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ANALYSIS OF AIR PASSENGER DEMAND TRENDS AND GDP ELASTICITY IN SELECTED EU COUNTRIES

Antonio Danesi [1], Kinga Walawender [2]

[1] *PhD in Transport Engineering,University of Bologna, School of Engineering and Architecture,Viale Risorgimento 2, 40136 Bologna, Italy, tel. +39-(0)51-2093343, e-mail: antonio.danesi@unibo.it*

[2] *M.Sc. in Civil Engineering, freelance transport analyst, Os. Mlodych 6, 63-000 Sroda Wielkopolska, Poland, tel.: +48502601444, e-mail: walawender.kinga@gmail.com*

Abstract:
This paper examines air passenger demand trends in six countries of the European Union, i.e. Austria, Czech Republic, Germany, Italy, Poland and Slovakia. Data collected from 2004 to 2017, with reference to air passenger arrivals and departures as well as Gross Domestic Product (GDP) in the sample of countries under consideration, show different traffic trend curves, economic background and elasticity.

Keywords: *Air transport demand, air traffic trend lines, regression techniques, GDP elasticity.*

INTRODUCTION

Global air traffic growth averaged 6.5% during the past five years, as a consequence of lower air fares, higher living standards in emerging markets, growth of tourism and travel and new airline business models [1]. Past studies and experiences [2] suggest that air transport demand is strongly related to socio-economic variables, such as per capita income and Gross Domestic Product (GDP). Indeed, air transport demand is typically considered to approximately outpace GDP percentage growth by a factor of two [2], that leads to a rough estimate of 2 for the value of GDP elasticity regarding air traffic volumes.

Following the global economic crisis started in 2008, the EU has faced a period of economic vulnerability and uncertain socio-economic perspectives and the majority of EU countries is still fighting against weak economic growth. On the other hand, the air passenger market has performed quite well in recent years also at EU airports [1], with annual rates of increase well above GDP trends.

In the present research, air passenger arrival and departure data for a selection of EU countries in the period 2004-2017 have been analysed and compared to the values of GDP taken as a measure of the local economic background.

1 AIR PASSENGER DEMAND AND GDP DATA

The present study considers total (national and international) air passenger arrival and departure data to/from the airpots of the following EU countries: Austria, Czech Republic, Germany, Italy, Poland and Slovakia. Year 2004 has been chosen as the beginning of research data set, as it is the first one to have all of those six countries together in European Union.

Fig. 1 and Tab. 1 show the differences in passenger volume trends in the selected countries. The highest values belong to Germany, followed by Italy, then Austria, Czechia and Poland and last but not least Slovakia. Indeed, between 2014 and 2017, the total number of air passenger arrivals and departures increased from 18 to 28 millions in Austria, from 10 to 16 millions in Czechia, from 136 to 212 millions in Germany, from 81 to 144 millions in Italy, from 6 to 38 millions in Poland and from 1 to almost 2,5 millions in Slovakia.

As far as traffic units are concerned, the most rlevant growth was registered by Germany, with a total increase in air passenger traffic by 76 millions of units, while the most dramatic percentage increase was gained by Poland, where air passenger traffic in 2017 became six times the value registered in the base year 2004.

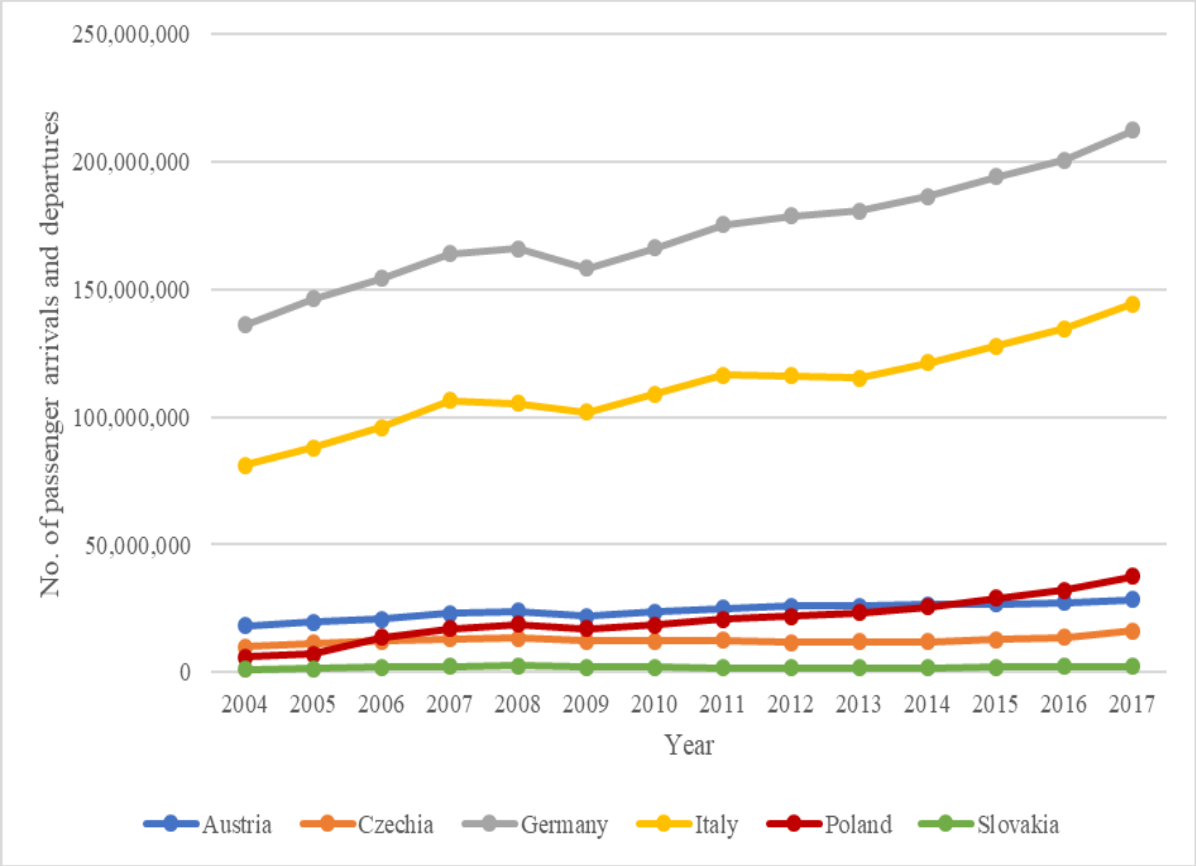

Fig. 1 *Number of air passenger arrivals and departures in years 2004-2017 for selected countries.*
(Source: https://ec.europa.eu/eurostat/data/database)

Tab. 1 *Rates of increase for passenger arrivals and departures, in the selected EU countries.*

YEAR	AUSTRIA	CZECHIA	GERMANY	ITALY	POLAND	SLOVAKIA
2005	7.59%	13.22%	7.50%	8.24%	16.23%	40.57%
2006	5.79%	8.04%	5.47%	9.11%	94.03%	39.82%
2007	10.09%	7.62%	6.29%	10.82%	24.62%	5.08%
2008	4.25%	2.53%	1.21%	-1.01%	9.39%	16.30%
2009	-8.71%	-7.91%	-4.59%	-3.22%	-8.97%	-24.96%
2010	7.86%	-1.01%	5.05%	7.11%	7.84%	-3.41%
2011	6.82%	3.33%	5.53%	6.57%	12.25%	-3.91%
2012	3.30%	-7.18%	1.87%	-0.17%	5.65%	-13.55%
2013	-0.83%	1.27%	1.23%	-0.65%	6.76%	-0.39%
2014	2.44%	1.58%	3.13%	5.11%	10.48%	7.33%
2015	1.42%	4.90%	4.02%	5.37%	12.42%	16.30%
2016	1.60%	7.89%	3.48%	5.34%	11.62%	11.04%
2017	4.22%	18.94%	5.83%	7.31%	16.79%	11.32%
TOTAL (04-17)	54.82%	63.43%	56.27%	77.69%	518.60%	122.27%

Fig. 2 and Tab. 2 represent the annual values of real Gross Domestic Product (GDP), calculated using chained–linked volumes in accordance to the year 2010, so that the GDP values are not affected by inflaction rates.

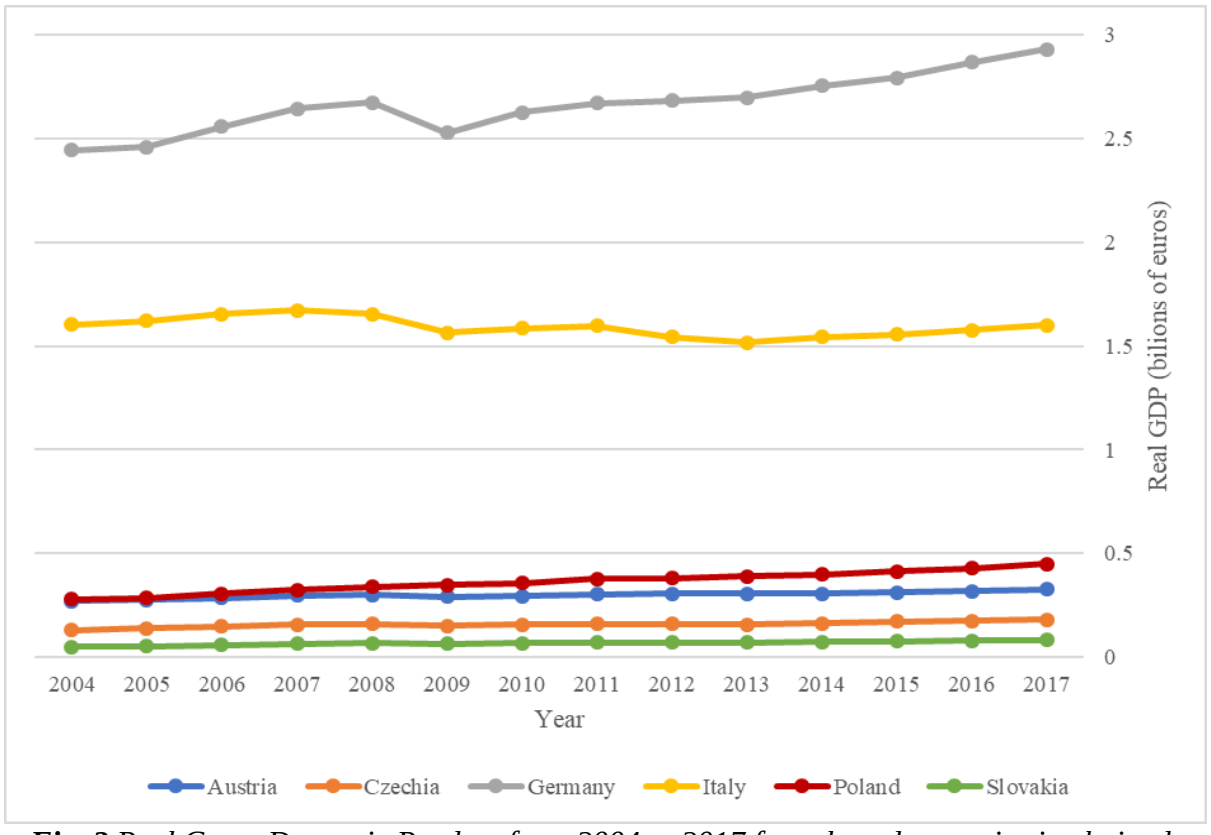

Fig. 2 *Real Gross Domestic Product from 2004 to 2017 for selected countries in chained-linked values to the base year 2010.*
(Source: https://ec.europa.eu/eurostat/data/database)

Tab. 2 *Rates of increase for Real Gross Domestic Product (in chained-linked values to the base year 2010), in the selected EU countries.*

YEAR	AUSTRIA	CZECHIA	GERMANY	ITALY	POLAND	SLOVAKIA
2005	2.24%	6.29%	0.64%	1.02%	2.69%	6.47%
2006	3.63%	6.88%	3.95%	2.12%	6.62%	9.10%
2007	3.82%	5.14%	3.39%	0.98%	6.16%	10.19%
2008	1.42%	2.20%	1.13%	-1.02%	4.68%	5.94%
2009	-3.82%	-4.44%	-5.48%	-5.47%	2.30%	-5.44%
2010	1.93%	2.41%	3.97%	1.46%	2.99%	4.36%
2011	2.83%	2.25%	1.73%	0.67%	5.43%	4.07%
2012	0.67%	-0.48%	0.43%	-3.30%	1.01%	1.77%
2013	-0.03%	-0.56%	0.54%	-1.83%	2.00%	0.88%
2014	0.38%	2.63%	2.10%	1.84%	2.82%	3.13%
2015	1.19%	5.45%	1.42%	0.81%	3.78%	4.52%
2016	2.19%	2.00%	2.68%	1.35%	3.56%	2.91%
2017	2.77%	4.49%	2.15%	1.41%	4.44%	2.91%
TOTAL (04-17)	12.04%	34.38%	19.93%	-5.37%	61.64%	61.29%

Fig. 2 and Tab. 2 illustrates that the countries belonging to the research sample differ very much for what concerns the level and rate of increase of their economic systems.

Fig. 3, 4, 5, 6, 7 and 8 compare trends in annuale rate of increase in air passenger traffic and real GDP, for each country included in the research data set. All graphs confirm that a more or less strong relationship exists between air passenger volumes registered in the selected countries and their real GDP values.

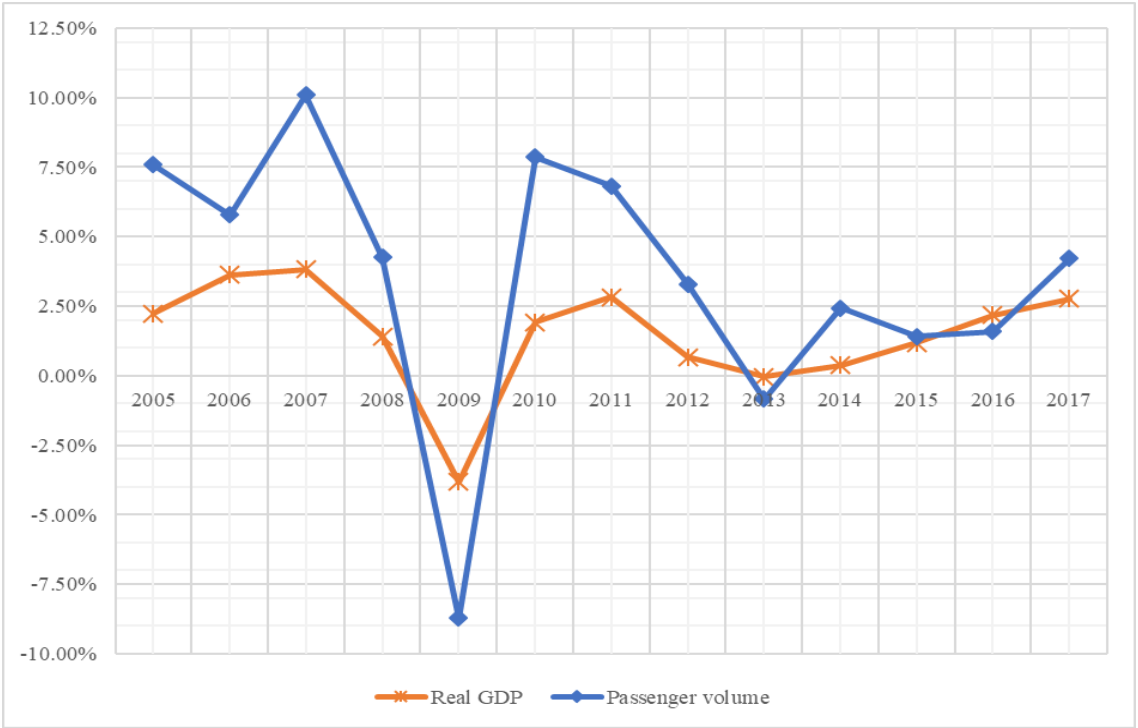

Fig. 3 *GDP and passenger volume annual changes for Austria, from 2005 to 2017.*

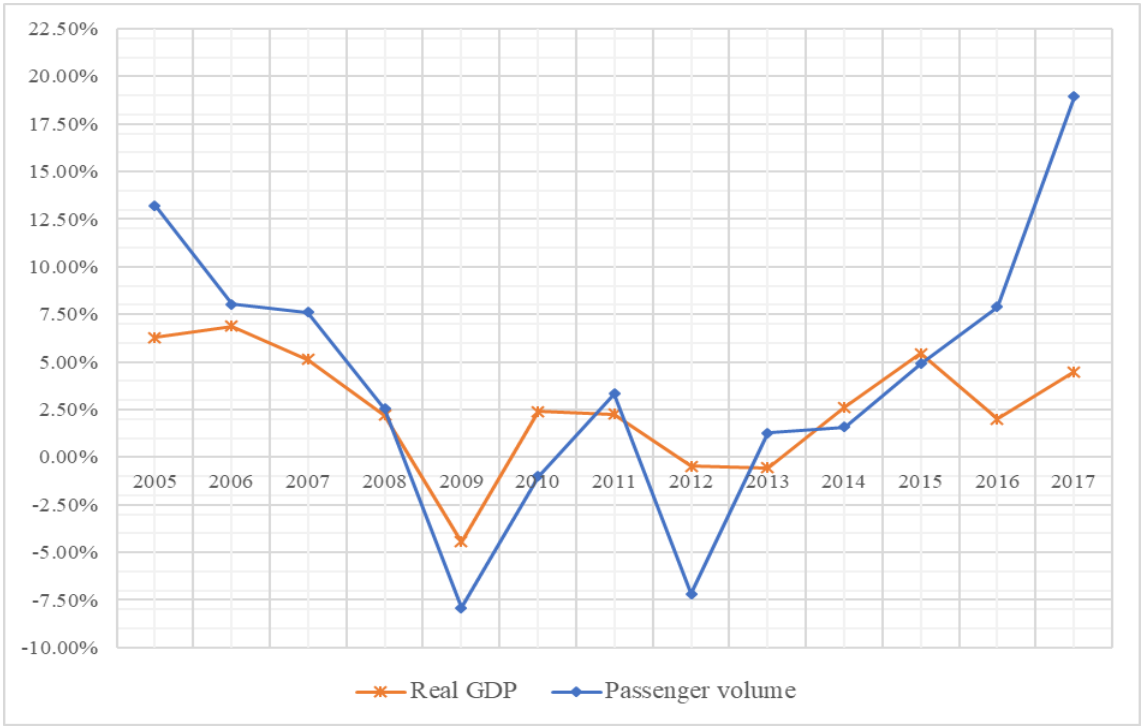

Fig. 4 *GDP and passenger volume annual changes for Czech Republic, from 2005 to 2017.*

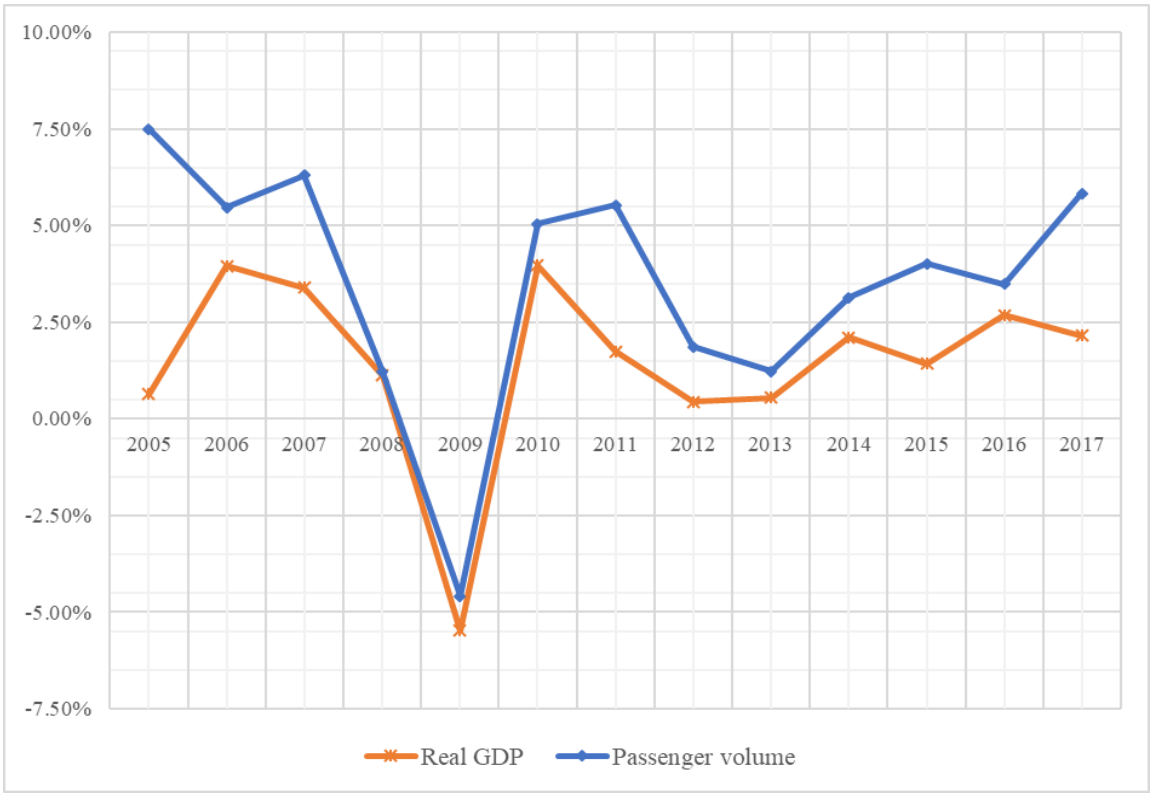

Fig. 5 *GDP and passenger volume annual changes for Germany, from 2005 to 2017.*

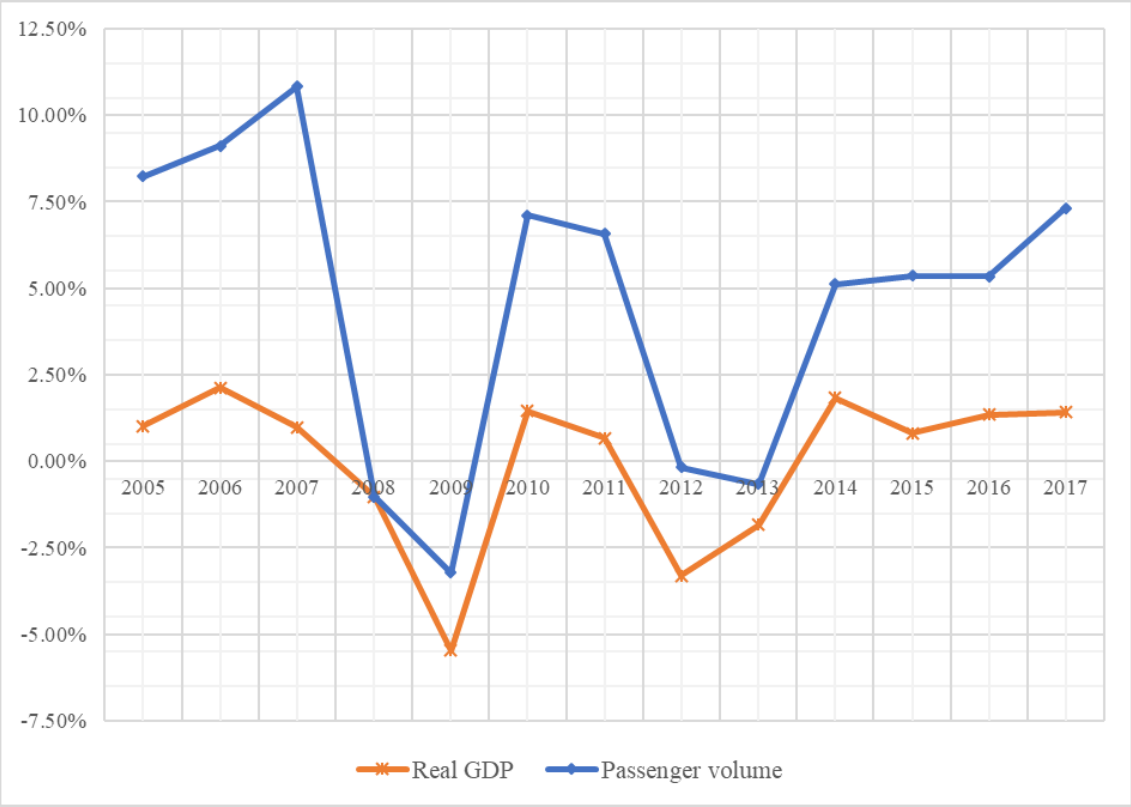

Fig. 6 *GDP and passenger volume annual changes for Italy, from 2005 to 2017.*

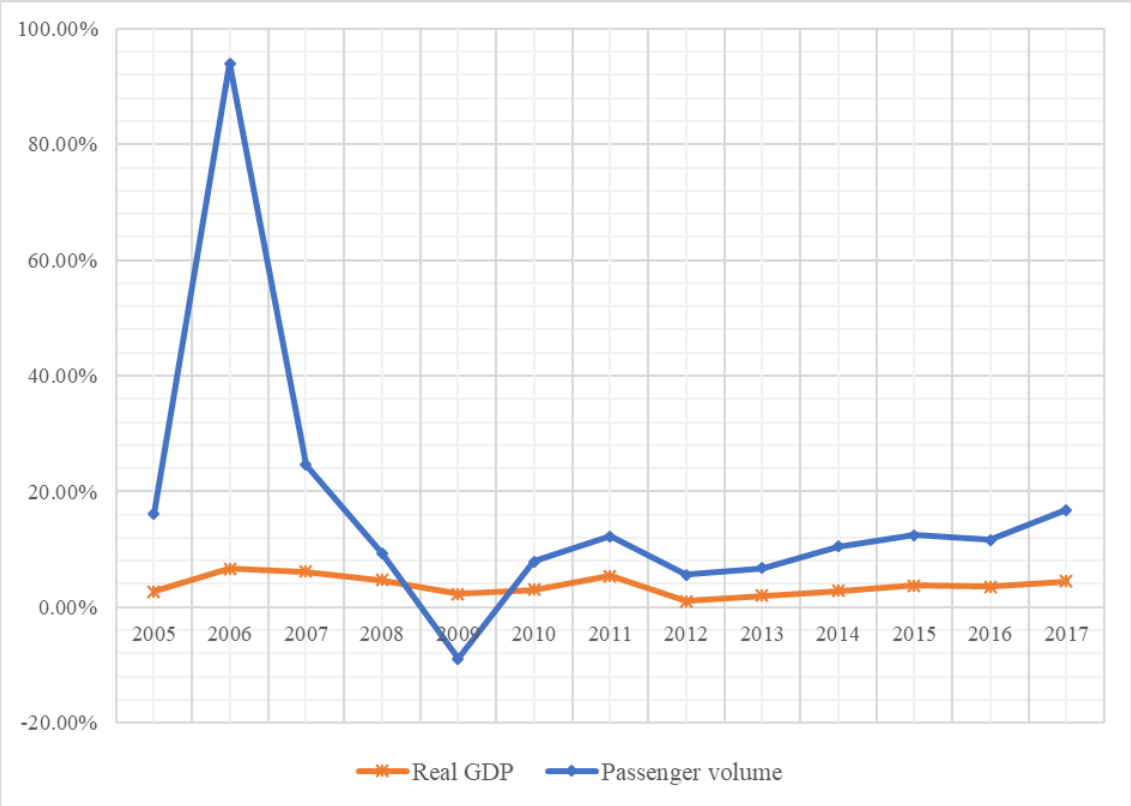

Fig. 7 *GDP and passenger volume annual changes for Poland, from 2005 to 2017.*

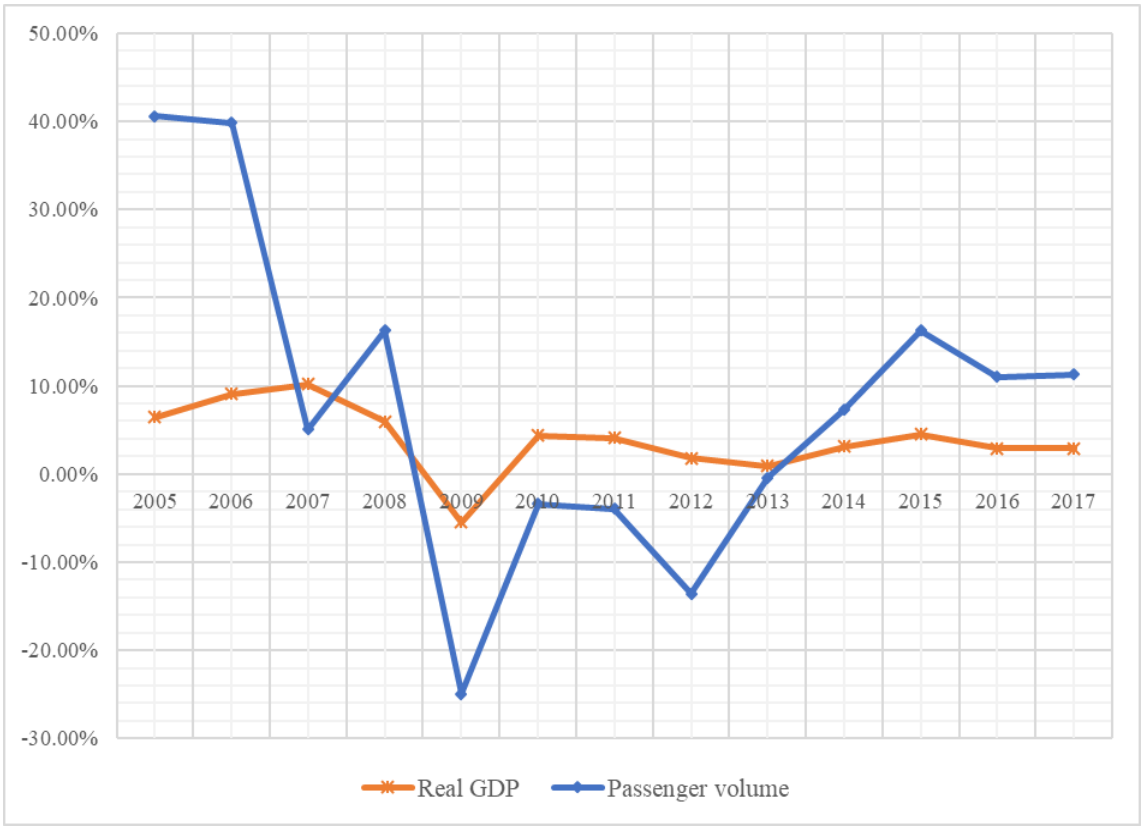

Fig. 8 *GDP and passenger volume annual changes for Slovak Republic, from 2005 to 2017.*

2 REGRESSION ANALYSIS OF TIME SERIES

In the practice of air transport market analyses and forecasts, the most popular regression techniques are those based on linear and exponential trends, where the first one is taken into account under the hypothesis of decreasing annual rates of increase and the second one is taken into consideration when traffic rates of increase appear to be constant [2, 3, 4, 5]. In both cases, under the purely statistical perspective, the problem can be reduced to the linear statistical model, by applying the method of least squares [6, 7, 8].

If y_t is the passenger volume, i.e. the total number of air passenger arrivals and departures, during year x_t, with t=1,…,n, under the linear trend hypothesis, the statistical model to calibrate can be written as:

$$y_t = \hat{y}_t + e_t, \qquad \hat{y}_t = \beta_1 + \beta_2 x, \qquad e_t \approx N(0, \sigma^2), \qquad t = 1, \ldots, n \qquad (1)$$

where: y_t *– passenger volume,*
x_t *– year,*
e_t *– normal distributed errors,*
β_1 *,* β_2 *– parameters to be estimated.*

On the other hand, as far as the exponential trend is assumed to be valid, the reduction to a linear statistical form can be provided by the following substitution of variables:

$$Y_t = \ln(y_t) \qquad (2)$$

The equation of the regression curve can be changed accordingly:

$$y = ab^{bt} \rightarrow \ln y = \ln a + bt \quad (3)$$

where: a – (estimated) value of the base year traffic volume,
b – (estimated) constant rate of increase in traffic data.

In order to estimate the parameters of the regression models, the method of least squares can be applied both in the case of linear and exponential regression models.

2.1 Linear trend lines

In order to see how air passenger volumes, i.e. air passenger arrivals and departures for each country, have changed from 2004, data from Eurostat database have been plotted. First, a linear regression line has been fitted, in accordance to (1). Tab. 3 presents the values of R^2 obtained in the linear regression analysis, i.e.the results in terms of the amount of variance shown by the data sample, which can be explained by means of the linear regression model. The best data fit is shown by to Germany, while R^2 of Slovakia is very low (8%).

Tab. 3 *R^2 values from linear trend lines fitted for selected countries, in the period 2004-2017, with reference to air passenger time series.*

COUNTRY	R^2
AUSTRIA	0.92
CZECHIA	0.39
GERMANY	0.95
ITALY	0.94
POLAND	0.93
SLOVAKIA	0.08

2.2 Exponential trend lines

Tab. 4 presents the values of R^2 obtained in the regression analysis performed under the hypothesis of exponential traffic trends. The most important factor when it comes to exponential trend line is the constant rate of increase, which is also presented in Tab. 4.

Tab.4 *R^2 values from exponential trend lines fitted for selected countries, in the period 2004-2017, with reference to air passenger time series.*

COUNTRY	R^2	b/100[%]
AUSTRIA	0.90	2.95
CZECHIA	0.40	1.67
GERMANY	0.95	2.89
ITALY	0.93	3.64
POLAND	0.84	11.4
SLOVAKIA	0.11	1.79

The highest b coefficient belongs to Poland, whereas Czechia closes the table with 0.1 %. While the idea of this research paper is not to compare both methods, similarities may be seen as to which countries are first and last on both lists. We can note that R^2 values are very similar so, in at least our case, it is noticeable that a coefficient of the rate of increase in exponential trend does not differ a lot from a linear trend.

The problem of choosing between linear and exponential trends is a delicate matter. It often happens that a linear trend is chosen for a statistical model instead of exponential one, giving values higher than 0,9 for R^2 coefficient. Moreover, making predictions of traffic on the base of the exponential increase hypothesis rather than linear, gives generally different results, even in case of a short period. In order to correctly choose a trend, a critical issue is to take into consideration a particular situation, but simple quantitative methods may be of help – for instance, RESET test [5].

3 AIR PASSENGER TRAFFIC ELASTICITY WITH RESPECT TO REAL GDP DATA

Elasticity (ε) indicates the percentage change that will occur in one dependent variable (y) when another independent variable increases its value by one per cent [2, 6]:

$$\varepsilon = \frac{\frac{dy}{y}}{\frac{dx}{x}} = \frac{d(\ln y)}{d(\ln x)} \qquad (4)$$

where: y – air passenger arrivals and departures (milions),
x – real GDP values (milions of euro).

Tab. 5 shows the estimates for the elasticity values obtained by fitting a linear regression line taking the natural logarithm of air passenger volumes as a function of the natural logarithm of real GDP values.

The ln-ln relationship fit the data particularly well for the case of Austria, Germany and Poland, which show an elasticity value of air traffic with respect to real GDP equal to 2.5, 2.3 and 3.4 respectively. Also the statistical data concerning Czech Republic are fitted quite properly by the regression model, with a resulting value for GDP elasticity equal to 1.1. On the other hand, the variance of neither the Italian nor the Slovak data set are explained for an enough relevant part by the regression model and in the case of Italy the estimated value of the GDP elasticity shows a negative sign, which is not consistent at all with the past experiences and studies.

Tab.5 *Results of the ln-ln regression model for the estimation of elasticity of air passenger traffic volumes with respect to real GDP annual values (calculated in chained-linked values to the base year 2010), in the selected EU countries.*

COUNTRY	ε	R^2
AUSTRIA	2.5	0.97
CZECHIA	1.1	0.75
GERMANY	2.3	0.96
ITALY	negative value	0.17
POLAND	3.4	0.92
SLOVAKIA	0.9	0.30

3 CONCLUSIONS

This research shows that, for the selected EU countries, namely Austria, Czech Republic, Germany, Italy, Poland and Slovak Republic, different air passenger traffic trends, real GDP trends and values of elasticity of air passenger traffic with respect to real GDP data can be observed.

All countries under consideration show a significant increase in air transport demand, with particular regard to Poland and Slovak Republic, which also register a very strong increase in their real GDP values. On the other hand, GDP values show a quite weak increase as far as Austra and Germany are concerned, while Italy registers a decrease in its real GDP between year 2004 and year 2017. Therefore, it can be stated that air passenger demand has increased in the selected EU countries more strongly than the local economic variables, as represented by real GDP data.

Following the regression analysis leading to the estimation of the elasticity of air passenger traffic with respect to real GDP values, it can be observed that the relationship between GDP and air passenger demand appears to be valid, at least for the cases of Austria, Czech Republic, Germany and Poland, with values of GDP elasticity of air passenger demand ranging between 1.1 and 3.4.

For what concerns the Italian air transport systems, the increase in air passenger transport demand has been registered even in presence of very weak economic development. The latter observation, together with the case of Poland, where GDP elasticity of air traffic appears to be particularly high, with very impressive growth in air passenger volumes, seem to confirm that the economic variables are not the only drivers tat can prompt air transport demand.

Furthermore, it can be noted that the impressive increase registered by the air transport market in Poland seems to support the need for massive infrastructural investments, including the construction of new airports, that are in the plans financed by the national and local authorities.

Generally speaking, the outcomes of the present research, which demonstrate that different EU countries have shown quite different paths in the development of air passenger traffic between 2014 and 2017, lead to the conclusion that different values of the average annual rate of increase and/or different GDP elasticity values of air passenger traffic should be taken into consideration in different national airport systems, when causal as well as temporal forecasting methods need to be specifid, calibrated and validated. Air passenger traffic forecasts are tipically very difficult to be derived, but they are absolutely necessary for airline operators, airport managers and air transport planners and analysts in their job.

Further research on this topic may investigate more deeply the relationship and elasticity of air traffic with respect to GDP, with reference to an extended sample of EU and non-EU countries, that can be classified accordingly to their economic trends and the level of maturity of their transport market. In addition, a study may be conducted for different countries in order to identify and isolate the effect of socio-economic as well as transport system variables that can lead to local air passenger transport development in presence of flat or even decreasing trend in the values of GDP.

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