-term prediction accuracy but a scenario-based assessment of structural redistribution dynamics under exogenous geopolitical shocks.

Potential structural breaks associated with the COVID-19 pandemic and the 2022 war were considered qualitatively in the interpretation of the results. The absence of formal structural break testing constitutes a methodological limitation and is acknowledged as a direction for further research.

A comparative analysis of passenger traffic growth rates was also conducted for the selected airports, the EU as a whole, and the 55 member countries of the European Airports Association. Graphs and tables were used to compare and visualise the results.

Results

One of the key factors determining the level of tourism development is the state of passenger air transportation. Air accessibility directly influences tourists' decisions, especially those of international travellers, when choosing a destination. Affordable and frequent flights stimulate short-term tourism, and the development of hub airports and low-cost airlines makes countries more accessible to a wider range of travellers.

In the context of globalisation and increasing competition between tourism markets, not only is the availability of tourist facilities important, but also the quality of transport infrastructure, service, digital technologies, and environmental standards. According to Pohuda et al. (2024), tourism development is of strategic importance for the national economy, as it acts as a powerful multiplier of growth in related industries, such as transport, hospitality, retail, entertainment and culture. Tourism generates foreign exchange earnings, creates jobs, contributes to infrastructure development and improves a country's international image.

Jaisinghani et al. (2024) note that the experience of Central and Eastern European countries shows that under favourable conditions (political stability, a safe environment and convenient transport connections), tourism can become one of the drivers of economic growth. Poland, Hungary, Slovakia and Romania demonstrate a steady increase in tourist flows, which indicates effective policies aimed at enhancing tourist attractiveness, investment in promotion and improvements in travel convenience (CEIC, 2024). For Ukraine, particularly in the post-war period, tourism may become an important component of economic recovery through the development of domestic tourism, the reconstruction of heritage sites, the expansion of airports, the attraction of investment to tourist regions and the creation of a safe environment for guests. Tourism is not only leisure or entertainment, but an economic resource closely linked to international mobility, air transport and the overall level of a country's openness to the world.

To achieve the stated aim of the study, an analysis of passenger traffic dynamics at European airports located along the border with Ukraine was carried out, which made it possible to assess the redistribution of Ukrainian passenger flows between these airports. A sharp increase in the number of passengers at airports in Poland, Slovakia, Hungary, Romania, Lithuania, Latvia and Moldova occurred in 2022–2023, as Ukrainian airports were forced to cease operations. Therefore, a comparison of passenger flows in 2021 and 2023 is appropriate and allows for a quantitative assessment of the changes in passenger traffic.

The obtained forecast indicators for 2022–2024 were compared with actual published statistical data for each of the 11 airports mentioned above. The analysis of the quantitative characteristics of the passenger traffic time series at these airports revealed the following:

- In 2022, actual passenger numbers at all airports were close to the average values between the pessimistic and optimistic forecasts. At the airports of Rzeszów (Poland), Košice (Slovakia) and Suceava (Romania), values were above the average forecast, while passenger traffic at Suceava Airport even exceeded the optimistic forecast.

- In 2023, actual passenger traffic figures at almost all airports studied (except Vilnius Airport) exceeded the average forecast, while passenger numbers at Rzeszów and Suceava airports again turned out to be higher than those predicted under the optimistic scenario.
- In 2024, passenger traffic indicators at all 11 border airports to Ukraine exceeded the average forecast, while figures for Rzeszów and Chişinău airports were again higher than those predicted under the optimistic scenario.

Subsequent analysis of the total passenger flow at these airports confirmed the abrupt nature of changes in passenger numbers in 2022–2024. The results of the analysis of total passenger traffic dynamics at the 11 airports located near the border with Ukraine are presented in Figure 1.

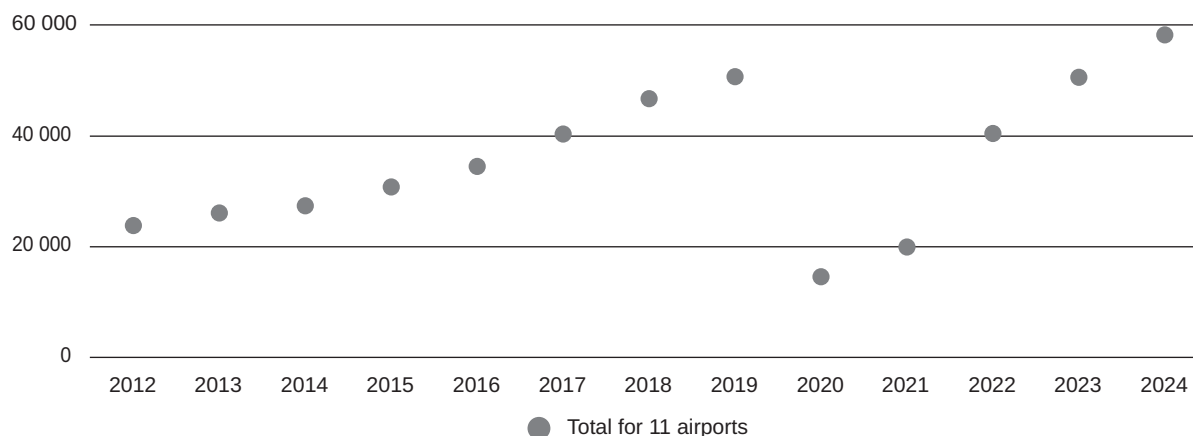


Fig. 1. Total passenger traffic at 11 airports near the border with Ukraine, thousand passengers

Source: Own elaboration.

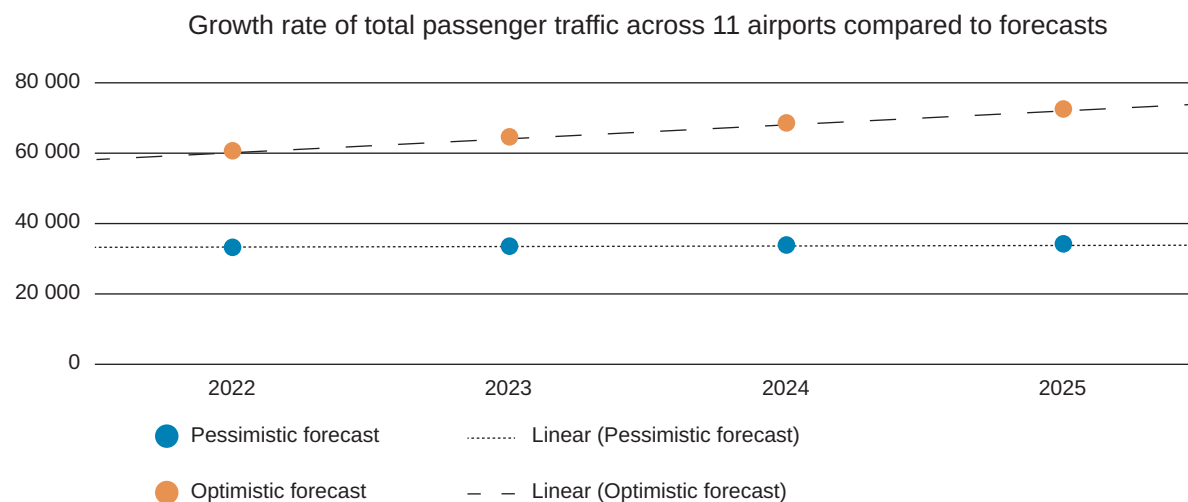


Fig. 2. Growth rate of total passenger traffic at 11 airports compared to forecasts

Source: Own elaboration.

The following features are noteworthy. Already in 2023, the total passenger traffic of these airports had practically returned to the pre-pandemic level of 2019 (50.65 million passengers in 2019 and 50.53 million in 2023). For comparison, passenger traffic in the EU in 2024 was still slightly lower than in 2019 (1,035.12 million passengers in 2019 and 1,000 million in 2024). Despite this, pan-European air passenger numbers recovered only in 2024 (2.45 billion in 2019, 2.33 billion in 2023, and 2.5 billion in 2024) (ACI, 2023).

An assessment of passenger number dynamics using simple regression analysis showed that the actual growth rate of total passenger traffic at these 11 airports is significantly higher, even

compared to the optimistic forecast (excluding the sharp decline in 2020–2021), amounting to approximately 8.9 million passengers annually versus the forecasted 3.98 million passengers (Figure 2).

The results of the comparative analysis of passenger traffic growth rates in Europe (55 countries), the EU, and the 11 airports under study are presented in Table 1.

Table 1. Comparative analysis of relative growth in the number of air passengers in Europe, the EU, and 11 airports bordering Ukraine, %

Years	Europe (55 countries)	EU	11 airports bordering Ukraine
2012–2013	4.41	1.53	9.56
2013–2014	4.23	4.70	4.99
2014–2015	2.70	4.93	12.46
2015–2016	5.68	6.34	12.07
2016–2017	4.58	7.70	16.98
2017–2018	9.52	6.12	15.86
2018–2019	6.74	3.90	8.51
2019–2020	–47.05	–73.26	–71.35
2020–2021	15.38	35.07	37.01
2021–2022	29.33	118.21	103.15
2022–2023	19.95	19.29	25.13
2023–2024	7.43	2.77	15.16

Note: Values in bold italics indicate the sharp increase in growth rates in 2021–2022.

Source: Own elaboration.

The table highlights a sharp increase in growth rates in 2021–2022. The recovery of air passenger traffic, and in particular tourism flows, began in 2021 following the lifting of epidemiological restrictions. However, a significant jump occurred in 2022, when the percentage growth in the number of air passengers at the 11 airports bordering Ukraine (103.15%), the EU (118.21%), and Europe as a whole (29.33%) differed substantially. In 2022, full-scale military operations began in Ukraine. Under these conditions, the operation of Ukrainian airports became impossible, and the flow of Ukrainian refugees was added to that of Ukrainian travellers, who were increasingly redirected through foreign border airports by tour operators and transport providers. An analysis of individual airports within the group of 11 border airports shows that relative passenger growth in 2022 compared with 2021 was significantly higher than the European and EU averages, in particular at Rzeszów (Poland) – 185.8%, Lublin (Poland) – 205.3%, Kraków (Poland) – 140.7%, Košice (Slovakia) – 221.7%, Suceava (Romania) – 120.4%, and Riga (Latvia) – 128.7%.

The differences in indicators between Europe, the EU, and the total passenger traffic of these airports are especially noticeable when comparing data for 2021 and 2024. During this period, relative growth in the number of air passengers in Europe (55 countries) was about 67% (from 1,500 million to 2,500 million passengers), while in the EU it reached 167.52% (from 373.809 million to 1,000 million). For the total flow of border airports, the increase was almost 193% (from 19.88 to 58.2 million passengers).

The average annual relative growth in passenger numbers in 2020–2024 for these 11 airports is significantly higher than the corresponding indicator for the EU and Europe as a whole (16 percentage points of average annual growth versus 13.6 percentage points in the EU, and 11 percentage points in Europe) (Figure 3).

Sharp fluctuations in air transportation volumes are possible in both positive directions (such as the hosting of Euro 2012, the introduction of visa-free travel between Ukraine and the EU, and the recovery after COVID-19) and significantly negative directions (such as the start of the military conflict in eastern Ukraine and Crimea, and the forced closure of all airports in 2022) (Figure 4).

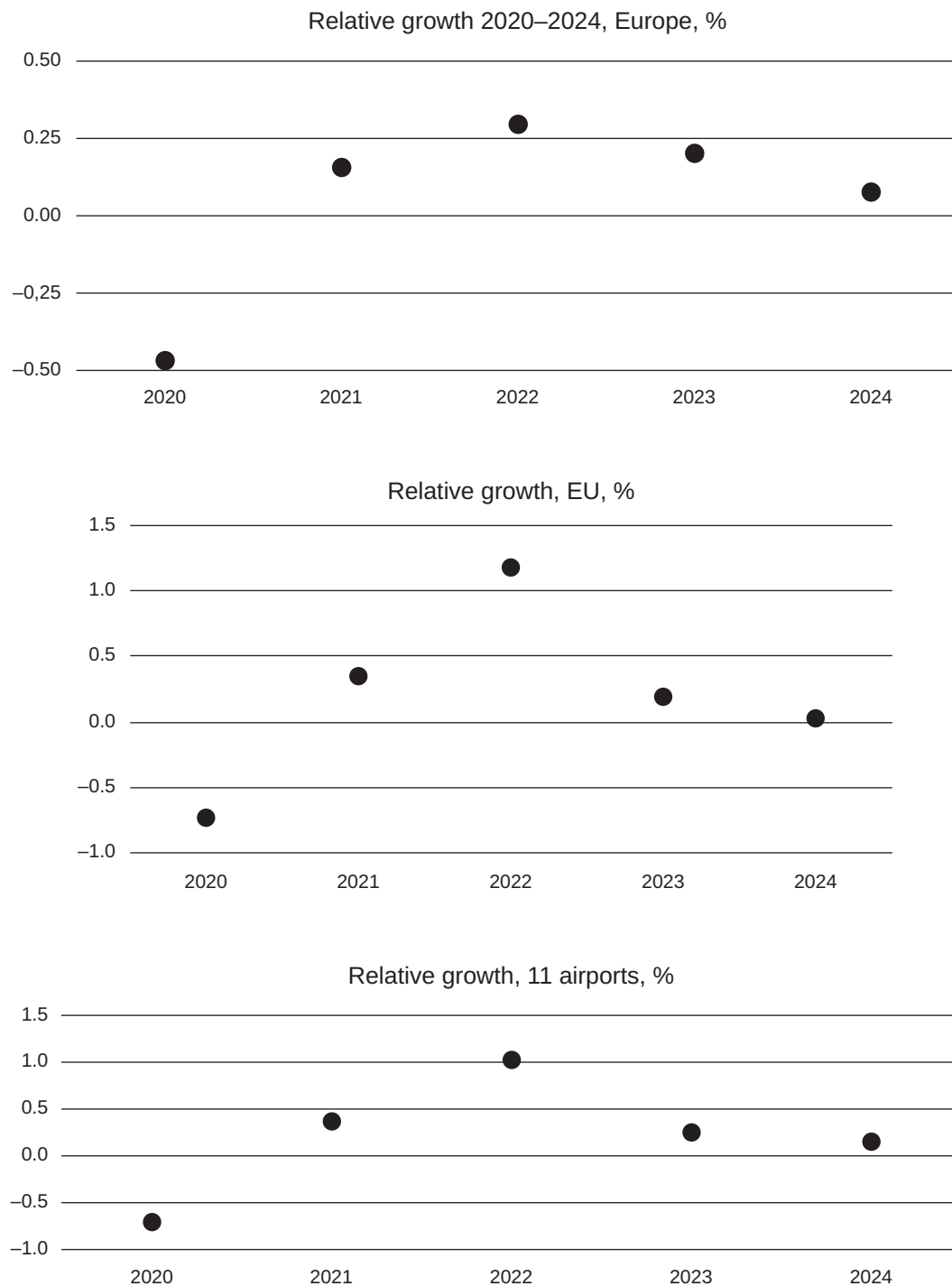


Fig. 3. Average annual ex post relative growth in passenger traffic in Europe, the EU and border airports

Source: Own elaboration.

At the same time, even after the exclusion of Donbas and Crimean airports from Ukrainian airspace in 2014, Ukraine's contribution to EU air passenger traffic has steadily increased and reached 4.34% in 2021 (Figure 5).

The closure of Ukrainian airspace for civil aviation from 24 February 2022 led to an increase in the share of airports adjacent to the Ukrainian border in EU passenger traffic (from 5.32% in 2021 to 5.82% in 2024). According to forecast estimates of Ukrainian passenger flows, values ranged from 18 to 22.5 million passengers in 2022, from 18.6 to 23.5 million in 2023, and from 19.1 to 24.5 million in 2024. The sharp increase in total passenger traffic in 2022 compared with 2021 at

airports near the Ukrainian border – doubling from 19.88 million to 40.39 million passengers – and in 2024 compared with 2021 – nearly tripling to 58.2 million passengers – is largely attributable to the aggregation of these airports' own traffic with redirected Ukrainian passenger flows. Thus, it can be stated with a high degree of confidence that the observed growth rate of total traffic across the 11 airports increased primarily due to the forced redistribution of Ukrainian passengers.

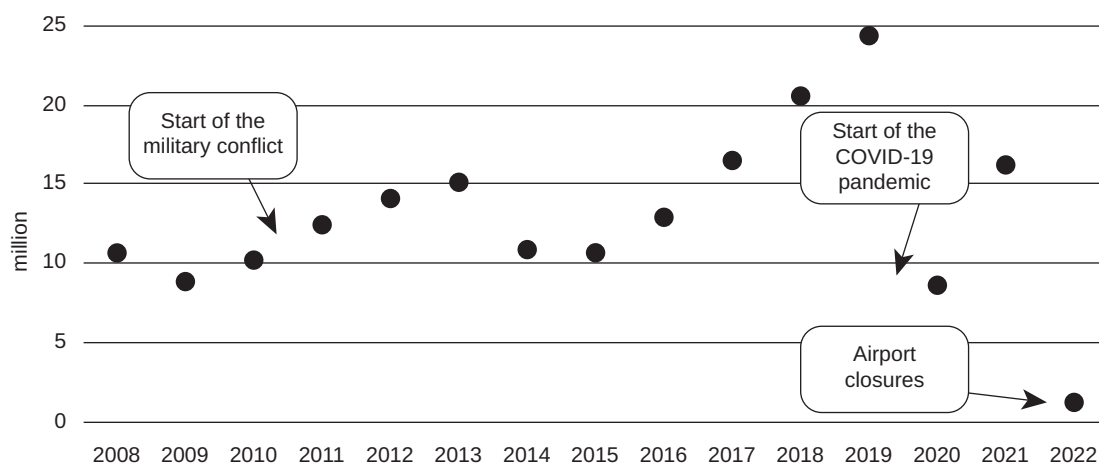


Fig. 4. Fluctuations in air passenger numbers in Ukraine

Source: Own elaboration.

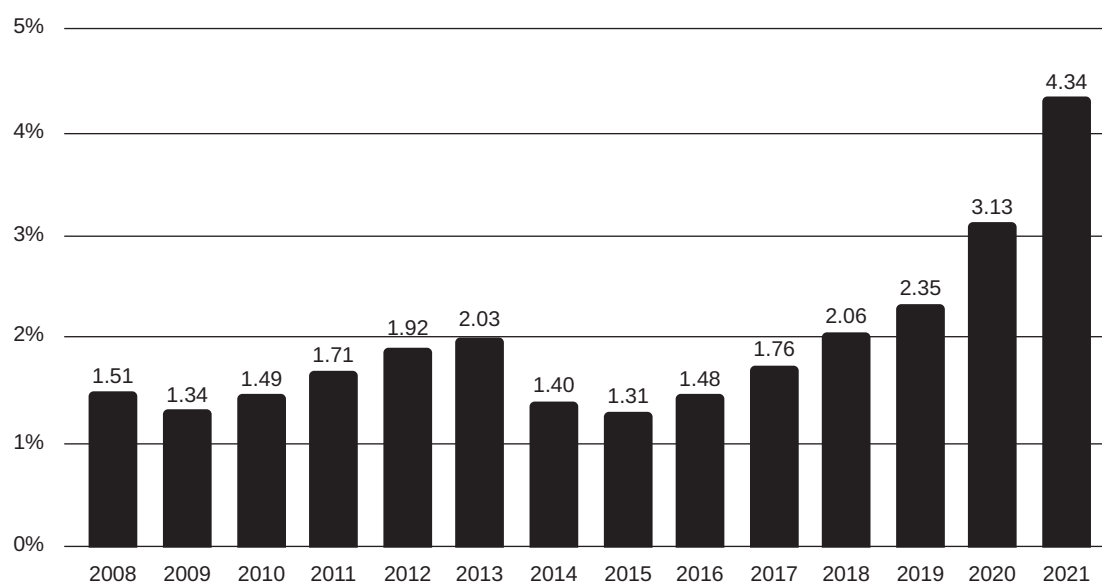


Fig. 5. Ukrainian air passenger traffic as a share of total EU flows (%)

Source: Own elaboration.

The conducted assessments make it possible to obtain the expected (under optimistic and pessimistic scenarios) values of passenger numbers for each of the 11 airports bordering Ukraine, as well as the total passenger flows for these airports in 2025 (Table 2).

The analysis of the data for 2022–2025 allows a number of systemic conclusions to be drawn regarding the dynamics of passenger traffic at regional airports in Central and Eastern Europe and Ukraine. First, the results indicate the complex and non-linear nature of the mobility recovery process. Based on the calculated forecast data for 2022–2025, it is possible to identify the influence of both 'deferred demand' formed as a result of pandemic-related restrictions and the impact of the war in Ukraine. The analysis of passenger traffic at 11 European airports located along the border

with Ukraine shows an unprecedented increase in traffic volumes in 2022–2024, largely due to the cessation of operations at Ukrainian airports. In 2022, actual passenger traffic at most of the airports considered was close to the average value between the pessimistic and optimistic forecasts. At the same time, for some hubs, such as Rzeszów, Košice and Suceava, the actual figures even exceeded the optimistic scenario. In 2023–2024, many airports recorded a sharp increase in actual passenger traffic, which is explained not only by the recovery of tourism but also by changes in travel routes resulting from the war in Ukraine, as a significant number of passengers who previously departed from Ukrainian cities were forced to redirect their travel through the infrastructure of neighbouring countries.

The fact that actual passenger volumes at several airports exceeded even optimistic pre-pandemic trend projections suggests not only temporary substitution effects but also a potential structural reconfiguration of regional aviation demand patterns.

It is worth emphasising that certain events can cause a short-term surge in tourist flows. This supports the argument that individual external events, regardless of their nature (e.g. pandemic, war), may trigger a sharp but temporary increase in passenger flows. Such effects last only as long as there is immediate demand or interest and do not necessarily translate into sustainable development. Examples include football championships and cultural events such as Eurovision: although interest may increase during and shortly after the event, it tends to decline quickly in the absence of a consistent regional development strategy. Without a systematic approach to building a territorial brand, developing tourism infrastructure, and maintaining an international media presence, tourist interest fades once the event is over. In the long term, such factors do not generate sustained growth, which can be explained by the absence of continuing demand and follow-up activities capable of attracting tourists.

The projected values for 2025 reflect the continuation of historical time-trend extrapolation under the two specified regression scenarios. These values represent statistical projections derived from linear trend models and do not incorporate potential geopolitical resolution factors or structural recovery mechanisms. Therefore, any interpretation of post-war passenger surges should be clearly distinguished from the quantitative forecast results and treated as scenario-based expectations rather than direct outputs of the regression models. This may indicate the importance of transitioning from a reactive to a more proactive model of airport infrastructure and regional tourism development. Without a clear strategic vision, systematic territorial marketing, investments in infrastructure, and the creation of tourist attractions (such as international events, cultural or sports forums), passenger traffic may again decline towards average levels. In addition, sustaining positive dynamics requires attention to the competitiveness of regional airports, in particular through the expansion of route networks, the attraction of low-cost carriers, the improvement of ground transport links to hubs, and close cooperation with local authorities and tourism organisations. Without an adequate response to these structural challenges, even a temporary increase in passenger traffic will not translate into sustainable regional development.

In this context, it is reasonable to assume that the next significant increase in passenger traffic in the region could occur after the end of the war in Ukraine. This would primarily affect Ukrainian airports, which are currently completely excluded from the international air transport system. Their reopening may be accompanied by a temporary increase in passenger volumes, both domestic and international, driven by post-war reconstruction, the return of part of the population, and the resumption of humanitarian, business, and tourist travel. Considering deferred demand and the anticipated international interest in Ukraine as a symbol of resilience and recovery, this growth is likely to be sharp but temporary, unless it is supported by a national tourism strategy.

At the same time, for 11 airports in neighbouring countries (Poland, Hungary, Romania, Slovakia, Lithuania, Latvia and Moldova), which in recent years have effectively become transit hubs for Ukrainian passengers, the opposite dynamics are likely. With a reduced need for alternative routes for Ukrainians following the reopening of Ukrainian airspace, demand for their services is expected to decline. This will likely be reflected in a reduction in passenger traffic, especially at border airports such as Rzeszów and Debrecen.

Table 2. Forecasted passenger traffic at 11 airports bordering Ukraine

	Rzeszów	Lublin	Kraków	Warsaw	Katowice	Košice	Debrecen	Suceava	Chişinău	Vilnius	Riga	Ukraine	Total flow of 11 airports
2022	Optimistic forecast	888.2	641.8	9,568.5	22,510.9	5,876.3	736.3	706.2	599.1	3,931.3	9,204.7	22,477.0	60,835.7
	Pessimistic forecast	445.9	314.6	5,371.4	12,285.4	3,377.5	349.6	352.5	430.4	2,367.0	4,681.9	17,991.0	33,253.3
	Real data	731.1	330.1	7,394.2	14,400.0	4,419.1	542.9	249.5	763.9	3,920.0	5,381.0	1,300.0	40,385.8
2023	Optimistic forecast	899.7	696.9	10,249.7	23,912.6	6,248.5	786.6	774.9	663.7	4,203.1	9,781.9	23,480.0	64,812.7
	Pessimistic forecast	421.7	326.3	5,497.3	12,335.8	3,420.2	348.8	374.2	472.9	2,432.9	4,660.7	18,558.0	33,585.4
	Real data	1,020.2	398.8	9,404.6	18,500.0	5,609.0	625.1	306.1	802.2	2,838.0	6,631.0	–	50,535.0
2024	Optimistic forecast	931.3	752.1	10,930.9	25,314.3	6,620.7	836.9	843.5	728.3	4,474.8	10,359.2	24,483.0	68,789.8
	Pessimistic forecast	397.4	338.0	5,623.1	12,386.2	3,462.8	348.3	395.9	515.3	2,498.9	4,639.5	19,125.0	33,917.5
	Real data	1,145.3	425.8	11,080.8	21,300.0	6,386.1	739.0	312.3	746.6	4,142.0	7,120.0	–	58,197.9
2025	Optimistic forecast	962.9	807.2	11,612.1	26,716.0	6,992.9	887.2	912.1	792.9	4,746.5	10,936.6	25,486.0	72,766.8
	Pessimistic forecast	373.2	349.8	5,749.0	12,436.6	3,505.4	347.3	417.7	557.8	2,564.7	4,618.4	19,692.0	34,249.5

Source: Own elaboration.

It should be noted that the steps already being taken by airports to stabilise future operations and maintain current passenger traffic volumes are quite noticeable. For example, Suceava and Chişinău airports are currently actively cooperating with representatives of the Ukrainian tourism industry, including airlines (Sky Up!, Skyline Express (Avianews, 2024)) and tour operators (Coral Travel, Join Up!). The runway at Debrecen Airport was restored in July 2024 (Vasiliev, 2024), and upgrades to taxiways and a new airport navigation system are also planned. Thus, the key tasks for the development of such hubs can be seen as reorientation towards new markets, retention of the existing passenger base through service expansion, introduction of new routes, and competitive pricing strategies.

Summary and conclusions

The war in Ukraine significantly affected the dynamics of air passenger traffic at EU border airports, creating a distinct regional aviation effect. Similar to this study, Prytula et al. (2024) emphasise the importance of adapting transport infrastructure to the challenges of the contemporary geopolitical environment, which is relevant for the sustainable development of the region. At the same time, while this study provides an analysis of the impact of military and geopolitical factors on tourism and passenger traffic, Nawrocka and Kozłowski (2025) conducted a retrospective analysis of investments in the development of a single airport over a defined period, assessing long-term socio-economic and environmental consequences. Both studies highlight the importance of aviation infrastructure for regional development and draw attention to the challenges of integrating infrastructure solutions with social and spatial dimensions. This study contributes to the literature by empirically identifying and quantifying a regional aviation redistribution effect caused by a large-scale military conflict. Unlike traditional demand-shock studies focused on pandemics or economic crises, it demonstrates how the forced closure of national airspace can generate measurable cross-border passenger concentration at neighbouring airports.

Analysis of statistical data for 2022–2024 shows a significant increase in passenger traffic at airports bordering Ukraine, indicating a shift in logistics and transport flows in response to military and economic challenges. The forecasting results suggest the continuation of passenger traffic growth within the framework of scenario-based extrapolation of historical time trends. Unlike the abstract network analysis of airports presented by Huynh et al. (2024), this study demonstrates the real consequences of a geopolitical shock for a specific segment of the aviation network and provides forecast data for further use by specialists in this field. What this study has in common with Huynh et al. (2024) is the analysis of structural changes in air mobility and the strategic implications for the aviation industry, which allows for the identification of a potential paradigm shift at both global and regional levels.

The study found that the impact of the war on the region's aviation infrastructure is heterogeneous, with passenger traffic growth observed primarily at airports serving as transport hubs for the movement of people and goods, while other airports show stabilisation or even decline. The results support the hypothesis of a complex regional effect that includes both economic and social dimensions, including increased population mobility and strengthened logistical connections. The complexity and global relevance of these dynamics are also highlighted in the work of Sun et al. (2024), which examines long-term structural inequalities in air connectivity between countries.

The novelty of the study lies in the identification and quantification of this effect, as well as in forecasting its further development, taking into account geopolitical and economic factors. Methodologically, the application of a dual-scenario deterministic trend extrapolation allows for comparison between pre-crisis and crisis-adjusted passenger dynamics, offering a transparent and replicable tool for scenario-based forecasting under geopolitical shocks. The study further adopts a regional perspective, linking external geopolitical and crisis-related events with changes in air transport flows and tourism patterns, and highlighting both immediate surges in passenger traffic at border airports and potential long-term structural shifts in regional aviation infrastructure. The practical significance of the results lies in the potential to optimise the development of border airport infrastructure and to inform adjustments to EU transport policy in the context of military operations.

Prospects for further research include analysing the impact of this regional aviation effect on the economic development of adjacent territories and assessing the potential for greater integration of transport systems.

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